THE IMPACT OF CONSTRUCTION ACTIVITIES ON MOSQUITO FAUNA AND THE INCIDENCE OF HUMAN MALARIA IN THE FEDERAL CAPITAL TERRITORY (ABUJA) OF NIGERIA

BY

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A thesis submitted to the postgraduate school, Ahmadu Bello University, Zaria inrpartial fulfilment of the requirements for the award of the Degree of Master of Science in Zoology

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

_____

Date

The above declaration is confirmed.

_____

Name and Signature of Major Supervisor

_____

Date

CERTIFICATION

This thesis entitled 'THE IMPACT OF CONSTRUCTION ACTIVITIES ON MOSQUITO FAUNA AND THE INCIDENCE OF HUMAN MALARIA IN FEDERAL CAPITAL TERRITORY (ABUJA) OF NIGERIA' by YAYO ABDULSALAMI meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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Chairman, Supervisory Committee Date

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Head, Department of Biological Sciences Date

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Member, Supervisory Committee Date

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Member, Supervisory Committee Date

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Dean, Postgraduate School Date

DEDICATION

This work is dedicated to the memory of my grandfather's brother, A. Saleh who passed away in the period of this work. This work is also dedicated to my two daughters Ummi H. and Ummi S. and to the future of the million Nigerian children who fail victims to the mosquito bite at birth.

ACKNOWLEDGEMENTS

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The benevolent efforts shown by my Head of Department, Dr M. Sani, who granted me permission to start the course on time despite the bureaucratic obstacles from above, is sincerely appreciated. The early stage of this work could not have been accomplished without the active co-operation enjoyed from our Fly-boys, who enthusiastically helped in the collection of the larvae and adult mosquitoes. I would not fail to mention also the assistance received from technicians in the haematology, laboratory, particularly Mr Ogunbiade and Mallam Habibu who helped me in preparations of the blood slides and identification of parasites.

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A B S T R A C T

A study of the impact of construction works on the mosquito fauna and incidence of human malaria was undertaken in the Federal Capital Territory (Abuja) of Nigeria from February 1986 to June 1987.

In summary, a total of 67 breeding sites were visited out of which 37 (55.2%) were found in Garki Municipal compared to only 6(8.6%) at Sheda Village. A total of 2,057 mosquito larvae were collected out of which 1,284 (61.8%) were Culicine larvae while 793 were Anpphelines. 2,411 adult Culex pipiens fatiqans were caught from the various outdoor resting places. The sex ratio, i.e. male:female was estimated to be 1.3:1. of the 40 adult Anopheline mosquitoes caught, 11 **were An.** fenestus.

The indoor resting Anopheline population was studied using the Pyrethrum spray-sheet collection (PSC) technique, 259 -female An. gambiae were caught out of which 11 were sporozuite positive on dissection. The sporozoite rate of the population for the period April-October 1986 was found to be 4.2%. 65.8% of the total number of Anopheles gambiae dissected were blood-fed. The blood-feeding rates of the population were highest in August and September - 70.3% and 71% respectively.

The disease transmission potentials of the mosquitoes for September and October at Garki were 0.08 and 0.03 respectively. 35 Adult Aedes aeqypti were caught feeding outdoors between 4-7 p.m. at Sheda. 177 malaria patients were hospitalized in the clinic between January to

December, 1986. The highest percentage in-patient cases due to malaria, (11.8%) was recorded in June. on blood examination, 31.3% positive slides were found in the age group 2-4 years.

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CHAPTER ONE

INTRODUCTION

The term malaria originated in Italy and refers to the connection between the disease and "Bad air" (mal-aria) that was believed to cause it (Boyd, 1949). It was suggested that the disease originated in Africa and spread in the wake of human migrations to the Mediterranean shores, to Mesopotamia, the Indian Peninsula and South-East Africa (Jones, 1909; Harrison, 1978). Besides the simple association of the disease with marshes or swamps, its aetiology remained unknown until around 1880 when Manson discovered some human filarial parasites in mosquitoes (Knowles and Senior-White, 1927). This gave a clue for considering mosquitoes as possible vectors of malaria parasites (Russel, 1952, 1956). Information on the mode of transmission came in 1897 when Ronald Ross in Secunderabad (India) found sporozoites of malaria parasite in the body of a mosquito that had previously fed on a patient with Plasmodia in his blood (Manson-Bahr, 1963). In 1900, Manson *et al.* confirmed that malaria is transmitted by female anopheles mosquito (Bruce-Chwatt, 1977).

Mosquitoes have a world-wide distribution, occurring throughout the tropical and temperate region and are only absent in Antarctica (Smith, 1978). However, some genera have a restricted distribution and may be confined to certain areas; for instance, the genus *Haemagogus* is

found only in Central and South America (Service, 1980). Certain mosquito species such as Culex pipiens fatigans and Aedes aegypti are said to be ubiquitous but are more widespread in the tropics (Mattingly, 1962). Anopheline mosquitoes are most frequent in tropical or sub-tropical regions but are also found in temperate climates and even in the artic during summer (Bates, 1949).

Malarial parasites belong to the genus Plasmodium which contains about 100 known species, out of which only four, P. malariae, P.vivax, P. falciparum and P. ovale, are recognised as malaria parasites of man (Bray, 1957; Hoare, 1949; Garnham, 1966). P. falciparum is generally confined to tropical or sub-tropical regions, and is the principal malarial agent in north-west India, Ceylon and in Africa (Garnham, 1966). On the other hand, P. malariae occurs not only in the tropical and sub-tropical areas but is also found irregularly in tempevate areas; while P. ovale occurs predominantly in tropical Africa (Garnham, 1966).

Indigenous malaria has been recorded as far north as 64^{o}N latitude, in (USSR) and far south as 32^{o}S latitude (Cordoba in Argentina). Its records include those in the Dead sea are at 400 metres below sea level, at Londiani (Kenya) at 2600 metres above sea level and in cochabamba (Bolivia) at 2,800 metres (Bruce-Chwatt, 1980).

During the 1950s the annual incidence of malaria was about 250 million cases with 2.5 million people dying of the disease every year (Russel, 1956). According to Lysenko, et al. (1966) in one of the greatest epidemics of malaria in modern times that struck the Soviet Union, more than ten million cases were reported between 1923 - 1926, and at least about 60,000 deaths were recorded. In 1938, the invation of Brazil by A. gambiae was followed by an epidemic with over 100,000 cases and at least 14,000 deaths (Bruce-Chwatt, 1980).

Between 1942-1944, the same mosquito invaded lower Egypt and caused about 160,000 malaria cases and more than 12,000 deaths, while in 1958 an epidemic of malaria in Ethiopia caused more than 3 million cases and 150,000 deaths (MacDonald, 1957). More recently it has been estimated (Scholten's, et al. 1972) that about 1.8 billion people live in areas that are considered malarious. Out of these people, about 287 million are said to live in Africa, in what is described as totally unprotected areas (Bruce-Chwatt, 1966).

In Nigeria, one of the earliest written study of cases of Relapsing fever caused by insect bites was the work of Mc-Cullah (1925). He studied about three hundred cases of relapsing fever in northern

Nigeria whose relationship he traced to insect bites. Most notorious mosquito vector species that have been incriminated for the transmission of such diseases like yellow fever (Aedes aegypti), filariasis (Culex pipiens fatigans) and malaria (Anopheline spp.) have been identified in Nigeria (Bruce-Chwatt, 1949).

Throughout most of Africa South of Sahara, Nigeria inclusive, malaria shows a high endemicity, but has a low epidemic potential (Bruce-Chwatt, 1980). In these areas, malaria causes significant mortality in todlers, and young children suffer frequent and severe attacks (Miller, 1986). High incidences of malaria as manifested by high spleen rates in children has been recorded in most parts of the country (Wilcock's and Manson-Bahr,1980) and malaria situation is thus described as holoendemic.

In a recent report by the Federal Ministry of Health Statistic Unit (Anonymous, 1986), a total of 10,568,403 cases of illness are recorded on the nations 20 most common diseases from various hospitals throughout the federation. The document covers the period 1981 - 1985 and deals with eight killer diseases in the country namely measles, malaria, pneumonia, dysentery, tuberculosis, tetanus, chicken-pox and whooping cough. The statistics further released that 9,703,770 people suffered from the eight killer diseases in the period which represent about 91% of total cases. From the total number of deaths due to these diseases, 5,191 were attributed to malaria which is second only to measles in death toll (Anonymous, 1986).

Malaria is a morbid disease with severe socio-economic implications (Baudon et al. 1985). In 1981 a study of economic aspect of tropical diseases in Ghana undertaken by the Ghana Health Assessment Project Team, estimates were made of the number of days of Healthy Life lost per thousand persons per year for each of the 48 disease problems; and malaria was ranked highest with about 32,000 Days of healthy life lost per/1000 persons per year due to the infection. Not much work has been done to assess the socio-economic impact of malaria in Nigeria, but it is sufficient to state that a lot of man-hour is being lost to sick-leave or child absence from the school due to malaria (Ekanem, 1984).

The acknowledge of the distribution and epidemiological characteristics of malaria in the country led earlier workers to start pilot control projects in certain places (Bruce-Chwatt, et al. 1965). Several control methods used in Nigeria include environmental manipulations to reduce mosquito breeding (Gilroy and Bruce-Chwatt, 1945), domestic spraying using organochlorines (DDT, BHC and Dieldrin) in Western Sokoto Mass malaria Campaign (Dodge, 1961) and Organophosphorus insecticides, fenithion and malathion (Gratz and Dawson, 1963). No sooner were the insecticide-based control manoeuvre pursued, than reports of development of resistance to DDT started

to appear (Ramakrishna and Elliott, 1959). Despite all the technical, operational and other problems encountered in the course of malaria control in this country, successive governments continued with the control policy and by 1974, a National Malaria Control Unit was established under the Federal Ministry of Health (Ekanem, 1984).

By the decree Number Six of 1976, the Federal Military Government decided to shift the seat of the central government from Lagos to Abuja. Abuja was therefore chosen to be the New Federal Capital Territory (FCT) of Nigeria as recommended by the Justice Aguda Report (Mabogunje, 1978). Henceforth, the government fully embarked on major projects including Dams and Roads constructions. It is assumed that these changes in the area will unavoidably alter the ecology and are most likely to have effects on both the floral and faunal compositions (Imevre, 1980). The construction of the surface run-off, the provision of soakaways for the houses, the building of central sewage lines, the burrow-pits made by the construction companies are likely to create breeding grounds for mosquitoes. And it is suspected that the influx of labour force to Abuja will increase the human malarial parasites pool for transmission by the mosquitoes in the area: i.e. such a condition is potentially favourable for malarial epidemic (Bruce-Chwatt, 1980).

The present study is aimed at finding the distribution of mosquito vectors in this area, and at assessing the incidence of human malaria in the territory with a view to advising the Federal Capital Territory Authority (FCTA) on the possible impact of construction activities on public health.

CHAPTER TWO

LITERATURE REVIEW

Information exists on the various aspects of the biology of mosquito vectors and also on the life of the parasite. An attempt will be made here to review the taxonomic characteristics of some important vector species, their global distribution and identification of the parasite.

2.1 General Morphology and identification:

Mosquitoes possess conspicous proboscis, numerous appressed scales on the thorax, legs, abdomen and wing veins and along the posterior margin of the wings (Service, 1980). They are slender and relatively small insects, measuring about 4-6mm in length while others may be as long as 10mm (Smart, 1965; Service, 1980). The body is distinctly divided into a head, thorax and abdomen. The head is more or less globular in shape, bear a conspicous pair of kidney-shaped compound eyes, and a pair of filamentous and segmented antennae (Service, 1980).

All species of mosquito can be conveniently differentiated into males and females by the examination of the antennal hairs which in males are long and feathery while in the females are short and inconspicous (Mattingly, 1962; Service, 1980). Below the antennae

a pair of palps may be long or short, dilated or pointed at their tips, depending on the sex of the adults of different groups (Stone, 1959). The proboscis or the mouth-parts consists of the labrum, labium an upper mandibles and a lower maxillae which are pronounced in females and reduced in males; the hypopharynx contains the salivary glands (Roberts, 1978; Service, 1980). Both the thorax and the legs attached to it bear scales and colour patterns that are useful in species identification (Brown, 1953; Service, 1980).

The abdomen composed of ten segments are covered dorsally and ventrally with brown, blackish or whitish scales in Culicinae while members of Anophelinae are almost devoid of scale (Smart, 1956). The adult Anopheline mosquito rests at an angle to the surface while the Culex rest horizontally (Mattingly, 1969). Anopheline peculiar larval adaptations include the loss of respiratory siphon, the presence of "float hairs" on all or most of abdominal segments and the ability to rotate the head through 180° while feeding (Mattingly, 1973).

2.2 Identification of Anopheline Mosquito:

The genus Anopheles includes all the known vectors of human and simian malaria as well as the major vectors of rural bancroftian filariasis within its area of distribution (Mattingly, 1969). It contains about 350 species distributed all over the world (Stone, 1959).

Members of the Anopheles gambiae (Giles) complex, An. fenestus (Giles) complex, An. moucheti (Evans), An. nili (Theobald) are known to be important malaria vectors in West Africa (Haddow et al. 1951; Hamon, 1963; Hopkins, 1952; Giles & de Meillon, 1968). The identification features of these species are discussed here under.

Anopheles (complex): At the beginning of this century, it was recognised that within the group of some Anopheles species some forms exist with some biologically and morphologically different characteristics (Mattingly, 1969). The detection of 'long-winged' and 'short-winged' forms of Anopheles maculipennis in the Netherlands and their association with fresh and blackish water of their breeding places provided the first clue (Bruce-Chwatt, 1980). Studies on egg markings, behaviour patterns and reproductive compatibility led to more information enabling the separation of the species into about five sibling species. More recently, the value of studying the structure and banding patterns of chromosomes in the salivary glands of Anopheles [illegible] identification of sibling species (Mattingly, 1969). These cytotaxonomic and cytogenetic methods led to the separation of An. gambiae into at least six species. Four of these six species have been given the provisional names of species A, B, C and D, and the other two An. melas and

An. merus are salt water species, usually found near the cost (Mattingly, 1969). The first two are extremely efficient vectors of malaria throughout tropical parts of the African continent (Bruce-Chwatt, 1980).

An. gambiae is a medium sized anopheline with irregularly speckled legs with pale spot in 3rd dark area of wing vein 1 and lower branch of vein 5 (Smart, 1965; Gillet, 1971). The palps are smooth with three pale rings including wide ring at tip which is occasionally divided into two. The thorax is grey, brown reddish-brown or nearly black with creamy-yellow scales along centre of back (Hopkins, 1952). The wing markings are also important features in species identification (Brown, 1952; Gillet, 1971). In An. gambiae, wings have pale areas which vary in size. Pale patches occur on costa and vein 1, with two pale interruptions at base of costa and pale spot in 3rd area of vein 1. The main branch of vein 5 is also pale except at the end, while fringe-spots occur at tips of veins 2-6. The abdomen is pale brown or occasionally much darker and hairy with scales on back of segments 8 and sometimes on segment 7, (Gillet, 1971).

An. melas is darker than typical An. gambiae and tends to have four ringed palps while An. merus breeds along East Coast salt-water and tends to have four-ringed palps also (Gillet, 1971).

An. fenestus (complex) is made up of An. fenestus, An. arumi, An. brucei, An. confusus, An. fuscivenosus, An. leesoni, An.parensis and An. rivolorum but these are difficult to separate as adults (Gillet, 1971). They are small dark anophelines with almost entire dark and smooth with narrow white rings including one at tip, the last two rings widely separated in most of the species, but broad and narrowly separated in An. arumi and An. brucci(Gillet, 1971). The wings are with or without single pale interruptions to base of Costa, and vein 3 remain pale only in the middle or else it is all dark (Mattingly, 1962, 1967; Gillet, 1971). The legs are usually dark,but with faint pale-tips to the tibiae and occasionally also to the first four tarsal segments while the abdomen is dark brown and without scales (Smart, 1956; Gillet, 1971).

An. moucheti is a small dark anopheline with two wide pale rings of about equal width at tip of the palps (Brown, 1952). The palps are dark and smooth with three pale-rings including one at tip: ring 1 small, 2 and 3 wide (Gillet, 1971). The thorax is grey at the centre with creamy scales, and dark brown towards edges. The wings have pale scales which are creamy-yellow in colour (Brown, 1952) with two pale interruptions to base of costa, and no pale interruption

to 3rd main dark area of vein 1. Pale fringe spots are found at tips of all veins except vein 6 (Gillet, 1971). The legs of An. moucheti are long and mainly dark, but with pale tips to all tibiae, and to most of the tarsal segments (particularly on the front legs). Its abdomen bears no scales (Brown, 1956; Gillet, 1971).

2.3 Malarial parasites

2.3.1 Classification:

There is still considerable uncertainty on the taxonomical status of malaria parasites, especially above the order level, these parasites are placed under the phylum Protozoa (Honigberg et al. 1964). This system of classification is based on morphological and biological criteria as well as on phylogenetic consideration. It includes malarial parasites Plasmodium spp under subphylum sporozoa, class, Telosporea (Telosporidia) and the sub-class Coccidia (coccidiomorpha). All members of the subphylum sporozoa are parasitic and do not possess cilia or flagella, except on male gametes of certain genera (Baker, 1977). The Telosporea possess sporozoites and reproduce sexually while the trophozoites of subclass Coccidia are intracellular in nature. Baker (1977) further divides the subclass Coccidia into two orders, Protococcidia and Eucoccidia. The latter include three sub-orders namely Adeleina (Adeleorina),

Eimeriina (Eimeriorina), and Haemosporina (Haemospororina). The common characteristics of the order Eucoccidia are asexual and sexual phases of reproduction and anisogamy. By similar classification, Garnham (1966) placed the Eucoccidia in the family of Plasmodiidae. They show blood schizogony, have mosquitoes as arthropod hosts and their gametocytes are restricted to mature erythrocytes.

2.4 MALARIA

2.4.1 Mechanism of infection by Plasmodium:

The infection caused by Plasmodium species may be classified into the exoerythrocytic and erythrocytic stages (Wernsdorfer, 1980). The exoerythrocytic forms infect the parenchymal cells of the liver, while the erythrocytic forms infect the erythrocytes (Petersdorf, 1985). The infections are usually characterized by rigor, fever, splenomegaly, anaemia and by a chronic relapsing course (Wernsdorfer, 1980). P. vivax and P. ovale mostly infect young cells, while P. malariae predominantly infect senescent cells and P. falciparum both old and young cell (Wintrobe et al. 1974).

The attachment of Plasmodium to an erythrocyte is a pre-requisite for the invasion and seems tobbe mediated by the following mechanisms: Glycophorins, i.e. certain glyco-proteins, are found on the surface membranes of erythrocytes and are believed to be receptors for

occupation or attachment by the Plasmodia (Howard et al. 1982). Facer (1983) has demonstrated that human erythrocytes with a deficiency in glycophorin A and B shows a significant resistance to the invasion by P.falciparum merozoites in vitro. After such attachment, some products from the apical organelles of the merozoites (See and Krier, et al. 1980) i.e. the rhoptries and micronema initiate invagination of the host cell Plasmolemma. When the malarial parasite is completely engulfed, the ring forms will multiply and give rise to hundreds of the schizonts. This in turn leads to lysis of the red cells. The release of toxins and other antigens cause the characteristic rigor and fever of malaria (Wintrobe et al. 1974). In the case of P. vivax, the mechanisms of attachment to erythrocytes is different from that manifested by P. falciparum. Miller et al. (1975) have reported that the initial recognition and attachment of P. vivax merozoites to erythrocytes are mediated by Duffy blood group-related antigens. This means that individual whose erythrocytes are Duffy-negative, are notlikely to be infected by P. vivax due to the inability to form a merozoite-erythrocyte (Duffy negative) complex.

2.4.2 Pathogenesis and Morbidity:

The occurrence and survival of malaria are only possible when the mosquitoes and the infected human populations remain above a threshold i.e. they are very unlikely when the populations are below the critical density for each (Wintrobe et al. 1974). The pathological

changes in malaria are primarily brought about by the Plasmodial infection of erythrocytes and the sequel to the host's response. Broadly, the pathophysiological changes can be classified under:

(i) acute attack; or

(ii) chronic infection.

(i) Acute Attack: In an acute attack, the shapes and sizes of infected erythrocytes are changed, e.g. P. vivax parasitized red blood cells are enlarged and become angular in shape when pressed by neighbouring cells, P. falciparum parasitized cells become smaller than normal erythrocytes and there are some degree of crenation of body-infected and non-infected cells, moderate enlargement and distortion of the red blood cells occur in infections caused by P. ovale; while in P. malariae parasitized erythrocytes, there are no distinctive changes in the size and shapes of the cells (Field & Shute, 1956). These altered erythrocytes are prone to agglutination and Phagocytosis and even non-infected erythrocytes are liable to Phagocytosis. In addition, [illegible] blood cells are lysed by the malarial parasites, particularly, the falciparum species. All these, result in a remarkable degree of anaemia and profound tissue hypoxia both of which can lead to shock and the death of such patients (Aikawa et al. 1980).

Also, capillary occlusions due to sequestration of the infected erythrocytes cause haemorrhage and necrosis in the perivescular areas of the brain, myocardium, intestinal mucosa and skin (as purpura).

In the heart there may be fatty, degeneration, focal fragmentation and necrosis of the cardiac muscles whereas in the lungs the changes seen are pulmonary oedema, congestion and accumulation of pigment laden macrophages in the capillaries. Acute pulmonary insufficiency syndrome (APIS) due to falciparum malaria is not uncommon (Aikawa et al. 1988).

In acute malaria, the spleen becomes dark red to chocolate colour due to congestion and accumulation of malarial pigments. The pulp becomes soft and friable and the spleen is easily ruptured. The white and red pulps show hyperplasia and hyperenia and the sinusoids are dilated with numerous blood cells. There may be profound haemolysis due to increased activity of the spleen by speeding up the rate of erythrocyte destruction. Thrombin in the spleen may also cause haemorrhages, necrosis and infarctions (Schnitzer, et al. 1973). There is also a generalized stimulation of the reticulo-endothelial system (RES) (Aikawa et al. 1980).

Daroff et al. (1967) observed that about 2% of patients with acute P. falciparum malaria will develop cerebral malaria. Such patients may develop oedema of the brain with broadened and flattened gyri, congested arachnoid blood vessels with "pink brain" appearance. Deposits of malarial pigments and patachial haemorrhages, capillary occulussions with erythrocytes

masses are all common (Connor et al. 1976). These pathophysiological changes of the brain caused by P. falciparum, reverse after the patients recover (Rigdon, 1944; Maegraith, 1965). Studies in animals, however, negated these findings because clogged brain capillaries irreversibly produce impedence of local blood flow (Maegraith and Onabanjo, 1970).

In acute infection by falciparum malaria, the placenta is enlarged and the intervillous spaces of the maternal circulation are clogged with parasites and macrophages containing malarial pigment. There are also focal lymphocytic infiltrations and lympocytic histiocytic villitis. Therefore, acquired intrauterine malaria through placental infection is quite common in endemic areas (Archibald, 1956).

The circulatory changes associated with acute infection by P. falciparum are two fold: (i) Vaso-constriction during the "cold" stage followed by (ii) vasodilation during the "hot" stage. The vasodilatation in the skin is associated with hypotension, decreased central venous pressure, enhanced vascular permeability with consequent increase in blood viscosity and in turn will lead to intravascular coagulation and capillary occlusion.

(ii) Chronic infection: Disorders due to chronic infection are mostly caused by P. malariae whose level of parasitaemia is usually low. Also, P. falciparum

which is usually associated with acute attacks can cause disorders typical of chronic infections more especially when acute infections are not properly treated (Aikawa et al. 1980).

In chronic malaria, the colour of the spleen becomes darker than in acute malaria because of increased deposition of malarial pigment in the tissues. The spleen may become fibrous and firm in texture and the number of follicles and capsules in it, are increased. The reticuloendothelial system shows marked proliferation. In the liver too, there is more deposition of malarial pigment which consequently gives the liver a black colour. The midzonal and central lobular kupffer cells become hypertrophied. The number, distribution and hence the activities of phagocytic cells in the liver are greatly increased (Aikawa et al. 1980).

Chromic hepatosplenomegaly, a condition usually referred to as "tropical splenomegaly syndrome (TSS)" is not uncommon in endemic malarious areas. It is characterized by infilteration of hepatic sinusoids with lymphocytes, very high levels of serum IgM and high malaria antibody titres. This condition results from defective T-cell control of immunoglobulin production leading to excessive macroglobulin production and immune complex formation (Plorde, 1985). Malaria

is also implicated as a contributory factor in the aetiology of Burkitt's lymphoma. In the presence of Epstein Barr (EB) virus and the continuous stimulation of the lymphoid system during chronic malarial infection, makes malaria more liable to neoplastic transformation (Plorde, 1985).

Nephrotic syndrome with marked oedema and albuminuria due to P. malariae infection has long been documented (Watson, 1905; Boyd, 1940). Proliferative glomerulonephropathy in patients who developed renal disease and nephrotic syndrome following P. malariae infection had since long been reported from East Africa by Ward and Kibukamusoke (1969). These authors also described the deposition of IgM, IgG, IgA, complement, fibrin and malarial antigen in the glomeruli.

In P. falciparum malaria proliferative glomeralonephritis with basement membrane thickening had been reported in 1946 by Spitz. Berger et al. (1967) had reported the deposition of [illegible] droplets in the kidneys of patients who suffered severe falciparum malaria. Fatty degeneration and necrosis of the kidneys were also described. They also reported mild thickening of the glomerular basement membrane and adhering of Bowman's capsules, in the same patients. Small quantities of IgG, IgM and BIC were deposited within the measangium and along the basement membrane in patient, who suffered from falciparum malaria

(Hartenbower, et al. 1972). However, these glomerular immune complexes disappeared from the kidneys of patients who responded to prednisone, cyclophosphamide and azathioprine therapy (Adeniyi et al. 1970).

Irregular chemosuppression or inadequate chemotherapy of falciparum malaria (especially with quinine) can precipitate a condition known as 'Black-Water Fever', which is characterised by fever, rigor, massive intravascular haemolysis, icterus, haemoglobinuria, collapse and often acute renal failure and uraemia (Edington and Gilles, 1976).

Individuals living in an endemic malarious areas are likely to suffer from the pathophysiological imbalance enumerated above. However, there are individuals whose haemoglobin genotypes are abnormal and these abnormalities tend to confer protection against malaria. Notably, haemoglobins carriers, individuals with thalassemia, glucose 6-phosphate or pyridoxal-kinase deficiency and haemoglobin F, are known to be protected against severe malaria attacks. S-haemoglobin is said to be capable of limiting intracellular parasitic growth and to prevent intense parasitaemia. The tactoids formed during sickling of A.S. cells may directly damage the parasites and render the deformed erythrocytes more susceptible to phagocytosis (Plorde, 1985).

2.4.3 Types of malaria

The genus Plasmodium includes malarial parasites of man and animals (including birds). The subgenera, Plasmodium (Laverania) affects man and the following species are said to be the causative agents of human malaria:

(a) Benign tertian group

Plasmodium vivax

(b) Malignant tertian group

Plasmodium falciparum

(c) Quartan group

Plasmodium malariae

(d) Ovale group

Plasmodium ovale

Of these, P. malariae, P. vivax, P. falciparum and P. ovale are the most common species that infect man. P. malariae can exist in man-mosquito-man, chimpanzee-mosquito-chimpanzee and chimpanzee-mosquito-man cycle. On the other hand, P. falciparum, P. ovale and P. vivax, predominantly exist in the man-mosquito-man cycle and then only affect chimpanzee and apes feebly and incidentally (Garnham, 1980).

As shown above, the disease conditions caused by Plasmodium could be insidious or abruptly acute, depending on the intensity of infection and the infecting Plasmodium. For example, falciparum

malaria in most cases is acute and life threatening; while *malariae* malaria is usually insidious and does not cause immediate serious effects. According to the causative organisms, malaria may be classified into four main types, namely: (i) Tertian malaria; (ii) Quartan malaria; (iii) Malignant or *Falciparum* malaria; (iv) Black water malaria (Plorde, 1985).

(i) *Tertian malaria*: The causative agents of this type of malaria are either *P. vivax* or *P. ovale*. Although the infection is rarely fatal, relapses are common and are the most difficult to cure. The symptoms are usually synchronized, occuring on alternate days, however, they may be irregular more especially during the early stage of the illness. The early signs of the disease are myalgia, headache, chillness and low grade fever for 48 to 72 hours. The spleen becomes palpable at the end of the second week of the paroxysms. *P. ovale* malaria is milder and the primary attacks are shorter than in *P. vivax* malaria (Plorde, 1985).

(ii) *Quartan malaria*: This is caused by *P. malariae* and the recurrent symptoms usually occur every third day. The disease is more disabling than in tertian malaria but responds better to treatment. A prolonged duration of asymptomatic parasitaemia is characteristic of this type of malaria. Nephrotic syndrome associated with oedema, albuminuria and haematuria are common. The paroxysms caused by *P. malariae* are more frequently seen during the wet season.

(iii) Malignant or Falciparum Malaria: This type of malaria is caused by P. falciparum. The cycle of multiplication is not synchronized and therefore the onset of the disease may be insidious and the fever continuous, remittent or irregular. Splenomegaly occurs rapidly, and mental confusion, postoral hypotension, oedema and gastrointestinal symptoms are all common. If attacks are treated promptly, recovery is usually uneventful but if delayed or left untreated in a non-immune individual, anaemia becomes severe and capillary blockage is eminent (Plorde, 1985). Other complications of untreated falciparum malaria include:

(a) cerebral malaria

(b) algid malaria

(c) bilious remittent malaria; and

(d) malarial cachexia (Wilcocks et al. 1980).

2.5 Distribution of malaria and its vectors:

Different mosquito species are found to be responsible for malaria transmission in the different ecological zones of the world (Service, 1980). Even within the same geographical region, an Anopheline species may be considered a primary vector of malaria in one area and a secondary vector in another, depending on local condition such as temperature, humidity and

human activities which affect the behaviour of the mosquito (Hamon, et al. 1970). In Central America and Mexico, the important malaria vectors include An. albimanus, An. albitaris and An. aquasalis. While in the Indian sub-continent, including Pakistan, Afghanistan and India, the primary malaria vectors of concern are An. culicifacies, An. fluviatilis, An. minimus and An. stephensi (Reid, 1968; Service, 1980).

It is generally accepted that the endemicity of malaria in a region is estimated by determining the spleen rate in children (2-9 years) and adults (Wilcock & Mansor.&Bhr, 1980; Wernsdorfer, 1980). The spleen rate, is defined as the percentage of persons (usually children of 2-9 years) that show a palpable enlargement of the spleen at a given time. Based on the spleen rate of children and adults, endemicity is classified as follows:

(i) Hypoendemic : spleen rate (0 - 10%)

(ii) Mesoendemic . spleen rate (11 - 49%)

(iii) Hyperendemic : spleen rate constantly over 50%, The adult spleen is also high.

(iv) Holoendemic . spleen rate constantly over 75%, The adult spleen rate is low.

America

The above figure shows that on the American continent, Plasmodium is endemic in Tropical South America (except for high altitude areas) including the associated islands like Haiti, Nicaragua and Honduras. Columbia, Haiti, Bolivia, Ecuador, Dominican Republic, Peru and Brazil are particularly at high risk of P. falciparum infection. Central America and Mexico are predominantly infected by Plasmodium vivax. North America, however, notably the USA and Canada have succeeded in eradicating malaria and are no longer endemic areas (Wilcock & Manson-Bahr, 1980).

Asia

Sri Lanka, the Indian subcontinent, and Pakistan are endemic to Plasmodium vivax. Bangladash and Nepal are infected by P. falciparum strains which are transmitted by A. balabacensis (an excellent vector for P. falciparum.) In South East Asia, areas like Thailand, Vietnam, Indonesia, the Phillippines, New Guinea, Singapore, Burma, Malaysia, and Korea are highly endemic to Plasmodium falciparum. Certain strains of P. falciparum are also prevalent in these areas whist P. vivax and P. ovale are moderately and sporadically distributed (Wernsdorfer, 1980).

Source: From Malaria surveillance: Annual Summary, 1979 Atlanta Ga. CDC. Nov. 1980

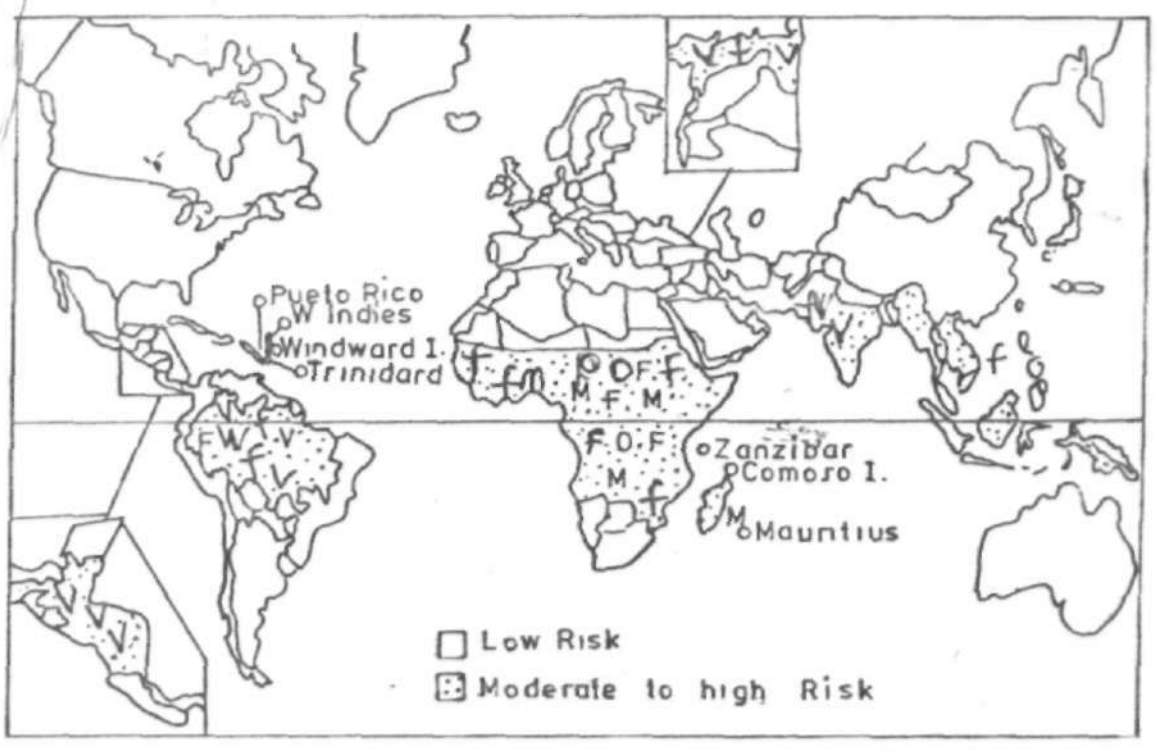


Fig 8 A map showing the geographical distribution of the four types of human malaria viz. falciparparum vivax, ovale and malariae

Key

[V] – P. vivax at low Risk

[f] – P. falciparum at moderately high Risk

[fmo] – P. falciparum, malariae and oval co-existing with P. faleiparum being prevalent.

[fvP] – vivax & P falciparum co existing with P vivax being prevalent

Europe

With the exception of Greece and European continental Turkey, is free from malaria. The USSR have eradicated malaria except for a small area in the Asian region adjacent to Afghanistan (Bruce-Chwatt, 1980).

Africa

With regards to Africa, all the tropical countries, as well as Malagasy are malarious. The parasite rate in children exceeds 50% in most areas, with P. falciparum representing between 80 and 90% of the parasite formula, followed by P. malariae (1-36%) (especially in West Africa) and P. ovale (0-11%) (Strickland, 1982).

Nigeria

P. falciparum is the most common infecting species in Nigeria (Molineaux and Grammiccia, 1980). Quartan malaria (P. malariae) is the next most frequent, while P. ovale infection occur scarcely (Anonymous, 1979). Mixed infections comprising P. falciparum and P. malariae are found frequently (Molineaux and Grammiccia, 1980).

The most important vectors of human malaria found to be abundant in Nigeria include Anopheles gambiae, A. (Giles). An. gambiae B (Ramsdale and Leport, 1967), and An. fenestus Giles (Lewis, 1934). The others that may be secondary vectors are An. melas, An. merus and An. nili (Mattingly, 1949).

2.6 DRUG RESISTANT STRAINS OF PLASMODIUM

Chloroquine received greater prominence in the Chemotherapy of human malaria fever, and the drug was extensively used in endemic malarious regions in South East Asia, South America and Africa. This extensive use of chloroquine has led to the development of resistant strains of Plasmodium (Wernsdorfer, 1980).

2.6.1 Distribution of drug resistance:

South East Asia: De-Gowin and Powell (1964) have reported the existence of R_1 resistant strains of P. falciparum in Malaya. This strain is now referred to as Malayan (camp) strain. Similarly, Harrinasuta et al. (1965) and Colwell et al. (1972) described P. falciparum strains in Thailand. In addition Succharit et al. (1977) have reported an R_{111} Chloroquine strain of P. falciparum from Vietnam.

South America: Rieckman et al. (1971) determined the presence of R_1 and R_{11} Chloroquine-resistant P. falciparum strains in Brazil. It has also been reported that Chloroquine resistant P. falciparum strains are spread over Columbia, Bolivia, Euadov, and Peru (Strickland, 1982).

Africa: Until very recently, no Chloroquine-resistant strains of P. falciparum have been suspected in the African continent (Schwendler, 1965; Lasch and Nguyen, 1965; Stevenson, 1966). However, Dennis et al. (1974) have reported the presence of P. falciparum strain tolerant to Chloroquine in Ethiopia. Later Fogh et al. (1974) reported the first confirmed case of R_1 type of resistant P. falciparum in Kenya. Thereafter, Spencer, et al. (1983) and Oloo et al. (1986) have reported cases of R_{111} types of Plasmodium strains in Western Kenya. The first case of R_1-type of P. falciparum resistance in W. Africa, was reported from Cameroun (Sansonetti, et al. 1985).

Nigeria: Earlier reports indicated the effectiveness of the 4-aminoquinolines (Chloroquine and Amodiaquine) in malaria chemotherapy and prophylaxis in Nigeria (Bruce-Chwatt, 1951; Charles, 1958; and Dodge, 1967). On the other hand recent studies (Olatunde, 1977) have shown a decreased sensitivity of P. falciparum to chloroquine. Adeyeoonmu, Salako and Adelusi (1980) have treated thirty-five children having P. falciparum infection with 25mg/kg chloroquine and observed the parasite reaction for 3 days during which time the parasites were found to disappear from blood films. About four years later, Salako et al. (1984) conducted an extended in vivo and in vitro tests of

sensitivity of P. falciparum to chloroquine and amodiaquine. Both tests were carried out in children and the result of the in vitro test showed a decreased sensitivity of the parasite to chloroquine. In Zaria, Midala (1986) in an in vivo test of P. falciparum to chloroquine confirmed decreased sensitivity of the parasite to drug. Jackson, Marcarelli and Segal (1987) have reported a case of R_1-type of P. falciparum strain resistant to chloroquine in Enugu, Nigeria.

CHAPTER THREE

MATERIALS AND METHODS

3.1 General description of study area:

The Federal Capital Territory (Fig. 1) refers to the area located between latitudes 6°45' and 7°45' east of Greenwich (Mabogunje, 1977). The area covers some 8000 sq. kilometres and has a relatively low population density with about 11-20 persons per sq. km (Anonymous, 1984).

Ecological status prior to construction activities:

Nigeria can be divided into two major ecological zones, that is forest and savannah zones (Hopkins, 1965). But at geographical characteristics, three distinct belts, the southern forest zone, the northern grassland and the middle belt between them can be distinguished (Mabogunje, 1977).

Abuja lies in the middle belt of Nigeria, an area occupied by the wide valley troughs of middle Niger and Benue rivers (Anonymous, 1981). Although the area lies near the northern boundary of Keay's southern savannah, both forest and savanna vegetation are found within the Capital Territory (Keay, 1960). Adejuwon and Jeje (1977) have reported two types of forests and three types of savannahs in the territory. Patches of rain forest vegetation are said to be

wide-spread covering some 592sq. km. They are found to occur in broad valley bottoms such as those of rivers Bobo, Mangol, and Afara Bokwoi. Riparian vegetation occurs along the other major river valleys notably Iku, Usuman, Wuye and Middle Gurara in a mixture with gallery forest and dense thickets (Adujuwon and Jeje 1977). Savannah woodlands cover some 1026 sq. km. or about 12.8% of the area; Park savannah is the most expensive vegetation type covering about 53% of the total area (Comben, 1964; Adejuwon, 1977; and Anonymous, 1981). Four species Albizia zygia, Butyrospernum paradoxium, Daniella oliveri and Parkia clappertoniana (Tuley and Alford, 1975). Shrub savannah occurs around the IZOM plains, middle Gurara, and along the Usuman valley between Cibiri and Gwako and between Gwagwalada and Tungan Aguma.

Drainage Pattern:

Abuja is an area of hilly or undulating country lying on precambrian granite which gives rise to rocky-bedded rivers with rapids and falls (Ologe and Ebisemisu, 1977). The area is drained principally by three main river systems; Iku, Tapa and Usman (Fig. 2). These rivers flow in a south-westerly direction to join River Guvara. River Guvara arise on the Western fringe of the Jos Plateau and joins the Niger about 60 miles south of the area (Ologe and Ebisemisu, 1977). The area is drained also by a multiplicity of seasonal streams.

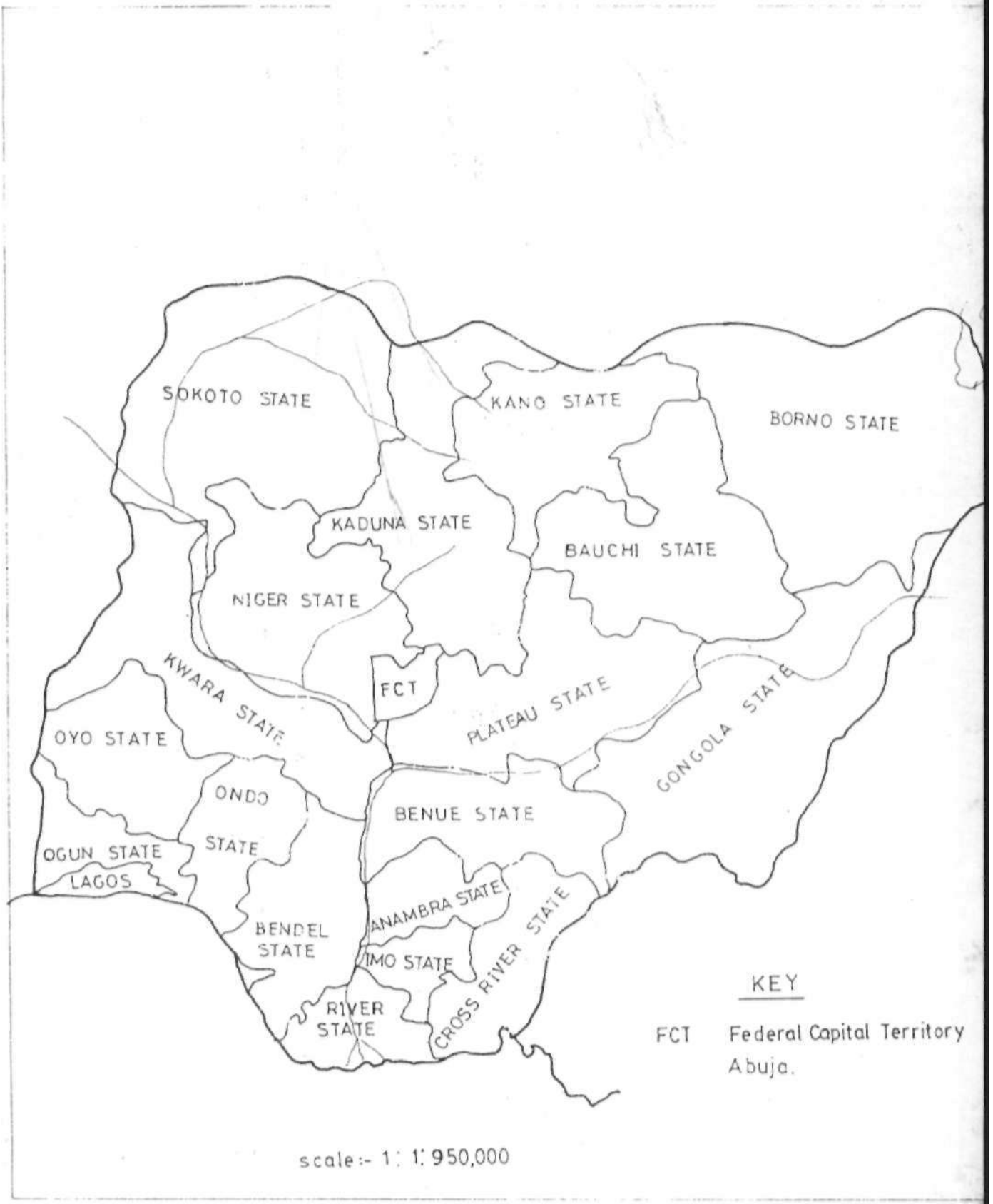
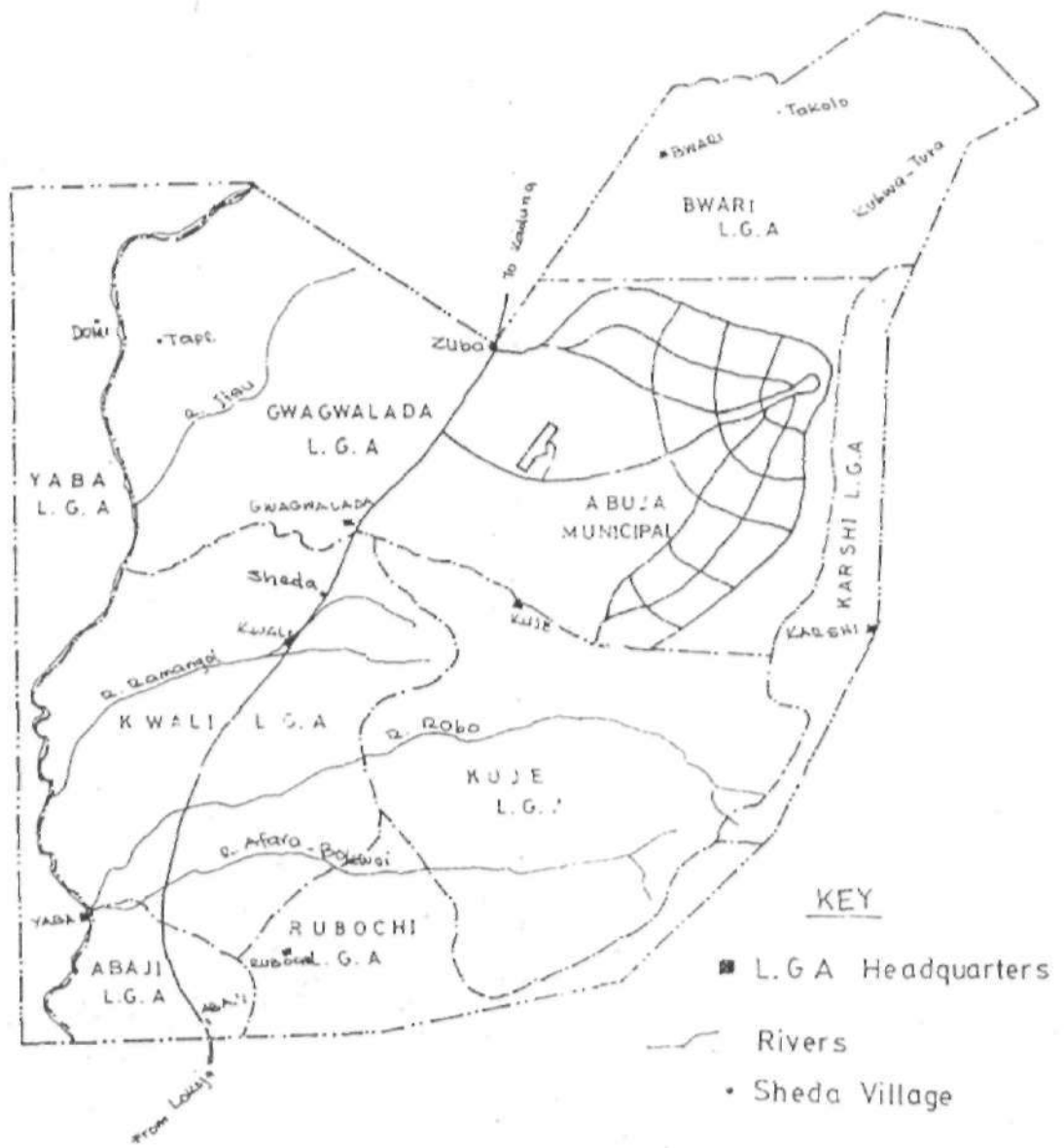


FIG. 1: SHOWING ABUJA IN RELATION TO NEIGHBOURING STATES



SCALE 1:750,000

FIG.2: THE F.C.T ABUJA SHOWING THE LOCAL RIVERS.

3.2 Entomological investigations:

The present research work covers Garki Municipal (city), Gwagwalada a satellite town, and Sheda a typical rural village in which is situated the Simulium Control Unit. Preliminary visits were undertaken to these localities to survey and map out the areas and observe any breeding around the newly occupied residential areas at Garki and Gwagwalada. Mosquito larvae were collected using an improvised dipper (Service, 1976) technique.

From 18 February, 1986, to 16 September, 1986 larval prospections continued on monthly basis. All sites where breedings was found were marked (Figure 3 and 4). Similar investigations were carried out at Sheda village. All specimens collected were preserved in 70% alcohol (MacMahon, et al. 1976). Larvae were later identified in the laboratory using simple taxonomic characters such as the palmate hairs, the presence or absence of siphon etc (Service, 1980).

Identification of Mosquito larvae:

Larvae were identified in the laboratory using simple taxonomic characters such as the presence or absence of the siphon, subventral tuff of hairs, pecten teeth, and the tergal plates (Service, 1980).

Culex spp larvae:

The genus is easily distinguished in the larval state by the invariable presence of more than one pair of subventral tuff of hairs on the siphon (Hopkins,

1952). The siphon is often long and narrow, but it may be short and fat (Service, 1980). The larvae of the mosquito species belonging to this genus have the following morphological characters:

Head - Mouth brushes composed of simple setae, usually very dense. Antenna usually long, almost spiculate, tuft usually beyond half, subapical setae usually well removed from tip except when antenna short.

Thorax - Setae usually long and branched; inner shoulder-hairs well developed and usually set in distinct sclerotized plate. Propleural group usually with one long simple setae, the other three are shortened; No air-sacs present.

Abdomen - Siphon in some cases very short, but usually long, and longer in some species than in any other genus. Pecten always present and usually well developed; always more than one pair of subventral tufts, lateral and subdorsal tufts also present (Hopkins, 1952).

Culex pipiens fatigans:

Hopkins (1952) further employed certain taxonomic characters specifically to identify larvae of mosquitoes belonging to this species.

Length - about 8mm; colour yellowish-brown, head and siphon not much darker.

Head - tuft of antenna composed of about 30 plumose branches placed at about ¾.

Abdomen - Comb a semi-circular patch of about 50 small scales.

Siphon variable in length, pecten composed of a very variable number of spines (9-18, but usually 12-14), none of the spines markedly spaced, usually 4 pairs of subventral tufts, the branches of which are nearly 1½ times the diameter of the siphon. Anal segment with a complete saddle, surface rather sparsely and very minutely spiculate, upper caudal seta double or tripple, lower single, lateral seta double or single. Ventral brush of about 12 pairs of many-branched tufts. "Gills" bluntly laceolate, dorsal pair usually about 11/3 length of saddle, ventral slightly shorter.

Aedes species:

In general, the larvae of mosquitoes belonging to this group have a short barrel-shaped siphon and only one pair of subventral tufts which never arise less than a ¼ distance from base of siphon. There are at least three pairs of setae in the ventral brush, and the antennae are not greatly flattened (Service, 1980). There are no enormous setae on the thorax.

Aedes aegypti:

The larva of this species is distinguishable from any other by the possession of very large metapleural spines, coupled with the shape of its comb-spines and pecten-spines (Hopkins, 1952). Length about 8mm, colour varying from dark grey to nearly white.

Head - about as broad as long. Antenna about one third 1/3.length of head, cylindrical, tuft a single minute seta at about 2/3. Thorax - the pleural tufts of meso and meta thorax have at their bases strong curved and sharply-pointed spines.

Abdomen - Comb a single curved row of 7-12 spines which have a large main terminal denticle and a number of basal denticles, of which one on each side of the terminal denticle is usually considerably larger than the rest, thus giving the whole spine a distinctly trifid appearance under low power.

Siphon - somewhat barrel-shaped, subventral tuft of 2-5 simple branches at just beyond ¼; Pectin extending to tuft and composed of 14-20 spines. "Giles", sausage-shaped, subequal, rather thar more than twice length of saddle.

Anopheles species:

Larvae of mosquitoes belonging to this group are distinguished by total lack of siphon (Service, 1980).

Abdomen - Has small sclerotized plates or the tergal plates all abdominal segments have a pair of well developed palmate hairs. On either side of the segments a group of spines joined together at their base to form a structure called "pecten" (Service, 1980). Evans (1932) used taxonomic characters such as 'clypeal' hairs, shoulder hairs to separate members of the different species.

Outdoor Resting Adult Mosquito Fauna:

Samples were collected with an improvised aspirator, vaseline bottles, test-tubes and insect net (Gutsevich, Monchadskii and Shtakel'berg, 1974) from natural resting places such as Culverts, under-bridges, tree-trunks, walls and behind bathrooms.

Indoor Resting Mosquito fauna: Sampling of the Adult Indoor resting mosquito was undertaken using Pyrethrum spray collection (PSC) technique (Service, 1976).

All the spray sheet collections were performed between 12 May, 1986 to October 28, 1986, at Garki, Gwagwalada and Sheda. Samples were collected fort-nightly and in the morning (08-10 hours). Houses were chosen at random for in-door catches. Removable int items such as chairs, stools are kept aside and the floor covered with the spray sheet before each room was sprayed thoroughly. After 10 minutes, we re-entered the room to collect the mosquitoes carefully from a the sheet with forceps. They (mosquitoes) were examined with a hand-lens counted, sexed and placed in bottles. On returning to the laboratory, different mosquito species were identified and the females Anopheles dissected for malaria parasites.

Culicine species:

The adults culicines are recognised more by their lack of ornamentation than any striking diagnostic characters (Service, 1980). Mosquitoes belonging to this group are easily separated from others by examination of their palps. In the female Culex the palps are much shorter than the proboscis, but never swollen at ends, and they may be hairy distally (Service, 1980).

Culex pipiens fatigans:

The description given by Gillett (1971) was specifically used to identify members of the species. Below are the taxonomic characters employedffor the identification:

Proboscis: Dark above, mainly pale beneath.

Palps: Dark

Antennae: First segment largely pale.

Thorax: Scutum uniformly brown, reddish-brown or pale brown.

Wings: Dark-scaled.

Legs: Mainly dark

Hind-Tibia-with pale, often inconspicuous spot at tip.

Abdomen: Distinctly rounded or blunt at tip, dark above with white or creamy bands, along base of each tergite; largely pale scales beneath (Plate I).

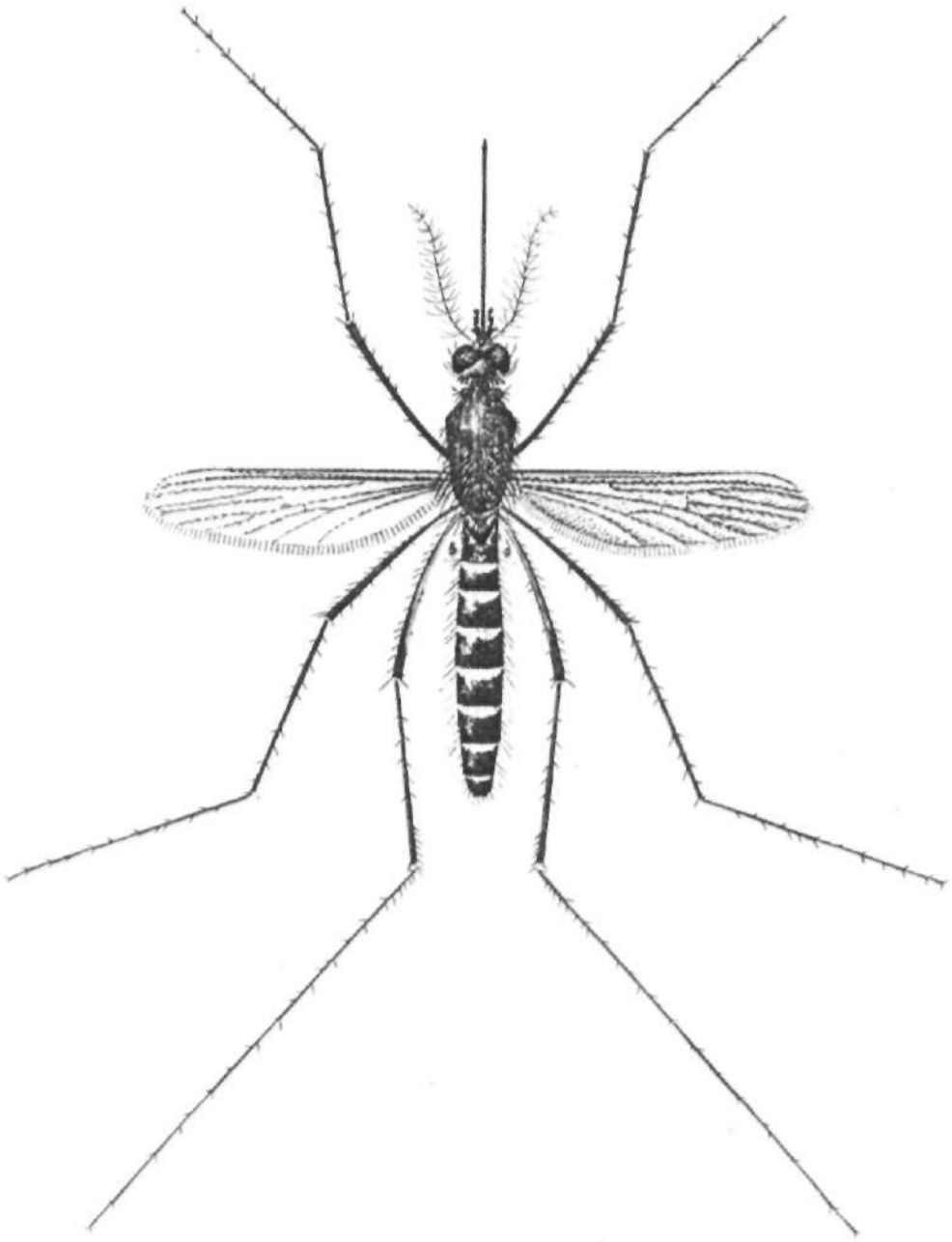


Plate 1: Culex pipiens fatigans (After Gillett, 1971)

Aedes sp.

Adults have conspicous patterns on the thorax formed by black, white or silvary scales, legs often have black and white rings. Scales on wing veins are narrow, and usually more or less black except at the base of the wing (Stone, 1959).

Aedes aegypti - is often recognized by the "lyre"-shaped silver markings on the lateral edges of the scutum - (Service, 1980). The following taxonomic characters as described by Gillett (1971) were used as follows:

Size: Small to medium-sized culicine with brilliant silver-white lyre pattern on thorax and five white rings on hind tarsi.

Head: Silver white stripe down centre (consisting of two rows of narrowly separated scales).

Proboscis: Dark

Palps: Short at base - outer one-third white

Thorax: Silver-white lyre-pattern on dark background (background paler in some specimens, particularly in dry regions or near the cost); two central Yellow lines (strings of lyre).

Scutellum: All white

Wings: Dark scalled except for white dot at base of costa.

Legs: Front-Femur-white tipped with white line in front

Tibia - black

Tarsus - segments 1 and 2 with white ring at base, segments 3-5 all black.

Middle - Femur - white tipped with line in front

Tibia - black

Tarsus - segments 1 and 2 with white ring at base.

segments 3-5 all black

Hind - Femur - white at tip

Tibia - black

Tarsus - segments 1-3 with broad white rings at base

segments 4 white except for black tip, segment 5 usually all white.

Abdomen: Pointed; black with white bands at base of segments 2-6; two silver-white spots down each side, conspicuous from above segment 7 (Plate II).

Anopheles sp.

In general, mosquito species belonging to this genus are distinguished by their spotted wings, dark and pale scales are arranged in small blocks on areas on the veins (Evans, 1938). The dorsal and ventral surfaces of the abdomen are entirely or almost devoid of appressed scales. In all Anopheles spp. the scutellum is rounded in outline (Service, 1980).

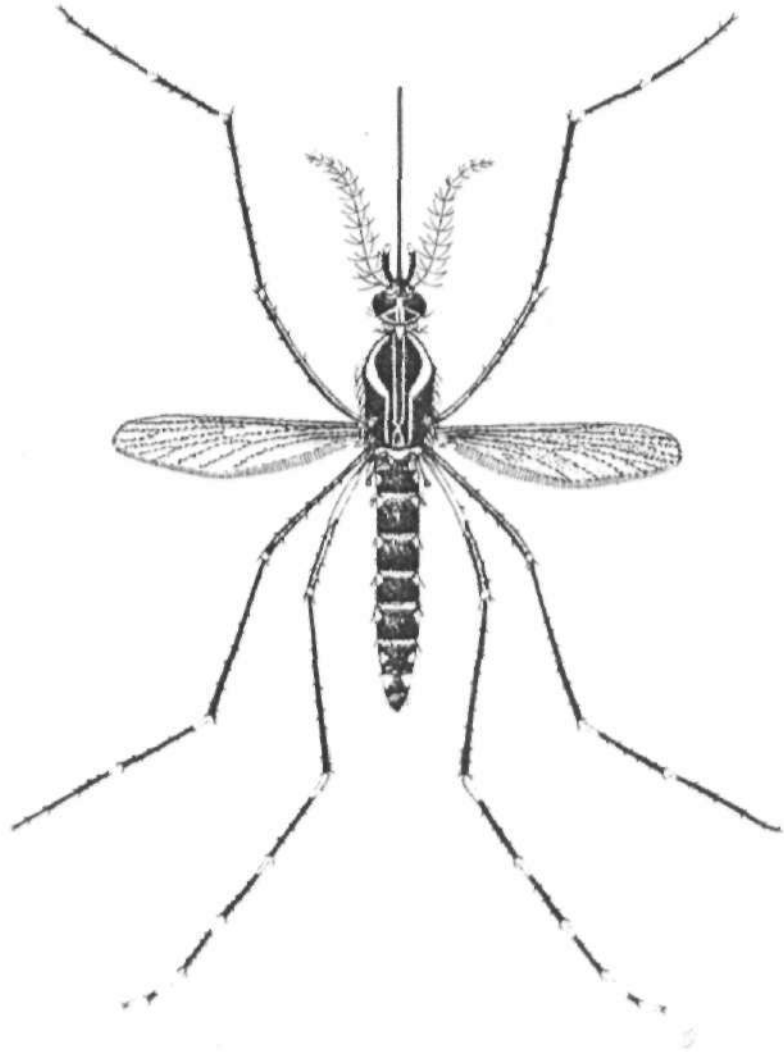


Plate 2: Aedes (Stegomyia) aegypti (After Gillett, 1971).

Anopheles gambiae and An. fenestus:

The taxonomic characters contained in the description given by Gillett, (1971) were used in the identification of these species.

Anopheles gambiae:

Medium-sized anopheline with irregularly speckled legs in 3rd dark area of wing vein 1 and lower branch of vein 5 mostly pale.

Palps: smooth with three pale rings including wide ring at tip.

Thorax: Grey, brown, reddish-brown or nearly black, with creamy yellow scales along centre back.

Wings: Pale areas very variable in extent (sometimes greatly reduced). Pale scales creamy yellow; pale patches on costa and vein 1 usually long; two pale onterruptions at base of costa;pale spot in dark area of vein 3 pale except at each end.

Legs: Irregularly speckled

Tibiae - narrow pale ring at tip

Tarsi - segments 1-4 pale at tips

segments 2-4 also pale at bases in front.

Abdomen: Pale brown (occasionally much darker) and hairy, often with scales on back of segment 8 and sometimes on segment 7 (Plate 3).

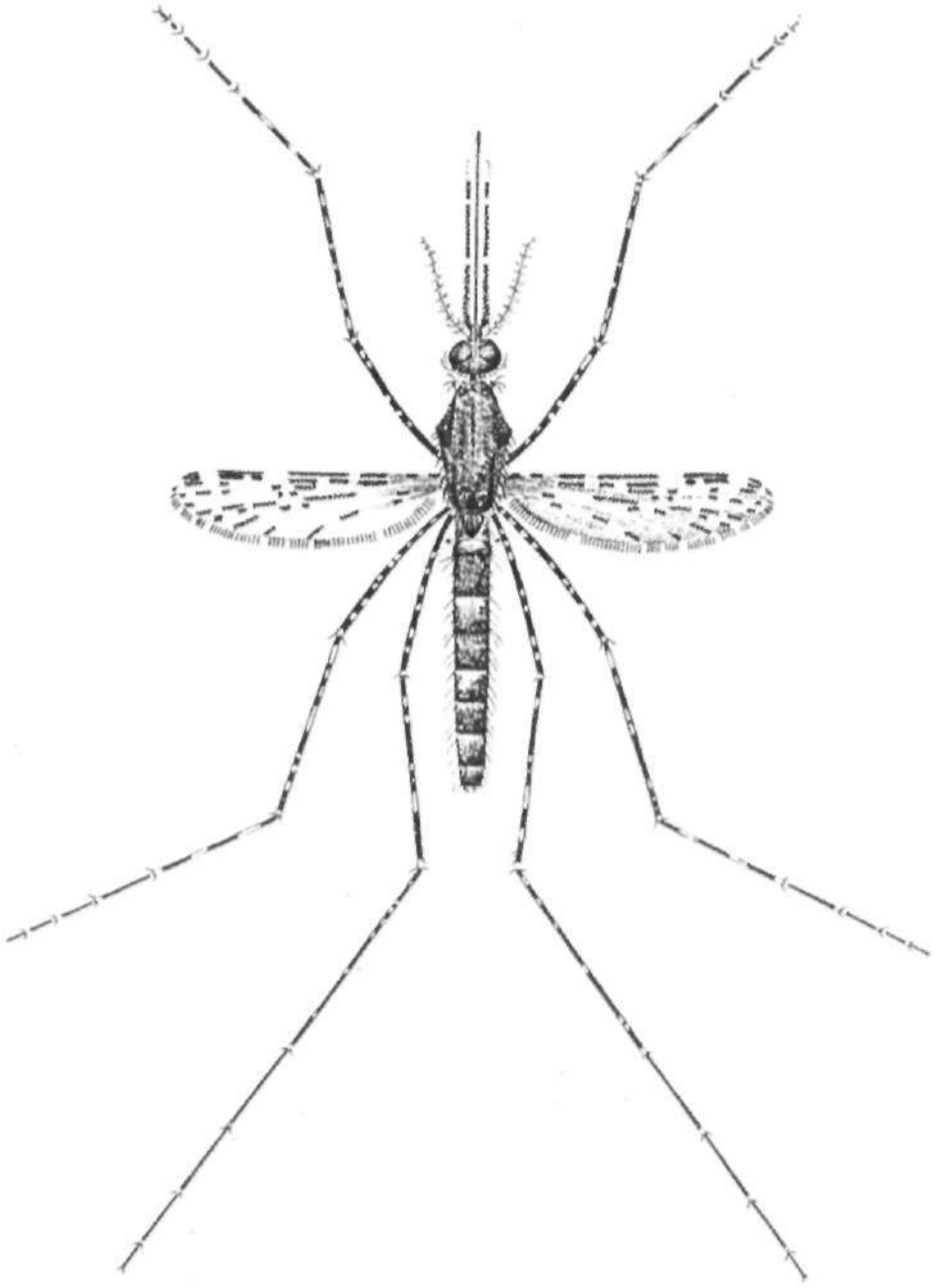


Plate 3: Anopheles gambiae (After Gillett, 1971).

Anopheles funestus complex:

Small dark anophelines with almost entirely dark legs and three narrow white rings to palps.

Palps: Dark and smooth with three narrow white rings including one at tip.

Thorax: Grey down centre, dark brown towards edges.

Wings: With or without single pale interruption to base of costa; vein 3 pale in middle or all dark.

Legs: Usually all dark, but with faint pale tips to the tibiae and occasionally also to the first four tarsal segments.

Abdomen: Dark brown, without scales (Plate 4).

Dissecting method: The presence of an infection in Anopheles may confirm the importance of a given species as a vector of malaria (Bruce-Chwatt, 1980).

All the female mosquitoes caught were dissected as described by Molineaux and Grammiccia, (1980); WHO, (1976) and Bruce-Chwatt, (1980) in order to determine infection. Flies that could not be dissected the same day were stored overnight in a domestic refregerator (Service, 1976).

Each specimen was dissected (using Shutes needles) separately in a drop of normal (0.85%) saline on a glass slide under a low power dissection microscope. The chitinous skin at the side of the abdomen was nicked between segments 6 and 7, while the abdominal

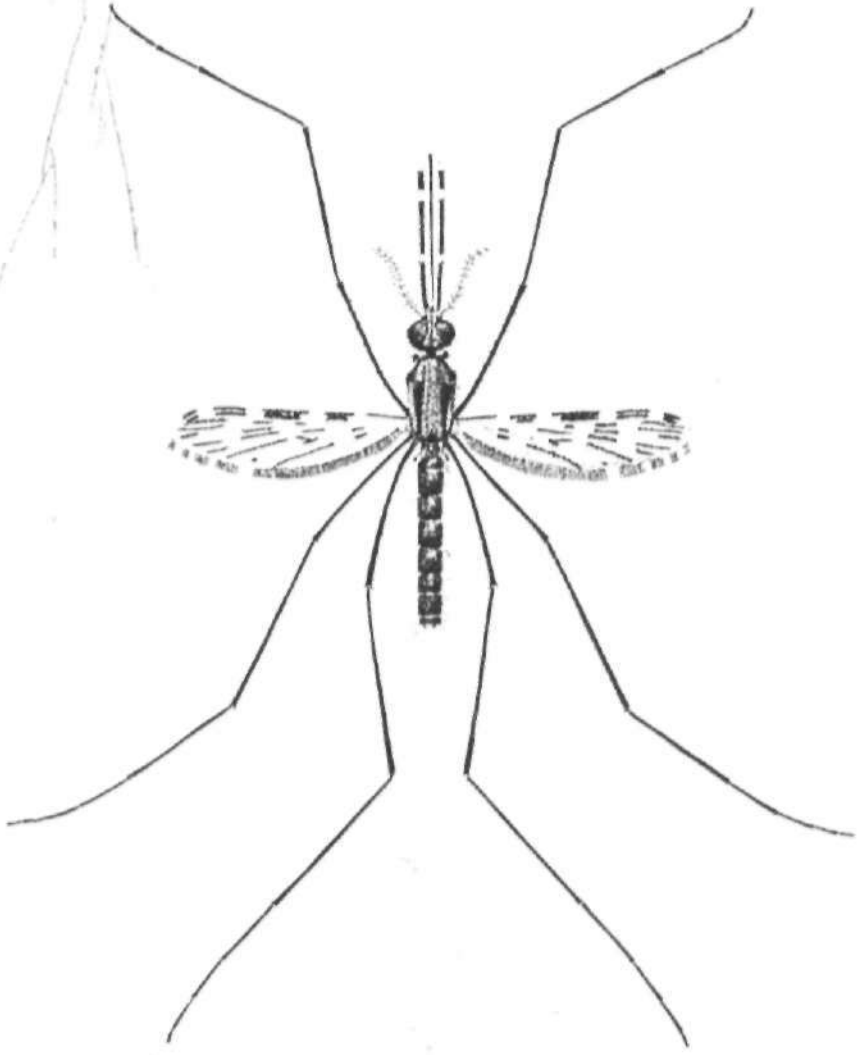


Plate 4: Anopheles funestus (After Gillett, 1971).

contents were drawn out gently to touch the drop of saline. The mid-gut was loosened and transferred into a fresh larger drop of saline on the same slide. The material was covered with a coverslip and care was taken to avoid excessive pressure on the specimen.

Oocysts were searched for around the periphery of the gut at (x 40) and later (x 100) power magnifications. The head of the female Anopheline mosquito was separated gently from the thorax by dragging out the small sausage-shaped salivary glands. Sporozoites were looked for in the salivary glands by examining under high power. Presence of the sporozoites was usually confirmed by fixing the slide with absolute methyl-alcohol and staining with Giemsa. The percentage of female Anopheles showing sporozoites in the salivary glands gives the sporozoite rate while those showing the oocyst in the gut, the oocysts rate (Bruce-Chwatt, 1980).

3.3 Parasitological investigations:

A definite diagnosis of malaria infection is established on the finding of parasites in the blood (Bruce-Chwatt, 1980). Two methods were adopted for the purpose of parasitological investigation in the area.

(i) Passive case findings: To gain general knowledge about the epidemiological situation in the area regarding malaria morbidity and mortality, the hospital returns for January 1986 to December, 1986 were examined. The record was obtained from the only hospital in the Federal Capital Territory which is situated at Garki Municipal town.

Active case findings: The prevalence of malaria was investigated in the population from children below the ages of one to adults over 55 years. Blood was randomly collected from people including school-children and those reporting to the haematology laboratory for any tests. Blood was obtained from the 2nd or 3rd finger of the left hand. The skin was cleaned with methylated spirit and left to dry before pricking it with a lancet (microlance). The blood was squeezed on to middle of a clean glass slide 25mm by 75mm.

Thin Blood film: Thin films were prepared by touching the drop of blood at an angle of 45° and spreading - towards the edge (Bruce-Chwatt, 1980). Each film was left to dry before it was stained.

Thick-blood film: Thick blood films were also prepared on other clean slides as described by Bruce-Chwatt, (1980).

Staining of the Blood film: The thin films were stained using Giemsa stain. The film was first placed in absolute methylalcohol for about 30 seconds; drops of the fixative were poured on the film by means of a pipette. The stain was freshly prepared by mixing 5ml. Giemsa stock solution with 100ml of buffered water. The slides were sustained on a glass-rod and the stain poured on each and left for about 20-30 minutes (WHO, 1961). The thick films were all stained with Field's stain (WHO, 1961, and Bruce-Chwatt, 1980). All films were examined under (x 40) and (x 100) power magnifications (Dowling & Shute, 1966; Molineaux and Grammiccia, 1980; Trape, 1985).

CHAPTER FOUR

R E S U L T S

4.1 Preliminary Observations:

The results obtained from the preliminary surveys are graphically shown in Figs 3&4; Table 1, and are summarized in Appendix 1.

All the major permanent breeding sites were found to be distributed around the tributaries of Rivers Kwata-kwata and Rafin-maitama. On the first visit to area I along the festival road at Garki, two breeding sites were noted at the point of entry of the gutter draining flats of houses in the area (Fig. 3).

It was noted that the gutters draining this area are constructed in a slanting manner to fit the elavated topography of the area. But at the point of entry into the valley, the gutters create a small pond which allows breeding. Species of Anopheline and Culicine larvae were collected from some points around (Appendix 1).

Borrow pits especially in Phase I Area I behind Bagudu Hotel were found to harbour larvae. Breeding was also noted around the bridge, in the central area, which bisects the city in the centre. Permanent and potential breeding sites were identified (Fig. 3).

Temporary breeding sites such as the P & T man-holes, in Area I around Neighbourhood centre, which contained larvae between June to August were identified.

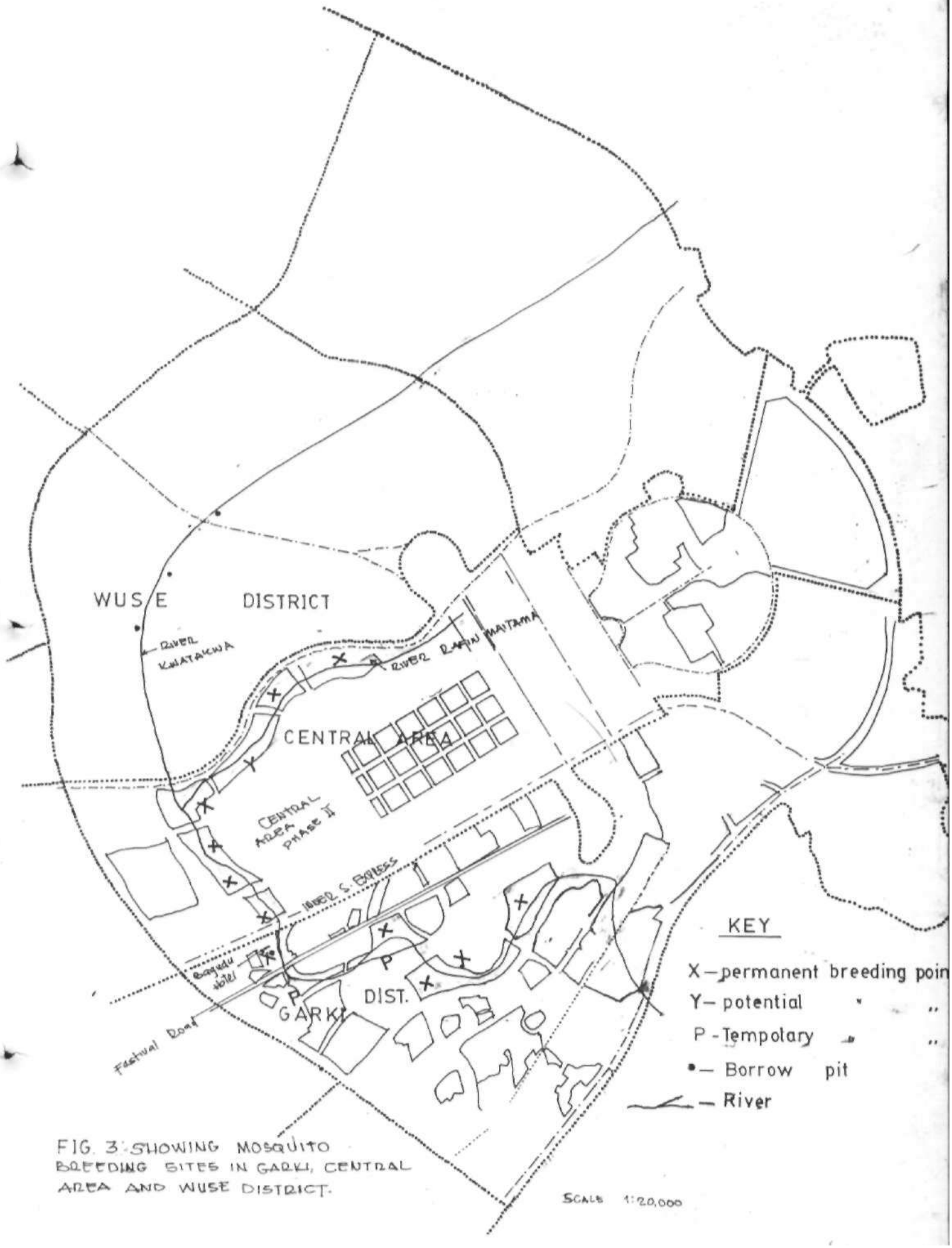


FIG. 3: SHOWING MOSQUITO BREEDING SITES IN GARKI, CENTRAL AREA AND WUSE DISTRICT.



Key

scale :— 1: 25,000

X permanent breeding point
Y potential " "
P Tempolary " "

FIG. 4: SHOWING MOSQUITO BREEDING SITES IN GWAGWALADA TOWN.

Preliminary survey at Gwagwalada:

On prospection, five breeding sites were located initially at Phase I Area I. Culicine larvae were found around water-tanks for the houses. No Anopheline larvae were found during this visit. The surface run-offs in this area, empty into a tributary of R. Usman. Both Anopheline and Culicine Larvae were found in this area (Fig. 4). Numerous temporary collection points caused by the accumulation of rain-water in depressions on road surfaces, around culverts and in flower pots were noted between May to September (Appendix I).

Preliminary survey at Sheda:

Some culicine larvae were collected from a 6m deep well, situated about 2km away in the bush. A well about 9m deep situated in Sheda research centre is found to contain some Culicine larvae. A total of 67 breeding sites were visited from February-October, 1986, out of which 37 were found in Garki Municipal, while 24 in Gwagwalada and 6 in Sheda village (Appendix I). Table 1 shows the monthly break-down of the mosquito larval collection in the area.

4.2 Entomological investigations

Outdoor resting collection (ORC) Results: Longitudinal collections of mosquitoes from natural resting places outdoors, started in October 1986. 2,411 adult Culex pipiens fatigans were obtained in

Table 1: Summary of results and averages of monthly larval Collection at FCT - Abuja: February-September, 1986.

Months	GARKI MUNICIPAL				GWAGWALADA				SHEDA			
	Anopheline larvae		Culicine larvae		Anopheline larvae		Culicine larvae		Anopheline larvae		Culicine larvae	
	Total	Av./dip	Total	av/dip	Total	Av/dip	Total	Av/dip	Total	Av/dip	Total	av/dip
February	-	-	65	3.02	-	-	25	-	-	-	-	-
March	55	2.7	195	5.02	-	-	44	-	-	-	-	-
April	42	2.0	78	3.7	36	3.6	71	7.1	-	-	43	-
May	71	3.5	127	6.0	52	2.6	181	6.01	-	-	77	-
June	73	3.6	219	7.0	89	2.4	-	-	53	5.3	-	-
July	109	[illegible]	-	-	-	-	86	-	5	-	31	-
August	-	-	-	-	119	3.9	-	-	38	3.8	-	-
September	51	2.5	-	-	-	-	22	-	-	-	-	-
TOTAL	401	-	684	-	296	-	429	-	96	-	151	-

the three areas studied. 1,360 were males, while 1,051 were females (Table 2). From these, 968 or (40%) were collected from Garki Municipal, while 730 and 713 Culicines were collected from Gwagwalada and Sheda respectively (Table 2 and 3). A detailed breakdown of the monthly distribution of the Culicine fauna in the three areas studied is presented in Table 3.

Anophelines: A total of 40 Anophelines (21 males and 19 females) were caught in outdoor survey in the area (Table 2). 11 were identified as A. fenestus, six were females out of which two were blood fed. 29 A. gambiae were identified out of which 2 were blood-fed. All the blood-fed Anopheline females caught from the outdoor resting places were found to be sporozoite negative on dissection (Table 3).

Aedes: Observations on Aedes mosquitoes were carried out between April-June 1987. Larvae were observed in an old pot behind staff houses at Sheda Research Centre. On 15 April, two adult Aedes mosquitoes were caught emerging from the pot. 20 houses were then randomly sampled, out of which four were found to have water-holding containers each with live Aedes aegypti larvae.

Table 2: Densities of mosquitoes in natural outdoor resting places in FCT - Abuja: October 1986 to March 1987

Area	Anophelines		Culicines		Aedes	
	No. collected		No. collected		No. collected	
	Males	Females	Males	Females	Males	Females
Garki	17	9	612	356	-	-
Gwagwalada	2	2	442	288	-	-
Sheda	2	8	306	407	-	-
Total	21	19	1360	1051	-	-

Table 3: Monthly densities of mosquitoes in natural outdoor resting places in FCT - Abuja: October 1986 to March 1987

Area	Genera of Mosquitoes	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Comments
Garki	Culicines males	219	135	91	50	55	62	4 male A. fenestus
	females	90	57	44	43	36	80	
	Anophelines males	1	10	5	0	0	1	4 female A. fenestus
	females	0	6	3	0	0	0	2 female A. gambiae blood fed
Gwagwalada	Culicines males	152	115	190	59	-	16	
	females	68	64	74	36	-	26	
	Anophelines males	2	0	0	0	0	0	Anophelines identified as members of A. gambiae.
	females	2	0	0	0	0	0	
Sheda	Culicines males	135	59	60	36	16	-	5 female A. fenestus identified. All collected from outside huts at Sheda. 2 blood fed. No sporozoite on dissection
	females	142	125	125	10	5	-	
	Anophelines males	0	0	1	1	0	-	
	females	1	0	6	1	0	-	

Three of the containers were abandoned pots, while one was an abandoned tractor tyre. The house index (H.I.) which shows the percentage of houses with live Aedes aegypti larvae, is calculated according to Service (1976) as follows:

$$\frac{a}{b} \times \frac{100}{1}$$

: a = Number of houses with live larvae

b = Total number of houses sample

i.e. $\frac{4}{20} \times \frac{100}{1}$

= 20%

35 adult Aedes aegypti were caught (Appendix 5) in the period April-June 1987. Most of the adults collection was performed between 4-7 p.m. The landing rate was highest between 5-6.

4.3 Indoor Resting Anopheline population by Pyrethrum spray Collection (PSC) Results:

The results under this section are grouped into two parts (April-May) representing the end of dry season with some showers of rainfall on some days, and (June-October) marking the wet-season according to the 1986 rainfall pattern.

Distribution of An. gambiae s.l.:

A total of 259 female An. gambiae s.l. were caught and dissected from the three areas, between April-October 1986. Of these, 155, 90 and 14 were caught from Garki

Municipal, Gwagwalada and Sheda respectively (Table 4). During April-May, only 50 female An. gambiae s.l. or (19.9%) of the total were caught. While between June-October, 209 i.e. (80.1%) of the whole population were caught (Fig. 5).

Anopheline Density:

The average number of female An. gambiae s.l. per bedroom per month for the whole study area was 2. The highest density 2.3 was observed in October while the lowest 1.2 in May. The index was highest at Garki (3.4) than at Gwagwalada and Sheda with mean averages (1.7) and 0.3 respectively (Table 5).

Sporozoite rate:

11 of the 259 An. gambiae s.l. dissected were found to contain sporozoites in the salivary glands. The sporozoite rate of the population for the period was found to be 4.2%. It is calculated according to Bruce-Chwatt (1980) as follows:

$$\frac{x}{y} \times \frac{100}{1}$$

: x = Number of female Anopheline mosquito sporozoite positive

y = Total number of female Anopheline mosquito dissected.

At Garki Municipal, eight of the 155 An. gambiae s.l. dissected were found to be sporozoite positive, while three of the 90 An. gambiae s.l. dissected at Gwagwalada

Table 4: Results of monthly salivary gland dissection of A. gambiae s.l. from Pyrethrum spray catches in the three Areas of FCT - Abuja: April - October 1986

AREA	Totals		April		May		June		July		August		Sept.		October	
	Examined	Sporozoite positive	Examined	Sporozoite positive	Examined	Sporozoite positive	Examined	Sporozoite positive	Examined	Sporozoite positive	Examined	Sporozoite positive	Examined	Sporozoite positive	Examined	Sporozoite positive
Garki Municipal	155	8	18	0	13	0	22	0	24	0	27	2	24	4	27	2
Gwagwalada	90	3	6	0	9	0	12	0	7	0	6	0	24	2	26	1
Sheda	14	0	0	-	4	0	1	0	2	0	4	0	2	0	1	0
TOTAL	259	11	24	0	26	0	35	0	33	0	37	2	50	6	54	3

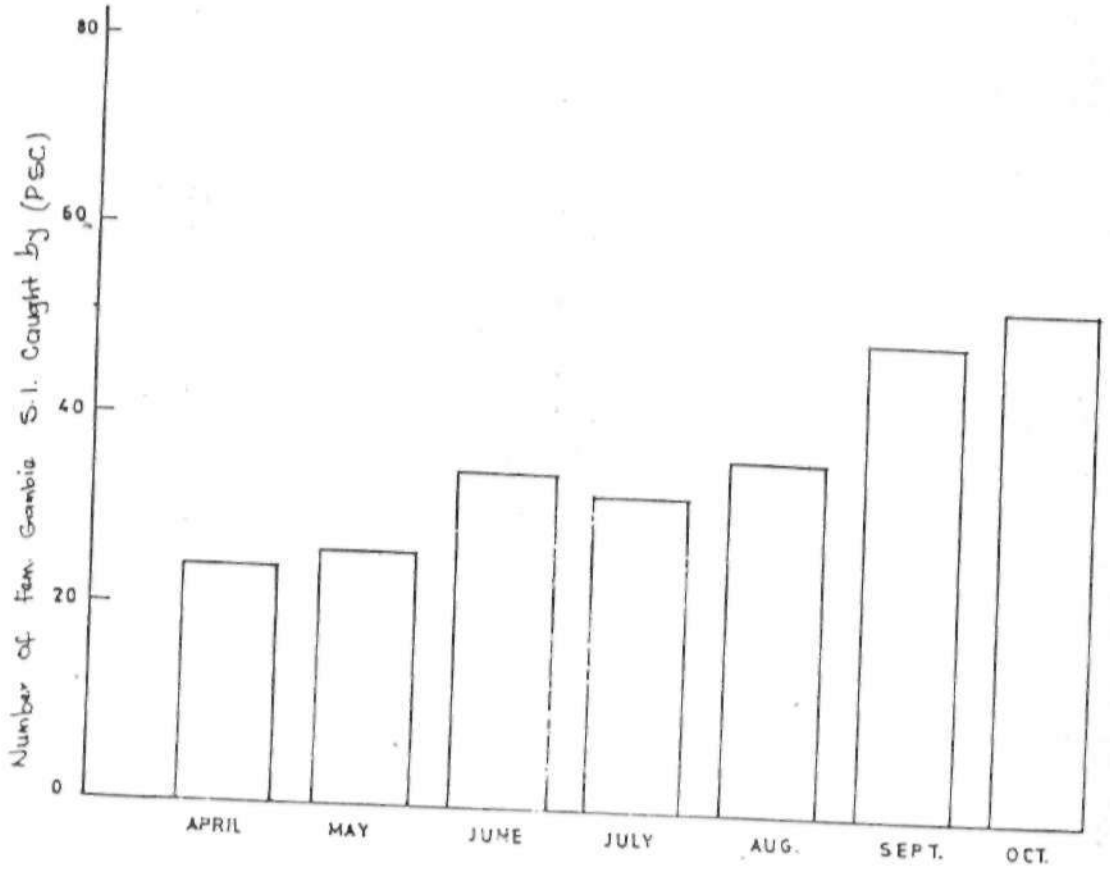


FIG.5 : MONTHLY VARIATION IN NUMBER OF AN. Gambiae S.l CAUGHT BY PYRETHRUM SPRAY COLLECTION (PSC) IN HOUSES IN F.C.T.

Table 5: Average number of female A. gambiae s.l. per bedroom per month, as shown by PSC catches in Garki, Gwagwalada and Sheda: April - October 1986

AREA	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	M.A.
GARKI MUNICIPAL	3.50	1.3	2	3.7	3	2.4	3	3.37
GWAGWALADA	0.86	1.43	2.0	1.25	0.87	3.33	2.44	1.74
SHEDA	0	0.22	0.43	0.50	0.44	0.22	0.25	0.27
AVERAGE	1.45	1.23	1.94	1.80	1.77	2.08	2.33	1.90

PSC = Pyrethrum spray catches

M.A. = Mean Average

Table 6: Monthly distribution of hospitalized cases of malaria by sex in relation to the total in-patient cases in FCT Hospital (January - December 1986).

Months	Sex No. Male	No. Females	Total	T.N.I.C.	Percentage bed space due to malaria	Diagnosis	Comment
January	12	12	24	228	10.53	Acute malaria	One case of Abortion
February	6	11	17	185	9.20	Acute to severe malaria	Malaria in pregnancy
March	7	9	16	242	6.61	"	One case of malaria in pregnancy
April	4	10	14	229	6.11	"	-
May	10	5	15	200	7.50	"	1 malaria with measles
June	14	8	22	187	11.76	"	-
July	3	10	13	186	6.99	"	-
August	7	6	13	202	6.44	-	A case of cerebral No.1

Table 6 (cont'd.)

	Sex		Total	T.N.I.C.	Percentage bed space due to malaria	Diagnosis	Comment
	No. Male	No. Female					
Sept.	4	5	9	156	5.97	"	-
October	4	2	6	196	3.02	"	
November	9	9	18	240	7.50	Severe malaria	Malaria in pregnancy
December	3	5	8	214	3.[illegible]	"	Malaria with measles

T.N.I.C. = Total Number of In-Patient Cases

Meas: = Measles

Table 7: Prevalence of malaria by sex and Age groupsin FCT

	Total no. Examined		No. of Positive Slides		Percentage Positive		Both sexes		Percentage Positive
	Male	Female	Male	Female	Male	Female	Total no. examined	Total Positive	
0 - 11 months	3	2	1	0	33	0	5	1	20
12 - 23 months	2	0	0	0	0	0	2	0	0
2 - 4 years	9	7	2	3	22	43	16	5	31.3
5 - 9 years	9	13	1	4	11	30	22	5	22.7
10 - 14 years	10	9	2	2	20	15	23	4	19
20 years +	22	54	4	15	18	28	76	19	25

were positive (Table 4). The corresponding sporozoite rates for Garki and Gwagwalada were 5.2% and 3.3% respectively. No sporozoite positive anopheline was found on dissection at Sheda.

Blood-feeding rates:

Appendix II summarizes the results on the blood-feeding pattern of An. gambiae as observed at Garki. 65.8% of the total number of An. gambiae dissected were blood fed. The blooding feeding rates of the population were highest in August and September with percentage rates of 70.3 and 70.6 respectively. An estimate of the disease transmission potentials of the moquitoes for the months of August, September and October was calculated according to Bruce-Chwatt (1980) as follows:

$$\text{Innoculation rate} = \text{Anopheline density/person/day} \times \text{sporozoite rate}$$

$$\text{Thus for August} = \left(\frac{19}{9} \div 3\right) \times \frac{7.4}{100} = 0.05$$

The corresponding figures for September and October were accordingly worked out to be 0.08 and 0.03 respectively (Appendix 11).

Parasitological investigation:

From hospital records, a total of 177 patients (91 females and 86 males) variously diagnosed as acutely or severely affected by malaria were hospitalized in the territory's central clinic, between January-December 1986 (Table 6, Appendix 4).

The total number of beds occupied for the period was 2,707 and the percentage bed-space due to malaria was (84%) with mean monthly average of (7.1%). The highest percentage in-patient case, 11.76% due to malaria was recorded in June (Table 6). The age group 2-4 years (Toddlers) is the most frequently affected, while 43 of the 91 adult patients admitted are women in their reproductive period majority of whom were pregnant on admission (Appendix 4).

Results of blood examination:

The results of slides studied was shown in (Table 7). A total of 163 patients variously referred to the Haematology laboratory in the clinic were randomly examined. 38 (22.6%) of the sample was found to be positive for malaria. P. falciparum was most frequently occuring and at times in mixed infection with P. malariae. About 14.1% of the people examined were children under the age of five. The most singularly affected age-group is 2-4 years with about 31.3% positive (Table 7).

CHAPTER FIVE

D I S C U S S I O N

Collections of water which provide habitats for anopheline larvae may be temporary or permanent, natural or man-made (Service, 1980). The breeding sites found in Garki Municipal Area, around tributaries of River Kwatakwata, such as those under the festival road Bridge in Phase I, Area I in the Central Areas and at Wuse District around Rafin-Maitama and also those at Gwagwalada around Areas 2 and 3, and in the old town market can be said to be both permanent and natural (Figs. 3 and 4).

Presently these types of habitats are more abundant at Garki than at Gwagwalada or Sheda. This may be attributed to the presence of the two small Rivers Kwatakwata and Rafin-Maitama which bisect the city in the centre forming marshy valleys (Fig. 3). This natural feature may be contrasted to that in Sheda where the only active breeding sites are the abandoned wells (Appendix I).

Ponds and borrow-pits are typical examples of man-made breeding habitats (Bruce-Chwatt, 1980). The borrow-pits such as those found around Wuse District and behind Bagudu Hotel at Garki are typical of the Federal Capital Territory now.

Temporary larval habitats such as those at Wuse Ring road, and the P & T man-holes in Area I and 2 at Garki are also a result of construction work.

37 or (55%) of the breeding sites were at Garki Municipal where the construction work is rapid. In contrast only six major breeding points were found at Sheda, where no construction work is going on at the period of study. Wells are the permanent source of breeding at Sheda and are therefore minimized compared to the situation found at Garki or Gwagwalada.

Not only the location of the habitat but also its condition such as; dissolved inorganic and organic matter suspended mud, temperature light and shade, is important in determining the nature of mosquito fauna at the point. For instance, it has been reported that Culex fatigans breeds in water with high organic content but Anopheles gambiae do not breed in such water (Hopkins, 1952). It has been shown that each species and often each group of species,sub-genus or genus has its own preferred type of habitat (Service, 1980).

Table 1, shows that 1,284 or (61.8%) of the total larvae collected are Culex larvae. This can be attributed to the fact that as an ubiquitous group, Culex breeds in a wide range of habitats, including pit-latrines in contrast to the more restricted breeding places of Anopheles (Hopkins, 1952).

Aedes larvae are said to prefer special habitats, usually containers such as discarded tins, bottles, motor-tyres (Hopkins, 1952). The incidental observation of Aedes breeding in pots around staff houses in Sheda (Appendix 4) happens to support Hopkins (1952) and

suggests strongly that flower-pots used for decoration in houses at Garki and Gwagwalada may provide good breeding points for Aedes.

A large number (2,411) of Culex, as compared to 40 Anopheles, were found resting in various outdoor resting places. This numerical supremacy of Culex over Anopheles or Aedes species may be attributed to the multiplicity of the ideal breedirg sites created for Culex as a result of construction activities. Culex appears to rest in a variety of habitats such as under the bridge, walls bdhind bathrooms or culverts; these resting places are quite abundant at Garki and Gwagwalada where construction activities are on. The availability of the resting sites may be one of the factors responsible for the presence of more Culex (684) at Garki than at Gwagwalada or Sheda. Hopkins (1952) has shown that adult female Culex can choose for oviposition, any type of habitat including rock-pools, sutters, tree-hole and latrines. Gutserich et al. (1974) has also reported that most mosquitoes usually disperse less than 2km and most only few hundred metres from their breeding places, and this may also partially explain the preponderance of Culex fatigans in the outdoor resting places.

In contrast the Anopheles female in general is more discriminately and prefers unpolluted water habitats, such as isolated borrow-pits or pools. In Tanzania the outdoor population of Anopheles

gambiae was found amongst dense growth of salt bushes, and also in crevices underground (Smith, 1961). In this survey, no collection was made from undergound or crevices, but five individuals of An. fenestus were found resting on a cool exterior of a hut at Sheda (Table 3). The investigation on Aedes fauna was limited only to Sheda. Apart from the primary school, the Simulium Research Unit, and the abandoned low-cost houses, the village can be described as typically rural.

The results (Appendix 4) confirm the predomestic habit of Aedes aegypti as reported by Surtees (1959), Pichon and Gayral (1970). Ideally the survey of Aedes aegypti in the Federal Capital Territory should be carried out extensively to cover Garki Municipal and Gwagwalada where new houses are continuously being completed and occupied by civil servants. The result is also very significant in view of the recent outbreaks of yellow fever epidemics in Benue, Ibadan and other places in Nigeria (Anonymous, 1987).

The aim of indoor resting mosquito population survey is to study the relationship between the mosquito fauna and incidence of human malaria. Apart from the inherent errors in the sampling technique used in collecting the Adult Anopheles from the Houses, the result depends not only on the time of the day the collection is made but also on the nature and sites of the houses, and the attitude of the inhabitants (Service, 1964). Improvement in sampling technique increases with

usage but specimens may be lost either due to inaccessibility of certain portions of the room to be sprayed or through crevices in the walls or roofs.

It is important to note that the number of mosquitoes obtained by Pyrethrum spray sheet collection technique, as in this study, has no direct relationship to actual mosquito population in the locality (Service, 1976). However it is evident from the results that differences exist in the total number of An. gambiae s.l. caught in the three localities. The highest number was caught at Garki while the lowest at Sheda (Fig. 6). In each locality, the distribution exhibit a definite seasonality (Fig. 6). At Garki the highest number of An. gambiae s.l. per month was caught in August and October, and the lowest figure was obtained in May. While at Gwagwalada, the highest number of female An. gambiae s.l. was observed in September and October and the lowest in April; and at Sheda the highest was noted in August and the lowest in April. The total distribution of An. gambiae s.l. showed peaks in the months of August, September and October (Figure 5).

The preponderance of the Anopheline mosquito vectors at Garki may largely be attributed to its geographic location, and the resultant local weather characteristics. Although no exact record of the rainfall during this study period was kept due to lack

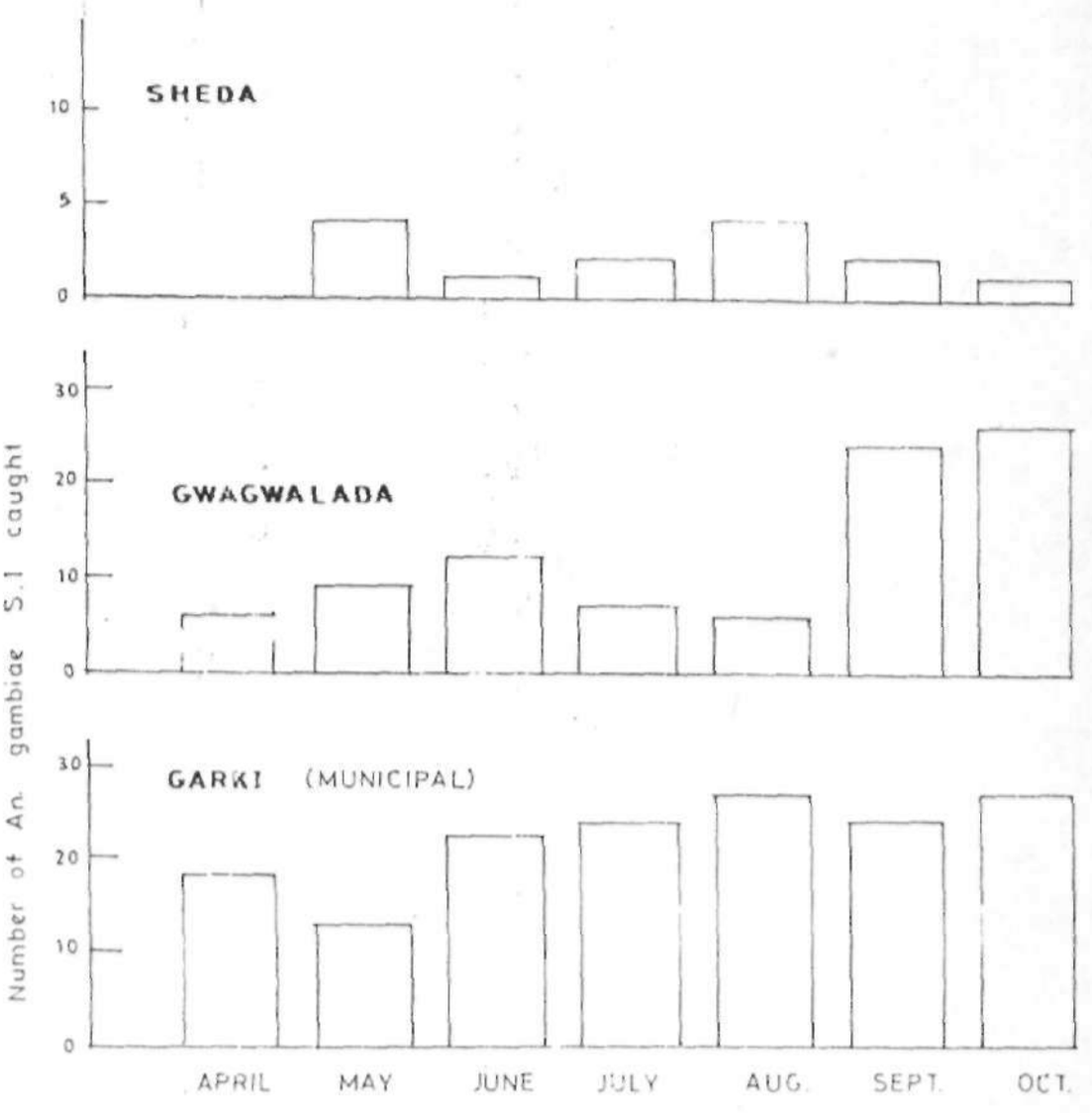


FIG. 6 : MONTHLY VARIATION IN No OF An. gambiae S.l CAUGHT BY (PSC) IN DIFFERENT LOCALITIES.

PSC = pyrethrum spray collection

of any metreological station in the territory, it is evident from literature (Oguntoyinbo, 1977), that rainfall in the Federal Capital Territory (FCT) exhibits a transitional character between the zone of double maximum to the south and that of a single rainfall maximum to the north. However, a reversal of this North-South decreasing rainfall trend, a rather unusually situation, exists in Garki and some parts of (FCT) because of its location to the windward side of Jos Plateau. This fact coupled with the elevated topography of the city accounted for the higher amount of rainfall experienced at Garki Municipal compared to Gwagwalada and Sheda. Peaks of mosquito population were found to follow peaks of rainfall (Fig. 5). The larger Anopheline mosquito fauna as observed at Garki Municipal may also be attributed to the rapid nature of the construction activities going on in the city. These activities created borrow-pits which are found to be good breeding sites for the Anopheline larvae.

The average number of adult female Anopheles of a defined species caught sheltering in human habitation or biting exposed individuals indoors or out of doors, is the Anopheline density. It can be expressed as a relative proportion per room, per person, per day (Bruce-Chwatt, 1980). A bedroom is defined for the purpose of this work, as any room in a house where people sleep. The result (Table 5) indicates some

characteristics of the Anopheline population in the localities studied. Taking the area as a whole, a mean average of 1.90 Anopheline per bed room per month has been found. This shows that throughout the period of study the mosquito population continues to survive at certain threshold level. When viewed individually, in each locality, the highest average density was noted in October which coincides with the little decline of rainfall after the heavy rains of July/ August. From the results it can be seen that peaks occur in the rainy months of July to October while in the dry months of April to May the population is lower. Although no past records on this subject concerning this locality was obtained from the literature, the findings did confirm the earlier reports elsewhere in the country (Mattingly, 1949; Dodge, 1961; Molineaux and Grammicciae, 1980).

In his studies on West African forest mosquitoes, Mattingly (1949) showed the seasonal trend in the distribution of the main malaria vectors. Molineaux and Grammiccia (1980) in a report on the Garki Malaria Project in Kano reported the preponderance of the main malaria vectors and the highest incidences of human malaria in the wet season as compared to the dry season.

In Zimbabwe, Taylor and Mutambu (1986), have shown malaria prevalence and transmission to be markedly affected by season and altitude. The reasons for this have been clearly explained by Leeson (1931) in his exposition of the effect of the inter-related factors season, temperature and altitude on the survival and migration of An. gambiae s.l. He did not find An. gambiae occurring over 600m altitude during the winter and the peak An. gambiae population occurred in summer. Reeds & Woods (1957) found the peak of mosquito population to follow immediately the end of rainy season and with malaria peak occurring one month later. Mutambu and Taylor (1986) have reported a decrease in the number of suitable breeding sites limited only to the pools left by major rivers drying up, while in the wet season the breeding sites rapidly multiply. The higher values of Anopheline density generally observed in September and October may not be divorced from the increased humidity and temperature conditions that is common in all Federal Capital Territory at this time (Oguntoyinbo, 1977). These weather conditions are said to be optimum for the survival of the mosquito vectors throughout the tropics (Service, 1980).

The Anopheline density index is also a function of the survival rate of the insect. Mortality can be induced in the mosquito population by factors other than harsh weather conditions (Service, 1976). Practices such as the domestic use of mosquito coil, the use of residual insecticides (shelltox), repellants (Off), have been observed to keep away the mosquitoes from the houses as reported (WHO, 1986). These may explain the relatively low catches made in some houses both at Garki and Gwagwalada (Table 5, Appendix 2). The use of mosquito proofings in the windows and doors and mosquito nets in the bedrooms was observed to discourage flies. Air-conditions and Table-fans are used often by inhabitants occupying government quarters at Garki and Gwagwalada and this was observed to discourage feeding activities of this in the night. In contrast the figures noted at Sheda where not such of these facilities were available appear to be more consistent throughout. The low number of Anopheline gambiae caught in houses at Sheda,may be largely due to the porous nature of dwelling rooms (huts) and possibly the low number of people in the village about 1000 as compared to high population about 200,000 at Gwagwalada (Census office, 1986).

The sporozoite rate is the percentage incidence of sporozoite infection in the salivary glands of Anopheles (Bruce-Chwatt, 1980). The total sporozoite

rate for the whole area of study during the period of investigation is 4.2% (Table 4; Appendix 2). The Anopheles gambiae s.l. is described as both anthropophilic and to some degree zoophilic (Service, 1980). The higher sporozoite rate observed at Garki, therefore, may be attributed both to the probable greater number of Anopheline population there (Garki) and also to larger number of inhabitants at Garki compared to Gwagwalada and Sheda. It is also possible that the domestic animals often found at Gwagwalada and Sheda are alternative hosts for the mosquito population, whereas at Garki Municipal, the vector mosquito remain strictly endophilic and anthropophilic for lack of alternative hosts.

The hospital records gave a picture of the severe cases of malaria only. Cases of malaria in pregnancy, cerebral malaria and others were recorded. The records of out-patients was not included in this study. Nevertheless, both the in-patients and out-patients records put together will not give an actual picture of malaria in the territory because not all people report to hospital for malaria as many resort to self-meditation. However, the record here provides some useful information in assessing the prevalence of malaria in the period of study (Taylor and Mutambu, 1986). From the result (Table 6) about 84% of the available in-patient cases in the central hospital during

the period of study, has been dominated by malaria cases. This shows malaria to be a significant public health disease among others in the territory. It also confirms the common view of earlier workers in the study of epidemiological significance of malaria in the tropics (Bruce-Chwatt, 1974,1980; Molineaux and Grammiccia, 1980).

When viewed against the seasonal variation in the mosquito population (Figure 7), the malaria incidence seemed to increase immediately following the month witnessing mosquito peaks. Mosquito population peaks appeared between August to October, while malaria peaks occurred between November, January and February. Lesson (1931) in similar studies found malaria peaks one month after mosquito peaks. The longer interval observed in this case may be associated with widespread use of anti-malaria drugs, particularly chloroquine as prophylaxis (Gardiner, et al. 1984). They have found a low malaria parasites rate (1.6%) in an urban community in Ghana where prophylactic use of chloroquine is rampant.

The blood examined for this aspect of the investigation was obtained from people reporting for haematological investigation in the laboratory; and may not be without bias. Ideally the sampling could have been randomly conducted from the city or the village. This was not possible because of problems beyond

the resources for this work. The data, however, can be relied upon because none of the cases studied had been clinically suspected for malaria. Many were referred to the laboratory for routine examination and other medical tests.

From the result (Table 7), 25.7% of the slides examined were malaria positive. There is no much differences between the sexes. Majority of the females examined were women in the reproductive period. It appears that children between 2-4 years were mostly affected. This may be attributed to the absence of immunity in this age-group and to lowered immunity in pregnancy (Bruce-Chwatt, 1980).

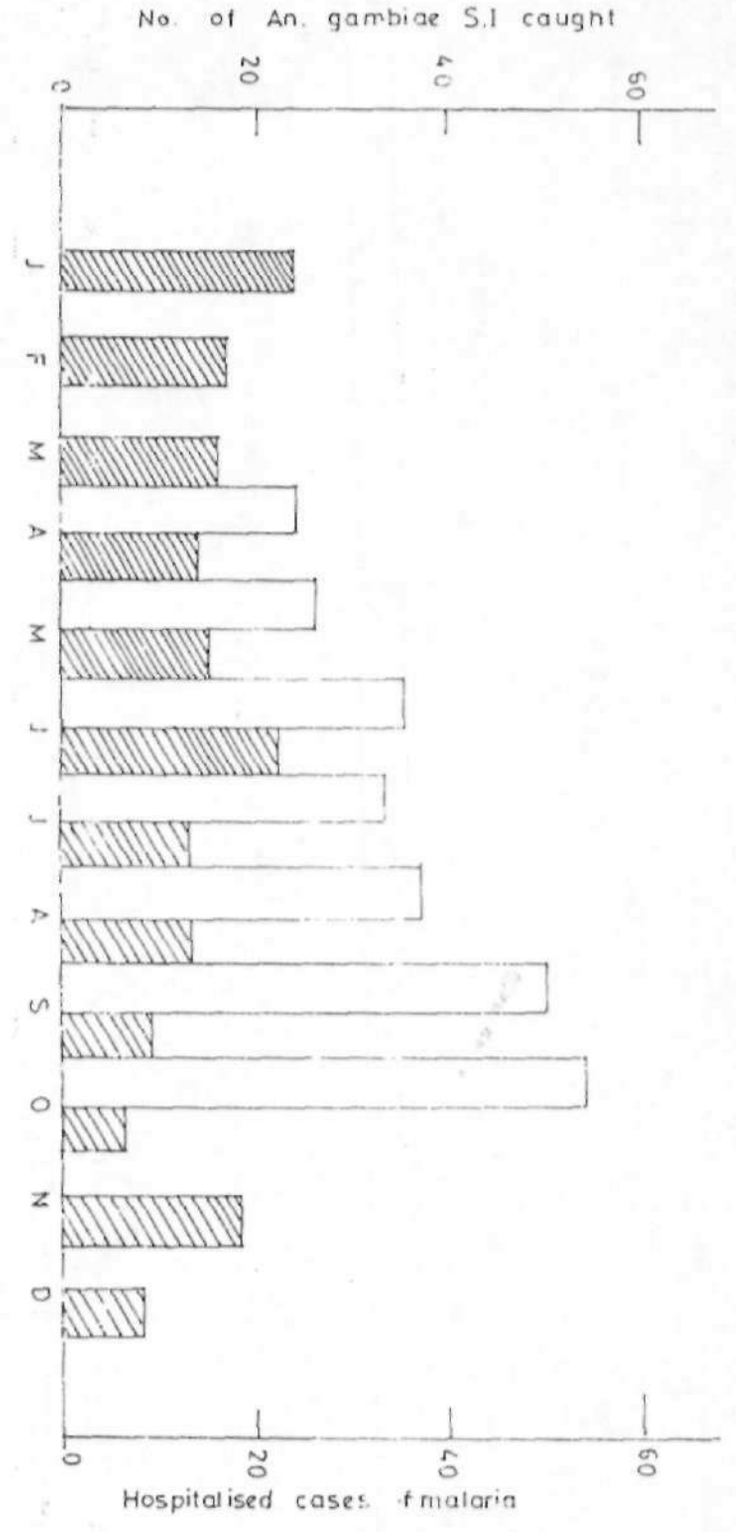


FIG. 7: COMPARISON OF HOSPITALISED CASES OF MALARIA IN F.C.T. CENTRAL HOSPITAL WITH CAPTURES OF An. gambiae S.I. BY P.S.C.

captures of An. gambiae

Hospitalised cases of malaria

SUMMARY AND CONCLUSION

The mosquito fauna and incidence of human malaria in Federal Capital Territory (FCT) Abuja has been studied. A total of 67 breeding sites were visited from February to October 1986, out of which 37 (55%) were found at Garki where the construction activity is accelerated. Table 1 shows that out of the 2,057 larvae collected, 793 were Anopheline larvae and 1,264 Culicine larvae.

2,451 Adult mosquitoes were caught resting out of doors between October 1986 to March 1987. On analysis, the results of the natural outdoor resting places surveyed (Table 2 and 3) showed that 40 mosquitoes belong to Anopheline genus out of which 11 were identified as An. fenestus. A large number 2,411 of the outdoor population were Culex pipiens fatigans. Slightly larger number of males, 1,381 were found in the outdoor population than females 1,070. The sex-ratio, i.e. male: female was estimated to be 1.3:1.

35 Adult Aedes aegypti mosquitoes were collected between April to June 1987. All the Aedes aegypti were caught feeding in the evening between 4-7pm. Out of the 20 houses randomly sampled for Aedes aegypti larvae-breeding containers, four were found with such containers.

The indoor-resting Anopheline mosquito population was surveyed using the Pyrethrum spray sheet collection (PSC) technique. 259 female An. gambiae s.l. were caught from all the three localities, between April-October, 1986.

On dissection, 11 were found to contain sporozoites in their salivary glands. The sporozoite rate of the population for the period was found to be 4.2%. Different sporozoite-rates, 5.2% and 3.3% were calculated for Garki and Gwagwalada respectively. From the hospital records, a total of 177 patients severely affected by malaria were hospitalised in the territory Central Clinic between January to December 1986. The total percentage of in-patients cases due to malaria for the period was 84% with mean monthly average of about 7.1%. The highest percentage 11.8% was recorded in June (Table 6). The blood examination result shows that the age group 2-4 years to be most affected by malaria with about 31.3% positive slides.

CONCLUSION

The construction work in Abuja is not only an engineering problem but also has major public health implications. For instance the borrow pits abandoned by the contractors at the construction sites are active breeding sites of Anopheline mosquitoes.

The gutters, culverts and even the domestic water-tanks are found to be good breeding sites of mosquitoes especially Culex pipiens fatigans. It is significant that the Federal Capital Territory Authority (FCTA), should recognize these findings and as a matter of policy makes it compulsory on all the contractors to "fill-in" any borrow pit on their sites. The authority could also legislate against indiscriminate digging of borrow pits in the city such as those behind Bagudu Hotel. The monthly environmental sanitation should be encouraged so that all occupied houses and their surroundings are kept clean, in order to discourage the pre-domestic breeding of Aedes aegypti. Likewise, the gutters and culverts should be maintained clean so as to reduce breeding of large Culex population.

The vectors surveillance study in general and the Aedes aegypti survey in particular, should be extended to cover all the development areas and continued on a routine basis by the vector control unit. The authority should equip its malaria vector control unit to enable it conduct adult mosquito control by residual insecticide spray of houses especially during the rainy-season and a month after. The health education unit should enlighten people about the need of using mosquito nets in bedrooms, and mosquito-proofs in doors and windows.

Prophylactic tablets, such as chloroquine, amodiaquine and fansidar, should be provided to all clinics and yellow fever vaccines should be readily available when needed.

Abuja is now a centre of attraction, inviting people from all over the federation and beyond, including places where the epidemic is affecting and with the vectors around, this can easily precipitate an epidemic in the city, when appropriate measures are not seriously planned and implemented.

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APPENDIX 1: PRELIMINARY SURVEY GARKI (ABUJA)

Date	General Location	Breeding Sites	Types of B.S.	Number of Dips	Anopheline Larvae	Culicine Larvae	Pupae Anoph.	Pupae Cule
18 February, 1986	Area 1 Festival Road	2	gutter	10	-	25	-	-
19February, 1986	Central Area Bridge	3	R. Valley	10	-	40	-	-
13 March, 1986	Area 8	7	Fadama	10	24	90	-	13
19 March, 1986	Area 11	6	Fadama	10	21	105	-	17
25 March, 1986	Area 1	2	Borrow-pit	10	10	-	-	-
10 April, 1986	Wuse District	4	Road side Depressions	10	-	77	-	18
20 April, 1986	Wuse-District	2	Borrow-pit	20	42	19	3	-
20 June, 1986	Area I	3	R. Valley	10	53	113	14	36
20 June, 1986	Area 2	2	Road-cute	-	20	69	-	-
20 June, 1986	Area 7	1	P&T Man-hole	-	-	107	-	12
10 May, 1986	Asokoro	5	Borrow-pits	20	73	118	11	15

Table 1 (cont'd.)

Date	General Location	Breeding Sites	Types of B.S.	Number of Dips	Anopheline Larvae	Culicine Larvae	
21 February, 1986	Sheda	-	-	-	-	-	
21 February, 1986	"	-	Rice-farms				Potential Sites
21 March, 1986	"	-	-	-	-	-	
14 April, 1986	"	1	Well	Water-Jar (1 litre Cap.)	-	44	
20 April, 1986	Village	1	Tractor tyre	-	-	21	
20 June, 1986	"	1	Pond	10	53		20 An. pupae
20 May, 1986	Shede Research Centre	1	Well	Water-jar (1 litre cap.)	-	77	
15 July, 1986	Sheda farm	2	Rice-farm	-	5	31	
18 August, 1986	3-km-Away Sheda-Kwali road	1	Borrow-pit	10	38	-	

APPENDIX 1: PRELIMINARY SURVEY GWAGWALADA (ABUJA)

Date	General Location	Breeding Sites	Type of B.S.	Number of Dips	Anopheline Larvae	Culicine Larvae	Pupae Anoph.	Pupae Culex
20 February, 1986	Area I	2	Gutters	-	-	25		-
27 March, 1986	Area 3	2	Gutters	-	-	45		8
22 April, 1986	Area 2	3	Isolated sites	10	36	57	-	5
14 May, 1986	Area 1	2	Road Depression	10	33	-	-	
14 May, 1986	Area 2	1	Culvert	10	-	102		23
18 May, 1986	Area 3	1	Flower-pot	-	-	29	-	-
18 May, 1986	Area 4	3	Isolated Borrow-pits	10	20	-	5	-
20 June, 1986	Area 2	1	Surface Water	10	69	-	7	-
10 July, 1986	Area 3	4	Broken bath-room sinks	-	-	86	-	13
17 August, 1986	Old-town	2	ponds	20	109	-	21	-
16 September, 1986	Area 2	2	Water-Tanks	-	-	64	-	9

B.S. = Breeding Sites

APPENDIX II: SPOROZOITE RATES AND NUMBER An. gambiae S.l. BLOOD-FED ESTIMATED FROM PSC. IN HOUSES AT GARKI MUNICIPAL: (APRIL-OCTOBER 1986)

Months	No. of bedrooms examined by PSC	No. of Occupants Adults and Children	Average number of occupants per bedroom	Average number of female An. gambiae s.l. per bedroom	No. of An. gambiae s.l. blood-fed.	No. of An. gambiae dissected.	No. of An. gambiae sporozoite positive	Sporozoite rate %	CALCULATIONS
April	6	21	3.5	3.5	14	18	0	0	Sporozoite rate % = Number An. gambiae sporozoite t x 100/1 Number An. gambiae dissected
May	10	28	2.8	1.3	10	13	0	0	
June	9	28	3.1	2.40	14	22	0	0	
July	9	24	2.7	2.70	15	24	0	0	
August	9	27	3.0	3.0	19	27	2	7.4	2/27 x 100 = 7.4
September	10	34	3.4	2.4	17	24	4	16.7	$\frac{4}{23} \times \frac{100}{1}$ = 16.7
October	9	28	3.1	3.0	13	27	2	7.4	$\frac{2}{27} \times \frac{100}{1}$ = 7.4

tve. = positive

APPENDIX III: MONTHLY DISTRIBUTION OF HOSPITALIZED MALARIA CASES BY AGE AND SEX IN FCT - HOSPITAL BETWEEN JANUARY - DECEMBER 1986

Age	January		February		March		April		May		June		July		August		Sept.		Oct.		Nov.		Dec.	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
0-11 Months	2	-	1	1	-	1	-	1	1	-	1	-	-	1	1	-	1	-	1	2	1	-	-	2
12-23 Months	-	3	0	0	-	-	-	1	2	1	-	-	-	1	1	-	-	-	-	-	2	-	2	1
2 - 4 years	1	-	1	1	3	1	1	1	1	-	2	1	-	-	2	-	1	-	2		1	3	1	-
5 - 9 years	2	1	-	2	3	1	1	2	1	-	2	-	-	-	-	1	-	2	-	-	-	4	-	1
10 - 14 years	1	1	-	-	0	1	1	1	1	1	1	-	-	1	-	-	-	2	1	-	-	-	-	-
15 - 19 years	-	1	2	2	-	2	-	1	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	1
20 yrs and above	6	6	2	5	1	3	2	3	4	3	8	6	3	7	3	5	2	1	-	-	3	5	-	-
Total	12	12	6	11	7	9	4	10	10	5	14	8	3	10	7	6	4	5	4	2	9	9	3	5

M = Male

F = Female

APPENDIX IV: RESULTS OF HOURLY CATCHES OF AEDES AEGYPTI AT SHEDA, (APRIL - JUNE, 1987)

	TIME			
	4-5	5-6	6-7	7-8
Date	Number Caught	Number Caught	Number Caught	Number Caught
15/4/1987	-	1	1	-
20/4/1987	-	6	-	-
4/5/1987	1	6	1	-
18/5/1987	-	4	2	-
1/6/1987	2	5	3	-
15/6/1987	1	7	1	-
Total	4	23	8	-

APPENDIX V

SIMPLE KEY TO DOMESTIC SPECIES (AFRICA)

(Applicable to both sexes. Including most of the Proved Malaria Vectors). After Evans (1938).

1. Abdomen with laterally-projecting tufts of species...2. Abdomen without such scale-tufts..... 3.

2. Colouration of integument predominantly light grey (exception in gorged females); winged with large areas of white or yellowish scales, or both

   Pharoensis Theobald

   Colouration of integument blackish, wings predominantly dark, but with well-marked white spots.....

   Squamosus Theobald

3. Species combining all the following characters: femora and tibial spotted, speckled or mottled, hind tars: with narrow, pale rings at apices of first 4 segments, front tarsi with broad apical pale band and two much narrower pale bands..... gambiae Giles and melas Theobald one or more of the above characters absent. 4

4. All the following characters present: leg without spotting speckling or rings (a part from those at joints); palpi not shaggy and with apex pale and not more than two other pale rings or bands, hind tarsi without a continuous pale

area involving the whole of one or more segments, wing field with at least some distinct pale spots or areas, costa with at least I pale spot (sometimes very small) on its base half 5

One or more of the above characters absent spp. not dealt with in this key.

5. Hind tarsi with distinct pale rings at apices of first 4 segments 6

Hind tarsi without distinct pale rings 9

6. 1st longitudinal vein with interruption in third main dark area 6

7. Front tarsi without very broad pale bands; and mesonotum with scales mostly broad or moderately so ..... hargreavesi

Fron tarsi with broad pale bands, or mesonotal scales mostly quite narrow.

spp. not dealt with in this key

8. Mesonotum with scales well developed and sometimes moalerately broad on anterior half, but narrow or hair-like behind

Moncheti Evans and Moucheti var nigeriensis

Mesonotal scales not as above.....spp. not dealt with here.

9. All the following characters present! general appearance very dark, size small (wing length no more than about 3.2mm), 3rd longitudinal vein either entirely dark or with a pale spot or area with its centre distal to the middle of the vein;

wings with the outstanding scales very narrow; female palpi with 3 pale bands (including that at apex); male palpi without pale scales at the base of club.....*fenestus* Gibs.

One or more of the above characters absent....10

10. Wing scales relatively broad, base of fork of 4th longitudinal vein near base of wing than is base of fork of 2nd longitudinal vein, female palpi with only 1 pale band, that at apex..... *nili* Theobald.