Price : 1/6 $ 0.40.

LEAGUE OF NATIONS

PUBLICATIONS OF THE HEALTH SECTION

MALARIA COMMISSION

Report on the Study Tour of the Malaria Commission in Certain European Countries in 1924. (C.H.273). 6/9 $1.60

Reports on the Tour of Investigation of the Malaria Commission in Palestine in 1925. (C.H./Malaria/52) 3/- $0.70

Rapport sur le voyage d'études de la Commission du paludisme en Espagne, 13 août-7 septembre 1925. *(French text only).* (C.H./Malaria/58(1).) (Ser.L.o.N.P.1926.III.14) 1/3 $0.30

Principles and Methods of Anti-Malarial Measures in Europe. Second General Report of the Malaria Commission. (C.H./Malaria/73). (Ser.L.o.N.P.1927.III.5) 3/- $0.70

Report on the First Results of Laboratory Work on Malaria in England. By S. P. James, M.D., assisted by P. G. Shute. (C.H./Malaria/57(1).) (Ser.L.o.N.P.1926.III.6). 1/- $0.25

Report of the Malaria Commission on its Study Tour in India (August 23rd to December 28th, 1929). (C.H./Malaria/147). (Ser. L.o.N. P.1930.III.9).. . . . . 3/- $0.75

In 1929, at the invitation of the Indian Government, the Malaria Commission sent a Sub-Commission to India for the purpose of carrying out an enquiry into malaria problems in a certain number of provinces.

On its return, the Commission submitted a report which covers the whole problem of malaria in India and the measures employed in the anti-malaria campaign. In particular, it deals with the problem of malaria in the towns, the problem of the periodicity of epidemic waves in the Punjab, the problem of malaria in the Ganges delta and in Bengal, etc.

The report concludes by recommending closer co-operation between the health authorities, energetic propaganda as to the efficacy of quinine, and the improvement of rural hygiene services by the addition of rural medical assistance.

The report is accompanied by numerous photographs.

Official No.: **C.H./Malaria/169.**

Geneva, June 1931.

LEAGUE OF NATIONS

HEALTH ORGANISATION

HOUSING AND MALARIA

(A Critical Summary of the Literature dealing with this Subject)

by

Lt.-Col. CLAYTON LANE, M.D., I.M.S.

Series of League of Nations Publications

III. HEALTH

1931. III. 6.

CONTENTS.

S. d. N. 995 (F,) 1.095 (A.) 6/31. Imp. J. de G.

INTRODUCTION.

This report follows a request from the Medical Director of the League Secretariat for a " survey of available literature in regard to the question of housing and malaria in the form of a critical summary ".

The second general report of the Malaria Commission of the League of Nations (document C.H./Malaria/73 ; Geneva, 1927) describes as indispensable two "primary measures" directed against malaria, the first being the treatment of the infected. The report states that the other primary measure which was recommended was described in the former report as follows :

> " The instruction of the inhabitants . . . as to how malaria is spread from member to member of the same family by the agency of particular mosquitoes which find the house a safe resting-place . . . In Europe, the majority of infected mosquitoes are found inside houses . . . The Commission strongly recommends that . . . an active and energetic endeavour should be made, wherever possible, to induce householders, especially housewives to make the killing of adult mosquitoes found within the house a part of the daily cleaning task. The Commission is convinced that that measure, if it could be effectively carried out, would have very remarkable results."

That conclusion clearly implies the steadfast conviction that malaria infection is essentially obtained in the house in Europe. In effect, the present survey of literature has resolved itself into the collecting and weighing of the evidence bearing on a possible connection between malaria and the house in all parts of the world.

For material from 1912 onwards, the procedure employed has been to read all abstracts dealing directly or indirectly with malaria in the *Tropical Diseases Bulletin* (instituted in 1912) in its *Sanitary Supplements* and in the *Bulletin of Hygiene.* Every paper whose abstract suggested that it might possibly contain appropriate matter has been read in the original. The majority proved useless for the purpose. In addition, earlier references compiled by Sir Andrew Balfour, Director of the London School of Hygiene and Tropical Medicine, have most generously been placed at my disposal and consulted in original. Moreover, others collected by Colonel S. P. James, I.M.S., of the Ministry of Health, have with equal generosity been laid open to me, as well as translations of German and Dutch works written at the beginning of the century and recently. Finally, references have been met with in the papers consulted, and these have been followed up in the originals whenever they seemed likely to prove of value.

It early became apparent that the amount of published works containing direct evidence of the rôle of the house in the transmission of malaria was relatively small, and it became equally clear that this was the case because there was assumption, often apparently unconscious, that the connection was real and essential. Thus the

fact that nearly all collections of anopheles reported in connection with malaria have been made in houses or outhouses ; that in malarious countries the screening of houses is habitually advocated, or their removal to a distance from anopheline breeding-places or sources of malarial infection, while the place of the day's work is unaltered —all these procedures at bottom assume that it is in the house that malarial infection is acquired. In face, then, of this assumption, the amount of evidence is not great, but such as exists seems to me to be strikingly strong. It is considered below from a number of aspects.

I am indebted to Colonel James for the following historical items not incorporated in the body of this note or in its list of references.

1897. — On May 7th, Ronald Ross caught in a rest-house in the Sigurghat the first "dappled-winged mosquito" that he had ever seen (Ross's "Memoirs", page 208).

1898. — In September, Grassi and Bignami collected all the mosquitoes they could find in houses of malarious patients at Maccarese. They included many specimens of *Culex vexans* and *C. penicillaris* and about ten specimens of anopheles. The culicines were liberated on September 26th, 1898, in a room in which a healthy person slept, and the anopheles on October 20th. The person fell ill with an attack of æstivo-autumnal malaria on November 1st (Grassi, " Studi di uno Zoologo sulla Malaria ", 1901 edition, page 142).

On November 13th, 1898, Bignami and Bastianelli repeated this experiment, using only spotted-winged mosquitoes (*Anopheles claviger*). They collected about a hundred of these mosquitoes from houses occupied by persons suffering from malaria in Maccarese and liberated them on November 13th in a room in which a healthy person slept from that date until December 2nd. This person developed an attack of malarial fever " of double tertian type " in the beginning of December (Grassi, *Ibid.*, page 144).

In December 1898, Grassi and his collaborators also began to practise Ross's plan of catching mosquitoes in houses containing persons suffering from malaria and examining them for developmental forms of the parasite. They found that at that period of the year 75 per cent of *A. claviger* caught in certain rooms occupied by persons who were all suffering from malaria contained developmental forms of the parasite (Bastianelli and Bignami in " Annali d'Igiene Sperimentale ", Nuova Serie, Vol. IV, No. 3, 1899, page 272).

1899. — In August, the malaria expedition to West Africa, despatched by the Liverpool School of Tropical Medicine, ascertained, by dissecting mosquitoes caught in dwellings, that at Lagos two species of anopheles (*costalis* and *funestus*) were acting as hosts and transmitters of all three species of the malaria parasite (Report of the Liverpool School Expedition to West Africa.)

1899-1900. — Stephens and Christophers, working in West Africa, gave some striking examples of " fever houses " in which infection persisted for weeks or months (Reports to the Malaria Committee of the Royal Society, Series 1-8, 1900 to 1903).

1. THE ANOPHELES ASSOCIATED WITH MALARIA ARE, IN THE MAIN, HOUSE-HAUNTERS AND NIGHT-BITERS.

The anopheles associated by experience with malaria are, in the main, house-haunters and night-biters, and at night their victim mainly spends his time in a house.

The general principle is implicit in a report by STEPHENS (1921) on malaria on a Venezuelan oilfield, chosen here at random as being typical of the advice regularly tendered in such cases :

> " We have here, then, an example of the conditions frequently found in the tropics—namely, native villages and a source of anopheles in close proximity to a white population."

Since the two populations white and coloured meet during the day at their work, it must be the homes to which they separately go at night that are held to be the site where they acquire their infection. The principle is treated by SYMES (1926) thus in speaking of Africans in Kenya :

> " It has been suggested that the native becomes infected with malaria in the open. The few observations we have made suggest that a native is bitten most frequently in his hut. Normally, he spends very little time outside during the evening."

CARTER (1927), by implication, accepts the house as the important site of infection in Ceylon in writing that *A. fuliginosus*, which has shown natural and artificial malarial infection, occurs frequently in local houses and cattle-sheds, and so must be regarded as potentially dangerous ; and, of *A. culicifacies* :

> " This species is highly susceptible to malaria infection, and, owing to this fact and its domestic habits, is, in India, regarded as one of the most important carriers of the disease."

Again, MACGREGOR (1927) writes of Mauritius that *A. mauritianus* will attack ferociously in the open during the day, and will enter houses and feed by day, but never, if free, at night, to his knowledge, and is not a carrier in Mauritius ; that *A. costalis*, which enters houses readily and which, although it will feed by day, feeds chiefly at night, is the main vector ; that *A. funestus*, of which there is no record of day feeding when not in captivity, is the vector of second importance. GARNHAM (1929, writes :

> " It is essential to know whether a mosquito is domestic in its habits, for, in the latter case, measures for its destruction are unnecessary, malaria as a rule being a household disease."

In this case, the principle is fully accepted. SWELLENGREBEL, SCHÜFFNER and SWELLENGREBEL DE GRAAF (1919) point out that, given the capability of acting as efficient host to plasmodia, the potential danger of an anopheles species depends on its commonness, its liking for human blood, and on whether or not it is a house-haunter.

2. MALARIA HOUSES AND ANOPHELES HOUSES.

That, where malaria prevails, certain houses may be particularly associated with this infection is an observation constantly made, of which the following are some published examples.

MÜHLENS (1902) quotes a number of instances of such house epidemics, from which the following are selected.

In Berensch, malaria appeared in two only of its twenty houses. In one, a 5-year-old boy fell ill at the end of March 1901, having tertian parasites in his blood; his sister of 2 years, who slept with him, followed in May, as also a man in the second house, 150 metres from the first, both showing the parasites.

Groden had over 200 houses and malaria appeared in two only. In one, the wife had untreated fever in 1901. In 1902, her child of 6½ years fell ill in March, and in May her husband, both having tertian malaria microscopically established. In the other house, two girls fell ill in April 1902, the infection being later microscopically established in one.

In Ellens, there were eight cases of confirmed malaria in 1902, occurring in four of its twenty-three houses. Four occurred in one house as follows : The wife had been ill in 1901. In 1902, there fell ill (*a*) her husband in the beginning of May, (*b*) the wife again fourteen days later, (*c*) their child of 15 months about the same time as (*b*), and (*d*) a servant nine days after (*b*).

FROSCH (1903) noted that R. KOCH showed in Fasana and Sigano, Istria, that malaria was a house infection, and reproduces a plan of the former, in which the malarious houses and the number of cases they contained is clearly marked. It illustrates the house character of the infection in a striking manner.

SCHOO (1905, page 219) had 218 patients in a town in North Holland, distributed as follows, in 1901 :

In	81	houses	1 case
”	38	,,	2 cases
”	13	,,	3 ,,
”	4	,,	4 ,,
”	1	,,	5 ,,

In another part of his practice, Schoo had houses with six, seven and eight malaria cases. He gives, on a plan, the distribution of these “ malaria houses ”, and adds that he can confidently call them such, for experience teaches that it is just in these houses where every year cases occur.

Alcock (1925) wrote :

> " There is the significant fact in certain Indian cantonments—and these not notoriously malarious—there may be (or once was to be) found some particularly malarious house having the oprobrious name of ' Fever Hall '."

Falconi (1913) noted that, in all regions where malaria prevails, its incidence in particular houses or streets of a town can be demonstrated. Mühlens and Svarčic (1925) wrote of one such " Malaria-Häuschen ", comprising a single room 4 metres by 4 metres, in which a family of five lived and in which over fifty fed mosquitoes were found. The finding of malaria houses is still common. Thus, Kligler (1925) said of Palestine : " In almost any village at all there are such things as ' malaria houses ' and such things as ' mosquito houses ' " ; while, in discussion on this paper, Bruce Mayne said, " It seems to be a general experience among field workers to encounter ' malarious houses ' ". Presumably, the well-known instances of " blackwater houses " are further examples of this condition of affairs. That there are constantly found houses particularly associated with malaria is evident from the literature published between 1902 and 1930. One reference not generally accessible may be added. Brigadier-General Testi (1919) stated of the Piave region that there were found there what were termed by Lieutenant-Colonel Mariotti-Branchi and himself " family epidemics ", in which all or nearly all members of a family were infected with malaria parasites, and anopheles captured in the houses concerned were infected to the extent of 25 per cent. The instances cited are merely a few of many.

3. ARRANGEMENT OF THE HOUSE AND THE HABITS OF THOSE WHO DWELL IN IT.

Seeing, then, that these extracts show clearly the existence of " malaria houses ", any particular character which they possess next requires elucidation. They do possess certain characters, and they are those which appeal to the instincts of at least certain malaria-carrying anopheles. For examples, *Anopheles maculipennis* shows by its habits that its preferences are for dark places without draught and with a comparatively equable temperature close to a food supply ; cobwebs add to the attractiveness. Of the condition of " malaria houses " in the regions where *A. maculipennis* is mainly concerned in the spread of this infection, the following are examples :

S. P. James (1919(*a*)) investigated an epidemic of thirty-two cases of tertian malaria which occurred in 1917-18 at Queenborough, Kent, England, in fifteen houses lying in four streets. In one house, there occurred five cases at intervals through the epidemic, and, finally, the landlady was found to be an apparently healthy carrier. In other houses there occurred 3, 2, 2, 2, and 2 cases, so that sixteen of the cases occurred in six houses and these (James, 1920(*b*)) became commonly spoken of as

" malarious houses ". A. J. GROVE, in discussion on the above paper, reported that he had examined a number of these houses and that nearly all were built on one plan :

> " The entrance hall gave place to a staircase which led to a central landing from which the bedrooms at either end and along one side opened. The ceiling of this landing supplied . . . absence of draught, stability of temperature, and, when the bedroom doors were closed, diminished lighting—in fact, almost complete darkness. *A. maculipennis* was found in many of the houses especially on the ceiling of the landing."

CAZENEUVE (1920) writes thus of autochthonous malaria in Kerhono, a suburb of Lorient on the west coast of France :

> " La distribution de ce paludisme indigène affecte un groupement conditionné par la proximité d'un marais, l'altitude, l'exposition au vent, la disposition des maisons. Il existe ainsi dans Kerhono un quartier paludéen, des maisons à malaria, à familles paludéennes . . . Des maisons sont essaimées par petits groupes en bordure de la prairie récente et du marais. Elles sont basses, au ras du sol, sans étage, selon le type primitif de la maison bretonne. Leur intérieur est souvent disposé en une seule pièce, sans grande ventilation ni lumière. Les murs sont tapissés de meubles et de rideaux, offrant de nombreux refuges aux moustiques . . . Dans ce quartier paludéen, toutes les maisons ne sont pas atteintes. Plusieurs, à un étage, claires et bien aérées, dont le rez-de-chaussée n'est habité que le jour, sont restées sans paludéens. Des maisons voisines, basses et sans étage, à l'intérieur encombré, sont, au contraire, devenues des maisons à malaria, dans lesquelles vivent des familles de paludéens."

JAMES (1919(*b*)) made the following observations in England :

> " A country lane leading to the edge of Arbrook Common in Surrey has on one side a row of modern two-storey houses and on the other a few primitive cottages. Anopheles bred abundantly in ponds on the edge of the common, and the adult insects were always to be found in great numbers in cowsheds and stables in the neighbourhood. During 1917, I lived in one of the houses in the lane and made observations on the anophelenes in relation to that house and to one of the cottages facing it."

James found that every evening throughout the summer about the same number of anopheles appeared to fly into both habitations. In the house, even when unmolested, they seldom remained more than a few minutes, and only once during the whole summer was a specimen found there in the morning, having apparently remained there all night. Of those which entered the cottage, " several quickly settled in dark corners and on the smoke-grimed rafters of the living-room and made no attempt to fly out " ; and some could always be caught at any time in the cottage.

Shelter of the kind which, as has been noted, anopheles prefer is, in Europe nowadays, mostly found in stables. But this is not always so. Peju and Cordier (1919) while noting that *A. maculipennis* seems almost domesticated, seeking out dark shelters in living-houses in which to dwell by day, yet report that the percentage of this anopheles in the total mosquito catch was the same in occupied dwelling-houses and in barracks deserted for six months—namely, 75 per cent—so that their conclusion that the insects which harboured in the latter were not there by food attraction seems incontestable. It is worth mentioning that, in rainy weather, the percentage of *A. maculipennis* in their house catches was only 10 or 12.

One potent mosquito-preventing habit of the primitive house-dweller requires special mention—that of the chimneyless hearth within the house. Thus Mühlens and Sfarčic (1925) noted that anopheles liked dark, dirty, damp dwellings, unless there was an open smoking fire. Haigh (1925) wrote of Albania :

> " On June 28th, in examining the villages of Aliku and Chausi (he mentions finding a spleen rate of 85 in twenty-six Aliku schoolboys), standing on a raised sandstone knoll overlooking the Vivari plain and forest in Southern Albania, I found that houses, cattle and goatsheds were swarming with mosquitoes. A goatshed made of basket work, and therefore with little protection from the wind, contained hundreds on the walls, roof, on cobwebs, etc. A cow and horse shed, the lower storey of a good house, built of stone and beams, with no light except from the door, contained similar numbers. The house above was constructed with two verandahs and doors which gave a through draught across the living and cooking room. In this room, which had an open rafter roof, blackened and shiny from the deposit of wood tar from the open fire on the cooking range, no mosquitoes were to be found. The inner sleeping-room, with ceiling and plaster, lighted by three windows, had numerous mosquitoes on walls, roof, bedding rolls, ornaments, etc., just like flies, and, if disturbed, these formed a cloud in the same way. The mosquitoes consisted of *maculipennis* and *superpictus*, more of the former, the bulk females, and generally gorged with blood . . . In houses, I have rarely found a mosquito resting on a smoked roof beam, but generally in the sleeping compartment, whether it possessed a roof or not."

Symes (1926) wrote of Kenya : " As one would expect, fires constitute a fairly efficient though not absolute protection against mosquitoes ", a conclusion based on " a considerable number of hut collections ". He adds :

> " In native villages it is in the huts set apart for the unmarried members of the community that the majority of anopheles is found. In these huts, no cooking goes on and no fires are lighted."

Similarly, Garnham (1929), writing of Kenya ; states :

> " In selecting huts for adult (mosquito) counts it soon became apparent that those with fires within them were unsuitable, as they contained few or no anopheles. A sudden diminution of anopheline density was shown to be due on numerous occasions to the inhabitants making a fire and cooking inside their huts."

The findings of HAIGH, SYKES and GARNHAM lead naturally to remarks by L. L. WILLIAMS, Jr., made in discussing the paper read by KLIGLER (1925):

> "In considering the *quadrimaculatus* rate (in North America) and its bearings on malaria, I would be most interested in the 'bedroom rate' rather than on the regional rate . . . I have observed a farming community of thirty houses in Isle of Wight County, all close to prolific *quadrimaculatus* breeding areas and with one or more cases of malaria in every home except one. This is the only screened house, and a well-screened house. In this group, the bedroom rate is quite high, it being quite usual to take twenty to sixty *quadrimaculatus* from a bedroom." [1]

The same factors seem to underlie findings by FRY (1922):

> "The day-time resting-place of anophelines in Bengal is in the cowshed, and the low mosquito infection rate which we found in Bengal may be explained by the fact that most of the mosquitoes which were dissected by us were not caught in the sleeping-rooms, where it was always difficult to find specimens. Cowsheds are packed with animals at night, and the number of anophelines found in them increases in direct proportion to warmth and darkness. The sleeping apartments of houses in Bengal are generally very clean and well kept. Though the cowhouses in the same compound may swarm with anophelines, it is exceptional to find a single specimen in a cookhouse or sleeping apartment."

The importance of the structure of the dwelling as a place attractive or distasteful to anopheles is emphasised by ALCOCK (1925). After noting the importance of drainage, he adds:

> "But the equal importance of dry, light, airy houses seems to have been realised only by C. W. Daniels, Colonel S.P. James and a few others. And yet there are facts of common observation that suggests the influence of the house."

After the lines quoted under "malarious houses" and a reference to James's observations in Kent, he continues:

> "There are places, not a few in the residential area, round London where anopheles larvæ are to be found, and adult anopheles in any cowshed or stable, though search for an anopheles in the excellent modern residence close by would be in vain."

In the same sense, MACARTHUR (1929) writes of Hung Jao, five miles west of Shanghai:

> "The selective habit of *A. hyrcanus* was much in evidence here. The men of the Coldstream Guards were accommodated in tents, and the officers messed in a house nearby. For a period of eight weeks the medical officer, Captain O. R.

---

[1] The interesting sequel is noted under "screening".

Oram, M.C., kept records of the number of anopheles in the house and tents respectively. During this time, only two single specimens were seen in the former, whereas on no occasion was any tent found free from them, and, if not disturbed by the occupants, forty or fifty anopheles per tent was a common morning sight."

About one hundred of the men shortly developed malaria.

What is now a matter of observation was inferred by Leslie in 1909 :

" Much, I believe, could be effected by improving the design of living-rooms and dormitories. It seems obvious that a well-ventilated, white-washed room will afford less shelter during the day to mosquitoes than a dark, dingy room."

It seems not inadmissible to suggest that the factors now seen to be active were those which, at least partly, determined the incidence of malaria in Europe in the past.

Addy (1898) describes ancient English cottages. The length of the " house-part " was, as usual, the rod, pole or perch—that of the single plough team with the four oxen standing side by side. Off it were other chambers. Windows were tiny and the fireplace without a chimney. He writes (page 52) :

" The house part of these cottages [fig. 1] corresponds to the *megaron* of a primitive Greek house, the *megaron* being the kitchen and men's room of the family. It also corresponds to the *atrium*, or ' house place ', of the Romans, that

Plan of Cottage at Westward — North Meols — England.

word being derived by some authorities from *ater* (black), on account of the blackened roof. In Chaucer's time the ' house part ' with its open hearth must have been black enough, as in the tale told by the " Nonne prest " :

" ' Full sooty was hir bowr and eke hir halle.' "

For dwellings of those of higher social position in the olden days, Addy instanced those still existing at Saterlander, in Oldenburg, said to be of the sixteenth century

or a little earlier, and having the dwelling-place, cattle-stalls and store-rooms under the same unbroken roof, and most meagre lighting, and adds :

> " The whole domestic life of the Saterlander is spent on the spacious ' floor ' (the central part of the house round which stand the farm animals in their stalls). In the background, about 6½ feet from the black wall, burns the open fire, the centre of domestic intercourse . . . The older dwellings have no chimneys. The smoke of the turf fire spreads through the whole building. This has the advantage that it scares away vermin."

Yet higher in the social scale are the ruins of an ancient manor house at Padley Hale, near Hathersage, Derbyshire, England, and of this Addy writes :

> " The house at Padley was not expressly built to keep out sunshine, but it would have served well for that purpose."

Finally, for the house of the noble, Addy writes of Peak Castle, mentioned in " Doomsday Book " :

> " In such a place life would hardly be bearable in the winter without a fire, but there is no trace of either chimney or flue in any part of the building . . . Unless such a flue existed, we are driven to the conclusion that a fire was burnt in an open brazier, thereby filling the room with smoke."

His general comment is :

> " It may be taken almost as an axiom that the smaller the windows the older the house."

There seems clearly at work in all these ancient buildings an antagonism between the pro-malarial effect of darkness and the anti-malarial effect of smoke. With the evolution of the chimney, the anti-malarial factor disappeared ; but in the existing houses, at least, the windows presumably were not enlarged. It can hardly be doubted that, in malarious parts, this particular advance in civilisation meant an increase in malaria.

The remarks above have all applied to the structure of the house relative to adult anopheles, infected or not. As a breeding-place of anopheline larvæ, water-holding recesses and receptacles outside the roof, walls or plinth of the house, and in wells, cisterns and domestic utensils, as intanced by *A. stephensi* in Bombay, are so well recognised as to need no detailed study here.

Regarding the interior of the house, M. D. Mackenzie (1923) wrote of South-East Russia :

> " At the time of the famine in the Volga Valley, thousands of refugees travelled 1,500 or 2,000 miles to Turkestan, where wheat was obtainable (November 1921 to March 1922). On the return of these peasants after the

harvest of 1922, malaria broke out in pandemic form throughout South-East Russia. The epidemic spread steadily throughout the winter, with the thermometer varying from 20° C. to 30° C. below zero from November to March. The spread of the disease during the extreme cold appeared to be due to the fact that the drinking-water-butt, combined with the almost tropical heat of the log-houses of the peasants, offered an ideal breeding-place for the anopheles remaining in the huts from the summer. During the intense cold of the winter, both larvæ (in the water-butts) and adult anopheles (in dark corners) could readily be found in a large proportion of the peasants' houses."

No dissections of anopheles for malarial infection were made.

Ioff (1926) writes in comment :

" This observation can relate to but a single case, as no one of many Russian investigators for the south-east has ever seen larvæ of anopheles in the water-butts within the houses. The females of anopheles domesticating in our dwellings have been found exceedingly seldom, and can by no means account for the numerous cases of malaria observed under our conditions *en masse* in winter and early spring months."

Christie (1924) caught mosquitoes in Russian houses during the winter, identified by Alcock as *A. maculipennis*, and reports that several cases of undoubted first infections of malaria have been noted during the winter months. Leaving aside the question of breeding in butts within houses during winter, it must be noted as strange that the same mosquito should hibernate in dwellings in, say, Holland, but not in Russia. The question of latency in first infections is dealt with below.

I may be mistaken in concluding that the recommendation of Heckenroth (1923) implies his belief that, in Dakar, anopheles breed in cisterns within houses. He notes that an insufficient water supply leads to storage both outside and within houses, and, in a paper entitled " *Mesures capables d'enrayer le paludisme à Dakar* ", urges the need of powers to inspect cisterns *inside* houses.

4. THE HABITS OF ANOPHELES IN RELATION TO MALARIAL INFECTION.

Of the " malarious house ", James writes (1920 (*a*) page 68) :

" The explanation seems to be that a mosquito (*maculipennis*) which has lived long enough to become infected has also acquired the habit of remaining for weeks and months in that house, *or of returning to it after every flight* ".

And, again (1920(*b*)), regarding the Queenborough results :

"The findings could only be explained on the assumption that the particular mosquito which had bitten the malaria-carrier remained in that house day after day and week after week, or that, if it made a flight outside, it succeeded in returning to the same house, which it instinctively knew to be the resting and feeding place which it had originally selected."

Schüffner, Swellengrebel, Swellengrebel de Graaf and Achmed Mochtar (1919) offer evidence on like lines :

"We do not know whether [*Anopheles*] *ludlowi* leaves the house it has once entered before the maturity of its eggs does compel it to do so, and whether, on return from its breeding-place, it does visit the same house or another one. We have only been able to make one single observation in Mandailing, which points to the fact that its sojourn in the same house may last longer than one night or one day. At Panjaboegan, we searched the house of a European who had just contracted malaria and who had developed into a gamete carrier of the third degree (more crescents than 1 to 19 leucocytes). Ten specimens of *ludlowi* were caught. Seven were found to be infected with coarsely-pigmented cysts, of which six had cysts of the size proportional to three or four days and in one the cysts were older."

The index of infection was 3 per cent round Mandailing, and 8 per cent further afield, as against 70 per cent in this house. The mosquitoes had stayed in the house or had returned to it.

In like manner the finding of infected or actually infective mosquitoes in the houses of those from whom they must have obtained infection is noted by Heydon (1923), who caught 101 *Anopheles punctulatus*, mostly at night when attempting to bite, sixty-three coming from the White Hospital, Namanula, Rabaul, and thirty-eight from his own bungalow. None showed infection ; while, of 136 caught in native quarters or huts, mostly when resting by day, eight showed sporozoits and eight oocysts. Again, Walch and Walch-Sorgdrager (1921) found mosquitoes with oocysts as follows :

	A. ludlowi	*A. sinensis*	*A. kochi*	*A. aconitus*
In dwellings :	17.2% of 58	1.5% of 7.038	12.5% of 72	2.5% of 40
In buffalo-stalls:	No mosquitoes found	0.9% of 225	0% of 7	0% of 3

Further, James (1929 (*a*)) writes of a farm in Kenya :

"The farmhouse was a thatched 'banda' divided into rooms by wattle and daub walls not reaching to the roof. It had an earth floor and no ceiling. We found that the farmer was up and about, but that he was only just recovering from an attack of malaria. His son was in bed with a similar attack. His daughter,

the only other member of the family at home during the visit, was about the house, but we found malarial parasites in her blood. Four houseboys, who occupied a hut a few yards from the door of the farmhouse, had enlarged spleens and parasites in their blood, and this was also the finding in twenty-four out of twenty-five native labourers on the farm. Then we searched for anopheles mosquitoes in the house and huts . . . and dissected thirty-eight of these. We found that the salivary glands of five (13.2 per cent) were heavily charged with sporozoits."

Observations associating malaria in the inhabitants of a dwelling with malarial infection of the mosquitoes caught in the dwelling itself are, then, forthcoming from widely separated areas. It remains to offer evidence regarding the alternatives laid down by James. Have anopheles, at least in certain circumstances, either a hospice-return instinct—one which brings them back to the place where they have already enjoyed food and shelter—or a stay-at-hospice habit ?

5. A HOSPICE-RETURN INSTINCT.

Accounts of three experiments on the question of a hospice-return instinct in anopheles have been collected from the literature. The usual procedure has been to catch adult anopheles in habitations in one place, stain them by spraying them with an aniline dye solution, release them at a distance from the place of capture, make fresh catches of mosquitoes in various places including the original site of capture, and determine whether any among the new captures are stained. A slight amount of staining may be overlooked by mere inspection, but may be made evident as a flash of colour when a mosquito is dropped into alcohol, chloroform and glycerine.

Le Prince and Griffiths (1917) captured in houses and barns in South Carolina, U.S.A., 272 *A. quadrimaculatus* and three *A. punctipennis* and stained them with eosin. After release, three only were recaptured, all of which in a negro shack from which a large percentage of the original captures had come, the distance in a straight line from the place of release being 3,090 feet and including a river 800 feet wide. They enquire whether this implies a homing instinct and add : " It would be easy enough to test by using different stains for the batches caught in different houses ". Such a test never seems to have been carried out.

Geiger, Purdy and Tarbett (1919), in Arkansas, U.S.A., caught and stained about 4,000 *A. quadrimaculatus* and released them at the point shown in Figure 2 ☼. The subsequent catching stations are shown thus □. Ten stained mosquitoes were recaptured at the points shown thus ● which were within the township of Lonoke. Of these mosquitoes, four-fifths had been caught originally at the stations indicated thus ◆ and one-fifth at the two marked thus ⊟. At the time of re-catch, such air currents as existed were from the south-west. Perhaps observations by Le Prince and Orenstein (1916) in Panama provide another explanation for these results than a

back-to-the-hospice instinct. These writers describe strong flights of anopheles in a direct route practically at right angles to a strong breeze from the breeding-grounds to a human settlement—to food, that is. As they put it : " The numerous observations showed that the anopheles knew where they desired to go ". In the experiments of GEIGER, PURDY and TARBETT, it may be that it was the aggregation of human beings in the township which attracted them ; they sensed plentiful food and made for it.

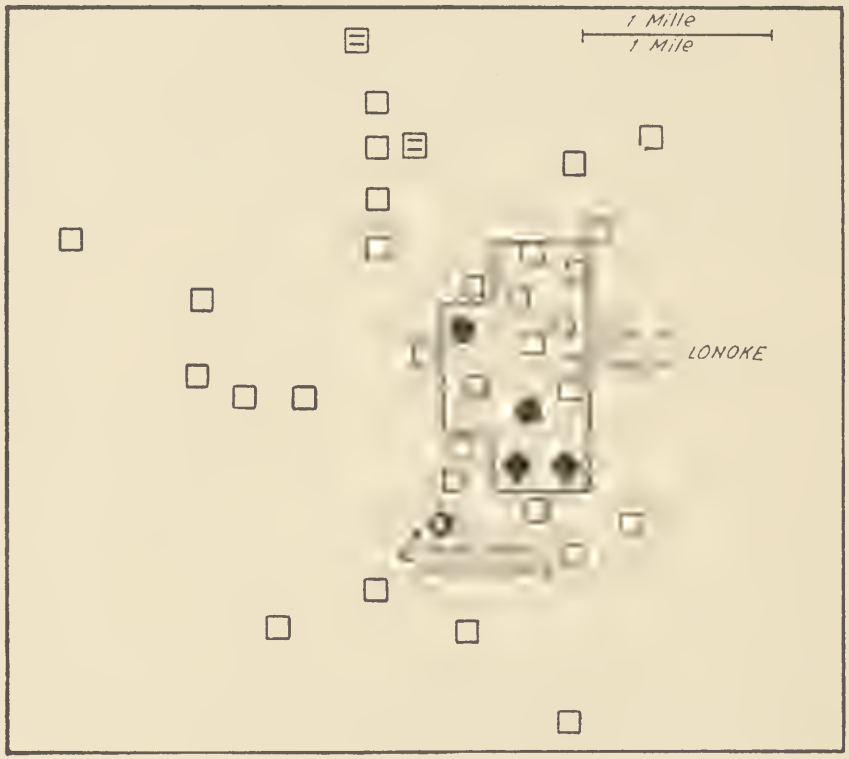

FIGURE 2.

GARNHAM (1929) collected 688 adult anopheles, mostly *A. funestus*, from native huts just outside a township in Kenya Colony and sprayed them with methylene blue and released them in four of a group of fifteen huts in another part of the town. " No coloured mosquitoes were obtained from anywhere outside the treated boma " ; presumably, the group of fifteen huts is meant. There were recovered eleven between the second and fourth days from eight of the untreated huts ; but not from the other three, which lay to windward of the places of release. These last were searched for the first time on the fifth day and no stained mosquitoes were found.

It cannot then be said that experiments so far carried out lead to the clear conclusion that anopheles have an instinct to return to their " hospice" after leaving it to oviposit. They appear, however, to have a tropism towards any ample food reservoir,

such as a large collection of human beings, and this may explain instances of apparent "back-to-the-hospice instinct". It appears to follow that, if a convenient breeding-place lies close to a convenient "hospice", a tropism towards food will bring anopheles back to this "hospice" after oviposition, and a "malarious house" may thus be established.

6. A STAY-AT-HOSPICE HABIT.

Such a habit is clearly not invariable among anopheles. Blacklock and Carter (1920) write :

> "That *A. plumbeus* has not been recorded more frequently in houses is, in our opinion, due chiefly to the fact, noted by Christophers (1916), that the females retire to the shelter of their breeding-places (rot-holes in trees) shortly after their feeding. Unlike *A. maculipennis*, they will remain but a short time in the house, and the chances of seeing them except in the mornings and evenings will be small."

While this quotation implies the belief that these anopheles feed and so infect or become infected in houses, it shows that a failure to surprise anopheles within the house is no evidence that feeding does not habitually occur within the house. The same is emphasised by J. G. Thomson (1929) for Southern Africa :

> "At night, in badly lit houses, anopheles can be detected with difficulty . . . They are silent during flight. The inhabitants of unscreened blackwater fever houses, as often as not, will state that they seldom see mosquitoes and are not bitten by them—this at the height of the malaria season, when the houses are nightly infested with anophelines, as the following incident demonstrates. Larvæ of *Anopheles costalis* were found in abundance in a spruit about 100 yards away. A hunt in the house for adult anophelines proved of little use ; none were found. The occupants declared they seldom saw mosquitoes."

Before sundown a window was closed with mosquito netting. Immediately the sun set, the netting became covered with mosquitoes trying to get *out of* the house.

> "On many occasions by adopting this procedure thirty, forty, fifty or more female anophelines (*A. costalis*) could be captured on the netting in a short time, and these were only a few of those actually present."

In the Philippines, Manalang (1928) reports a like experience with *A. minimus* :

> "The adult mosquitoes are typically wild in that they are but seldom found in the ordinary nipa house at night, much less in the day-time. The only occasions on which they have been caught during the day-time were when they were imprisoned inside wire screens. During the period of heavy catches, they have shown preferential harbourage in two houses and incidentally where most of the new malaria cases were registered." ("Significantly" seems a better adverb.)

Essed (1925) deals with *A. maculatus* in Tandjong, Sumatra. On analogy with Malaya, he concludes that this mosquito is the essential local host, because splenic and parasite indices are highest near its breeding-places, because it is the prevalent mosquito with the most extensive breeding-grounds, because it attacks man at night, and because it has been found locally infected. Further, from the nature of the catches in and out of doors, he concludes that *A. maculatus* feeds exclusively at night, and then immediately leaves the house.

Fricks (1920) and Le Prince (1926) deal with a somewhat similar condition in America. The latter writes of *A. quadrimaculatus*, the chief conveyer of malaria in the United States :

> " When it bites us in our homes, in most instances it rests on the walls of the room where it took its blood meal and remains there quietly all day. Occasionally, some of them go into an adjoining room."

He adds that, after feeding, this mosquito is sluggish and readily killed, and that children can easily be trained to kill every anopheles in a room. The former adds : " When in a condition to fly, they are most apt to leave the house just before dusk or soon after dawn". There is with this American anopheles a period after feeding during which it remains in the house ; but, at least in general, this interval is not long enough for it to become infective if the feed was infected.

The urge to leave a house, where the female anopheles has fed, is impelled by the necessity for oviposition, to which the blood feed is the biological preliminary. In true hibernation, there is no oviposition and, therefore, no need to leave such a house ; but neither does the insect feed, so that there is no possibility of an infective anopheles transmitting malaria. This condition Swellengrebel (1929) calls gonotropic association. But, as he has shown, there is in Holland for *A. maculipennis* an intermediate condition in which, while oviposition is in abeyance, feeding is not (he calls it gonotropic dissociation) ; while, at the same time, there is an autumn settling down of anopheles, the anopheline population ceasing to move from one " hospice " to another. Thus, when all the anopheles in any shelter were captured during the summer, the numbers were made up again within one to nine days. When the operation was repeated in September (the production of eggs ceases almost entirely from the beginning of the month in Holland), this was the case to a very slight degree, and was due to the hatching of some late larvæ which still survived. When capture was repeated in October, the room remained empty, although neighbouring shelters were still full of anopheles. During the summer, oocysts were found in the initial stage only ; this Swellengrebel attributes to the fact that, after a feed, anopheles leave the house. At that season, their proportion is one per house and 200 per stable, so that, when infected insects leave a house, they become so swamped by numbers as to escape detection. It is, at all events, clear that there is no evidence that *A. maculipennis* in Holland has in summer any tendency to return to the hospice. With the autumn settlement, oocysts gradually reach maturity during September to December, in spite of the less

favourable temperature (Figure 3, after SWELLENGREBEL, 1925), while the need for food in these anopheles with gonotropic dissociation ensures the entrance of sporozoits into man. It requires a large dose of these sporozoits to produce an immediate outbreak of malaria ; but that they are viable was shown by JAMES (1927, 1929 (*b*)) and confirmed by SWELLENGREBEL, the malarial attack coming on six to nine months

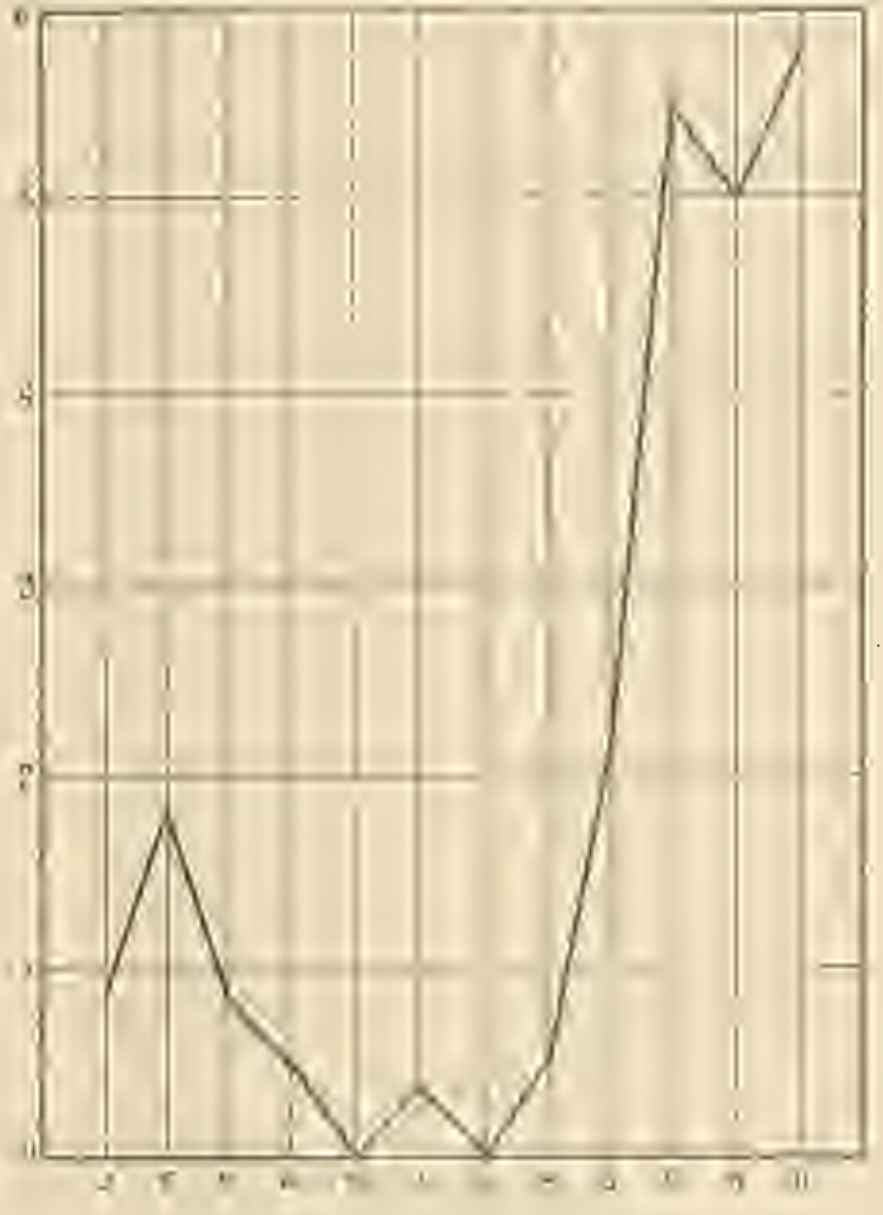

FIGURE. 3.
Average monthly percentage of infection of anopheles caught in malarious houses in the Netherlands.

later ; a circumstance which explains how the vernal epidemic appears in Holland before the new anopheline brood is reared, and that, nevertheless, the infection might be acquired in the house. Moreover, in Holland, there are areas where only gonotropic dissociation is found ; these are areas with endemic malarious centres, the presence or absence of this infection seeming to depend on anopheline density. There are areas where only gonotropic association is present ; these are free from malaria, even though the number of anopheles is high. There are areas with a mixed population in which, in early autumn, anopheles with gonotropic association settle down in lofts, threshing floors and other uninhabited places, whereas those with gonotropic dissociation settle down in inhabited dwellings. These biological types, it may be added, Swellengrebel associates, at least on the average, with certain anatomical differences.

The winter behaviour of *A. punctipennis, A. quadrimaculatus* and *A. crucians* in North Carolina, U.S.A., is reported on by Boyd and Weathersbee (1929). In very cold weather these anopheles might show hibernation, nearly always in unoccupied places with no feeding and no oviposition ; the condition was designated as hibernation because intense smoke might leave them undisturbed. In less cold weather there was evidently gonotropic dissociation, for the number of anopheles in occupied places increased and recently fed individuals were in evidence ; the first two species showing, as they do in summer, a particular tendency to linger where they feed. The gonotropic dissociation held up to January, as judged by the way in which the percentage of gravid females lessened after that date. Swellengrebel points out too that, as regards hot climates, nothing is known as to whether gonotropic disssociation, the requisite for a "stay-at-hospice" habit, is associated with æstivation or with any other special biological state.

Chagas (1925) states, however, that observations in Brazil, particularly by Godoy, show that certain individual anopheles remain in houses continuously for as long as twenty days, even after they have been fertilised and have fed on blood. These mosquitoes, it is pointed out, have completely developed ovaries associated with inhibition of oviposition, and are too heavy for ready flight. Among their normal fellows oviposition is followed rapidly by death ; but, when this function is suspended, life is prolonged to an extent which allows of the formation of sporozoits, so that there is brought into being an infective individual which is without any instinct urging it to leave the house. Chagas characterises this as a fact of capital biological importance, and sufficient in itself to establish the doctrine of the house infection of malaria. Whether or not it is related to the condition next considered does not seem clear, though Chagas states that, while he had never detected infection in mosquitoes caught outside houses, it is always easy in houses inhabited by gametocyte carriers to find anopheles with oocysts and sporozoits. With this he correlates the observation that children, even those in cradles who never leave the house, have a higher spleen index than adults.

There is some evidence that a stay-at-hospice habit may sometimes be due to malarial illness in the mosquito. SCHOO (1905, page 225) quotes PLEHN [1] as believing that, from the pathological changes in the stomach induced by the malarial oocysts, the mosquito falls sick and is unable to leave the house. JAMES (1926) urges that the habits of the *A. maculipennis*, which becomes infective, are quite different from those of normal insects :

> " Instead of making flights in the open, they pass almost the whole of their time in the house in which they first settled. At their first feed in this house they become overloaded with blood and almost too heavy and sluggish to make a satisfactory flight. They find a sheltered dark corner or hole within a few feet of the beds of the occupants of the house, and, night after night, make a short passage between their hiding-place and the sleeper in the bed in order to gorge themselves with blood. Their eggs ripen only very slowly, and, even when they are ripe, the insect is very loth to make the flight necessary to lay them. Often she drops them carelessly after a short flight, and returns to the hole she has made her home. Life in the household with the nightly feed of blood has become a habit to which everything else is subordinated."

All this reads like the description of a sick insect, analogous to the illness reported by BAHR (1912) in filariated *Stegomyia pseudoscutellaris*.

There is, then, considerable evidence that certain healthy anopheles at certain times have a stay-at-hospice habit, and that some anopheles show it because they are too sick to fly away. When there is no such habit, the almost uniform conclusion on the facts, formed by those who report its absence, has nevertheless been that the anopheles concerned feed in the house but leave it before ordinary methods of capture have secured them. If their feed gave them malaria, it was in the house that they acquired it, and, if they feed again on man after they have become infective, it will be in some house that that feed will take place.

7. THE BLOOD MEALS OF ANOPHELES.

The species of animals which furnished the blood meal of anopheles has been tested by workers. Results which have been collected for the present analysis are as follows :

---

[1] The citation of the article has not permitted of its being traced.

	Davis and Shannon (1928)	King and Bull (1923)	Kligler and Liebman (1928)		Boyd and Arris (1929)	
Country :	United States of America	United States of America	Palestine		Jamaica	
Species of mosquito :	*A. pseudo punctipennis*	*A. quadri-maculatus*	*A. elutus* *A. superpictus* *A. sergenti*		*A. vesti-tipennis*	*A. albi-manus*
Site of collection :	In houses		In houses	In stables	In houses	
Numbers collected.....	650	1,455	145	85	26	48
Percentage containing blood from :						
Man	50.0	38.4	40.7	—	42.3	50.0
Equines.....	8.9	20.1	5.5	All	15.2	8.3
Cow	5.5	18.6	16.0	were	15.2	20.8
Dog	21.8	10.0	—		15.2	6.3
Pig	2.5	7.7	—	from	3.8	8.3
Chicken	3.2	2.6	—	ani-	—	2.1
Cat	1.8	2.6	—	mals	—	2.1
Sheep and goat.....	6.2	—	—		7.6	2.1

Walch and Sadjito (1928), in the Dutch East Indies, reported these actual figures from catches in houses :

Mosquito	Number containing human blood	Number containing buffalo blood
A. ludlowi.....	10	2
A. rossii	5	38
A. vagus	0	6
A. aconita.....	3	36
A. tessalata.....	0	3
A. punctulatus	7	0

From buffalo stables near houses, *A. ludlowi* contained human blood three times and buffalo blood twenty-three times, the corresponding figures for *A. rossii* being 0 and 2.

Except for *A. rossii* and *A. aconita* the blood meals of anopheles caught in houses had predominantly been taken from man, and those caught in animal houses predominantly from animals, or solely so in the Palestine figures. The experiments do not suggest that, in the ordinary way, anopheles which have entered houses and fed on man continue to do so afterwards.

8. INFLUENCE OF ANIMALS AND ANIMAL HOUSES.

Roubaud (1919) enunciated the protection from malaria which he held domestic animals to confer on man in these words :

> " L'homme est protégé par les animaux. Cette protection est d'autant plus complète que la population anophélienne trouve plus aisément à satisfaire ses besoins de sang sur le bétail. C'est là ce qui règle la présence ou non des anophèles dans les maisons."

Whether anopheles fed on man or not was here regarded merely as a question of the amount of food available. Accordingly, the use was advised of animal houses surrounding and thus protecting human habitations. Later Roubaud and Leger (1921) modified this unqualified statement. Any kind of animal house would not protect man ; it must be of a certain type—low, dark and without draughts, and animals must be stalled in it at night. In other words, the main stress is removed from the animal as food to the kind of house in which it is stalled. The requirements of the stable attractive for anopheles, indeed, complies in all respects with what has been seen to be those of the similarly attractive human dwelling. No definite attempt seems ever to have been made to determine whether, if men and cattle are housed in new buildings of exactly similar construction, there is in *A. maculipennis* a preference for cattle.

Sergent and Sergent (1921) believe that they found in Vendée, in 1903, that the pig was more attractive than man, but the relative housing conditions were not stated ; at least, they reported that, though the inhabitants of Algeria surround their houses with animal houses to keep off robbers, they suffer from malaria. The same criticism seems to apply to the statement of Schüffner and Hylkema (1922) that a single buffalo can divert most *A. ludlowi* from the lodgings of one hundred persons. Sergent *et al.* (1924) later report no protection for man by animal houses, *A. maculipennis* enjoying the hospitality of the W.C. as much as that of the adjacent animal houses.

Regarding Albania, Haigh (1925) reports :

> " One woman with whom I conversed at Velivishti near Berat [25 per cent of Berat scholars were absentees in autumn as the result of malaria], who had three children suffering from malaria, informed me that mosquitoes had been present in the house ; but there were none there now, as the cow had been sold three weeks ago. No anopheles could be found in the empty cowshed, but the season was advanced (September 22nd) and breeding had almost ceased in the neighbouring river . . . The presence of animals seems to be a factor of great importance in attracting mosquitoes to the houses, and in some areas may be the *chief cause* of their presence."

Alcock (1925) wrote thus :

> " There is no general concord of evidence that the insect (*A. maculipennis*) prefers the blood of cattle to that of horses or pigs or rabbits or man, though there would perhaps be more general agreement that it prefers a cattle-shed or a stable even when empty to a well-constructed house, even when it is habited."

Wesenberg-Lund (1920-21) assumes that, formerly, in Denmark, *A. maculipennis* bit in the open by day. He attributes the disappearance of malaria in Denmark during the last hundred years to the fact that animals are now housed and man's working time in the fields is much lessened by mechanisation ; and *A. maculipennis* has followed the animals into their stables. It should, however, equally have followed man to his house, if that were the complete explanation. There is no mention made of what, on the evidence given above, is clearly of great importance—the general improvement in light and airiness of Northern European habitations during the last hundred years, a change in which Denmark has certainly participated. It is, perhaps, not going much too far to suggest that the type of cottage used in these latitudes by man a hundred years ago was not far different in these respects from the type of animal house now in use ; and it would seem, then, that the change in anopheline habitat in Denmark is more reasonably attributable to better housing of man than the housing at all of animals. That animals are more attractive to *A. maculipennis* than is man is, then, a position which was practically receded from by Roubaud when he insisted that, to be so, they must be stabled in a particular way. The practical question which results seems to be this : As a malaria preventive, is it not better to house man well than to house animals badly ?

It must, however, be noted that Missiroli and Hackett (1930) conclude, as the result of their investigations in Italy, as follows :

> " We believe, therefore, that, in Southern Europe at least, it is not any combination of attractive physical circumstances, such as darkness, warmth, dampness and freedom from draughts, which impels *maculipennis* to enter dwellings ; but, instead, the presence of a certain kind of food-supply to which by instinct it is drawn."

9. EFFECT OF CERTAIN PREVENTIVE MEASURES.

It is clear that, if the house is the place where infection is ordinarily obtained —the place, that is, where man is ordinarily bitten by infected anopheles—then certain measures which effectively prevent infective anopheles from biting man in the house will lessen or prevent malarial infection. Conversely, if malaria lessens or disappears after such measures have been applied, this fact will be good evidence that the house is a place, or the place, where infection is obtained. The effects of three such measures will now be considered : (*a*) effects of detection and destruction of adult anopheles in houses, (*b*) effects of screening houses, and (*c*) effects of house site.

(*a*) Effects of the Detection and Destruction of Adult Anopheles in Houses.

Ross (1911) reports that Sir William MacGregor employed a boy to kill mosquitoes by a net in his house in Lagos, West Africa, in 1901 ; but it does not seem clear whether this was an anti-malarial measure or merely designed to increase comfort.

Strachan (1904) writes :

> " In Lagos, we have tried the experiment of employing a ' mosquito catcher ' in certain large institutions ; but I am not able to say conscientiously that the results have been very valuable. The reduction of the number of mosquitoes of various kinds cannot have been greatly aided by this means, as a constant influx of new individuals replaces the few destroyed daily, though possibly the comfort of residents may be a trifle increased."

The reasoning is convincing so far as it goes, but if malaria is contracted in the house and if infected anopheles remain, or having left it return to its shelter and then remain, in the house long enough to become infective, the daily destruction of fed anopheles will prevent the transmission of malaria ; and, conversely, the fact that malaria had been controlled by this means would be evidence that malaria was contracted in the house.

In Cocoli, Panama Canal Zone, a temporary camp was installed in April 1908. It was surrounded by anophelene breeding-places too considerable to be got rid of with available funds, though oiling reduced the number of adult insects. A man was detailed to kill all mosquitoes found in tents. He worked daily up till 5 p.m. from April 10th to August 24th. In that time there were 17 cases of malaria, corresponding to a figure of just over one per cent of the force sick with malaria every week.

> " This was a lower sick rate than had occurred at other camps where anti-malarial work had been carried out for quite some time, but at Cocoli we were killing adult mosquitoes and the other places were not." (Le Prince in Ross, 1911, page 360.) Again, in June 1908, several hundred United States marines were stationed at Camp Diablo on the top of a hill, with a big marsh at its foot. Their malaria sick rate was 14 per cent per week. From the beginning of May 1909 to the end of November 1909, a string of railroad cars, which provided sleeping accommodation for labourers, was stationed between the swamp and the camp formerly occupied by the marines. Each morning the cars were examined and all mosquitoes found were killed in chloroform tubes, and during that period of thirty weeks only four cases of malaria occurred in the 40 labourers, although they were more freely exposed to the anopheles than the marines had been." (Le Prince in Ross, 1911, page 361.)

In referring to this, Gorgas (1915, page 199) wrote :

> " This method of killing infected mosquitoes was developed by Mr. Le Prince and his sanitary inspectors into one of our most effective antimalarial measures."

On one occasion some 500 anopheles caught alive were sent to Darling for examination. DARLING (1910) wrote :

> " It is noteworthy and speaks well for the practice of these daily killings that but one infected anophelene was found."

There are other references in the literature to this work in Panama which need not be detailed.

While, then, on the one hand *A. maculipennis* and *A. quadrimaculatus* are readily detected and killed in the house, it is, on the other hand, clear from the reports already noted by BLACKLOCK and CARTER, by THOMSON, and by MANALANG that this is not the case for *A. plumbeus*, *A. costalis* and *A. minimus*. But their work shows also that the failure of easy detection, in the house, of these species is no evidence that malarial infection is not transmitted by them in the house, for their presence there becomes unequivocally manifest when these mosquitoes are intercepted, practically trapped during flight into or out of the house. It is evident that the use of a mosquito trap may be an essential part of any scheme which is based on the detection and destruction of certain species of adult anopheles as an antimalarial measure. The earliest use of traps which I have been able to trace is recorded by KÜLZ (1909). He describes mosquito traps used by BLIM in Kotonou, Dahomey, West Africa. The latter noticed that mosquitoes were numerous in crab holes, used these as traps and burnt out the mosquitoes in them ; and then set up mosquito traps in houses, apparently with considerable success. These methods refer to the destruction of non-hibernating mosquitoes. Regarding hibernating mosquitoes, BERTARELLI (1914) pointed out the importance of destroying these ; and SCHAPIRO (see HERON, 1926) described their destruction in dwellings and stables by filling these with smoke, when the sluggish insects fly to a single spot of light deliberately produced and are killed by hand, or trapped on oiled glass. These two writers appear to have in mind the lessening of next summer's brood which such winter destruction will effect, each surviving female producing 7,500,000 descendants (EUGLING, 1921). WENYON (1921), however, wrote regarding Macedonia :

> " I call attention to the carriage of malaria by hibernating mosquitoes because of its importance in antimalarial work, for it emphasises again the advisability of destroying the hibernating female during the winter."

He points out that for hibernating *A. maculipennis* the conditions are not such as were found by PEJU and CORDIER for this mosquito in its active state :

> " As regards the hibernation of anopheles a very striking feature was their almost complete absence from uninhabited villages, though exactly similar conditions existed, apart from the presence of a population both animal and human. Even in an inhabited village the mosquitoes were more numerous in the occupied houses and barns."

(*b*) Effects of screening Houses.

The efficacy of house-screening in preventing malaria was investigated as long ago as the summer and autumn of 1899 in two experiments carried out in the intensely malarious Roman Campagna, mainly with a view to the testing of the mosquito transmission of plasmodium recently discovered by Ronald Ross. Celli (1900) reported on railway servants living in screened houses, the men on night duty being provided with bee-keepers' veils and leather gloves ; he did not neglect, he added, the blood disinfection of relapses and the killing of anopheles which gained access to the houses. From the point of view of the present survey the experiment was not, then, one in which the prevention of biting by anopheles in the house was the only factor concerned in preventing malaria.[1] In screened houses in Cervara-Salone, four of twenty-four persons fell ill with malaria ; they had been on night duty and were judged to have carelessly disobeyed instructions ; the families remained entirely free of it. In this same area twenty-four of thirty-one persons living in unscreened houses fell ill with malaria.

In the simultaneous experiment initiated and devised by Manson (1900) screening of the house, and, as an extra precaution, of the beds within it, was the only antimalarial measure used, and the question of possible relapse was eliminated, since none of those concerned had had malaria. Manson describes the experiment thus :

> "A wooden hut, constructed in England, was shipped to Italy and erected in the Roman Campagna at a spot ascertained by Dr. L. Sambon, after careful enquiry, to be intensely malarial, where the permanent inhabitants all suffer from malarial cachexia, and where the field labourers who come from healthy parts of Italy to reap the harvest, after a short time all contract fever . . . The only protection against mosquito bite and fever employed by the experimenters who occupied this hut was mosquito-netting, wire screens on doors and windows, and, by way of extra precaution, mosquito-nets around their beds. Not a grain of quinine was taken. Dr. Sambon and Dr. Low, Signor Terzi and their two Italian servants entered on residence in the hut early in July. They go about the country quite freely—always of course with an eye on *Anopheles* —during the day, but are careful to be indoors from sunset to sunrise."

That they entirely escaped malaria is a matter of history. As stated in the *British Medical Journal* for December 8th, 1900 :

> "Dr. Sambon and Dr. Low returned to England in robust health, having demonstrated in the most practical manner that, by adopting suitable precautions, it is possible to live through the malaria season in one of the worst haunts of that scourge without contracting the disease."

---

[1] For the same reason, the striking effects of Italian "bonification" are not evidential here.

Their precaution consisted in the prevention of mosquito bites while in the house, and the success of these precautions is direct and emphatic evidence of the importance of the house as the essential site where infection is acquired from at least the European anopheles.

In more recent years further light has been thrown on the effects of screening. MAXCY and ZIEGLER, BOYD, and perhaps COOGLE investigated the effects of screens of a mesh small enough merely to keep out flies.

MAXCY and ZIEGLER (1923) write of South-East Missouri, U.S.A. :

" In Table II is shown the attack rate in households with various degrees of screening, from no screening at all to a reasonably well-screened or ' *fly-proof* ' house."

" *Table II. — Malaria attack rate (based on histories) in houses well screened as compared with houses with poor or no screening.*

Screening	Number of households	Number of persons exposed	Persons per household	Number of persons attacked	Percentage of attacks
Good	112	513	4.6	45	8.8
Fair or Poor ...	147	714	4.9	111	15.6
None	144	698	4.8	127	18.2

" *Table III. — Malaria attack rate of houses of light construction as compared with houses of open frame or log construction, holding the screening factor constant.*

Screening	Malaria attack rate per thousand persons exposed	
	In houses of light construction	In houses of open frame or log construction
Good	8.6	13.6
Fair or Poor	15.3	16.4
None	21.6	16.7 "

The writers add that conclusions must take into account that " in openly constructed houses one is more likely to find the family low in the economic scale, large families living in a single room, inadequately treated when sick, poorly clothed and poorly fed—all factors tending to cause increased malarial incidence ".

The same mental reservation is desirable in weighing facts observed in Honduras and reported by DEEKS (1926).

" In Dr. CLARK's surveys of 2,607 of the native population living in unscreened quarters, 29.1 per cent were positive ; while of 135 non-immune foreigners living in screened quarters only 6.6 per cent were positive."

These people were performing their ordinary work, and the screens were presumably mosquito-proof and not merely fly-proof, as in the last-quoted case.

Boyd (1926) reports from South East Missouri, U.S.A., on 583 occupied rural dwellings with coarse screening of 12 to 14 meshes to the inch intended merely to keep out flies. The question of malaria was based on histories.

Screening	Number of houses	Population	Total cases	Cases per house	Rates per 100 residents
Tight Houses :					
Good	174	846	43	5.1	0.24
Poor.....	146	812	95	11.7	0.65
None	43	246	47	19.1	0.92
Open Houses :					
Screened	88	408	52	12.7	0.59
No Screens.....	53	258	61	23.5	1.12

Boyd adds, " These data show that [the statement that] ' no screening is better than poor screening ' is not true, but that anything which puts difficulties in the way of an anopheles is good ".

Coogle (1927) reports from Leflore County, Miss., U.S.A., that bi-monthly inspections of 104 screened and 104 unscreened houses showed an average of 2.2 *A. quadrimaculatus* per screened and one of 16.5 per unscreened house, while malaria cases in the two sets of houses were 24 and 84 respectively. In the paper in which he spoke of the " bedroom rate of anopheles ", Williams (1925) adds of the single well-screened house already mentioned :

> " The following year the owner of the screened home and two of his children came down with malaria. He stated that he had lost faith in us and our theory of malaria transmission. We searched his house immediately and found that his wife had removed the stoves from the bedrooms and had neglected to put the covers on the stove-pipe openings. We found 18 *A. quadrimaculatus* roosting in the first bedroom."

Aldershoff and Korteweg (1927) reported on an area under observation in Holland with this result :

Year	Screened Rooms		Unscreened Rooms	
	Number sleeping	Number getting malaria	Number sleeping	Number getting malaria
1924.....	2-3	3	1-3	14
1925.....	3-5	13	2-5	18
1926.....	217	4	120	16

Figure 4.
A. — Unscreened Barracks.
B. — Screened Barracks.

Experiments in which two bodies of men lived in exactly similar conditions in the notorious Mian Mir (now called Lahore Cantonment), India, except that the barracks of one were " completely mosquito-proofed " in July 1926 and the adjoining barracks were not, were reported by RUTHERFORD (1928) in a preliminary note and HANAFIN (1928). Figure 4 shows that in the first complete calendar year after proofing the percentage of those who fell ill in protected barracks was about a sixth of those in unprotected ones.

There is no question in the last case and little reasonable question in most of the others that the daily work of the two groups of persons was the same ; they differed mainly, and in the last experiment only, in that the one group was protected from mosquito bites in the house, while the other group was not. In Williams's case conditions were altered in the single particular that anopheles gained access to a house which formerly they could not enter.

All these observations afford direct evidence that the place where those concerned acquired malaria was the house or barrack where they slept, and where they lived generally when not working ; and that they at least largely escaped malaria if anopheles were prevented from biting them in the house.

(*c*) EFFECTS OF THE HOUSE SITE.

As noted in the introductory remarks, the removal of houses from near anophelene breeding-places and from the dwellings of those who are hygienically careless is the stock in trade of the hygienist reporting on the best means of preventing malaria in the more valuable and hygienically careful members of a mixed community.

It is so much a commonplace that the effects are rarely reported or are only incidentally noted. The persistent French work in Algeria, and that of the Dutch in their East Indian possessions occur at once to the mind. With unbecoming prejudice I select the following examples. Chalam (1923) made a two-years investigation under McCombie of the anophelene distribution and of anophelene malarial infection on a sugar estate in Assam, India. The only anopheles found infected was *A. listoni*, and in one part of the locality 3.8 per cent were so. It bred in a swamp and in the entering streams, and the spleen rate was 82. The average collection of *A. listoni* in houses near the swamp and stream was 6.8, in those comparatively close 4.9, and in those three-eighths of a mile to one mile away 1.6.

Christophers (1912) investigated villages and in the Andamans, Bay of Bengal. *A. ludlowi* breeding in saline swamps on the sea-coast was implicated as vector. The spleen rate in these villages averaged 32. He advised their removal to healthier sites inland, particularly Port Mouat, which had a spleen rate of 58. Covell (1926) reported: "As a result of Major Christopher's recommendations the villages of Port Mouat, Ogra Baraij and Bindraban were moved to healthier situations. The three villages are now healthy."

Malcolm Watson (1921, page 50) reports on an estate in which clearing of the virgin forest was being undertaken. As it proceeded, much of the work of the coolies was one to two miles form their lines. Accordingly, four new sets of lines were built, three about a quarter of a mile from the forest, and the other about 100 yards. The result was disastrous. The coolies were overwhelmed with malaria and soon had to be removed. They were again re-housed, this time about half-a-mile from the edge of the jungle and the fever rate became "very small and of little consequence". In this case the coolies were doing the same work in the same place throughout the time under report. Only their houses were altered in site. The fact that alteration of the site of the houses, the rest of the daily life being unaltered, determined whether the inmates suffered disastrously from or were relatively free from malaria, shows how vital is the house in the transmission of malaria.

CONCLUSIONS.

The matter may be summed up thus :

The anopheles associated by experience in the transmission of malaria are in the main house-haunters and night-biters, circumstances which make it likely that the house is important in the transmission of malaria. This likelihood is increased by the consideration that throughout that part of the world where malaria can be transmitted there are "malarious houses", houses where inhabitant after inhabitant acquires malaria. These houses have certain characteristics, at least in Europe ; they possess dark, dirty and often damp portions. In parts of Europe and in indigenous dwellings in the tropics, a chimneyless fire is efficient in driving away anopheles from places which would otherwise suit them, and it is suggested that this condition in the past must widely have influenced the incidence of malaria in Europe ; with the invention of the chimney it needed the further institution of ample lighting before houses again became distasteful to anopheles. There is slight, though disputed, evidence that *A. maculipennis* may actually breed inside houses ; it appears established that *A. stephensi* will do so in Bombay. It is the case that infected anopheles may be particularly associated with certain houses, and the question has been considered as to whether these mosquitoes have an instinct to return to a pleasant hospice after they have left it to oviposit. Such evidence as exists for an instinct of this kind is questionable ; the facts are perhaps explicable as showing a tropism towards food, and, if so, they emphasise the importance of abolishing breeding-places near houses, so that no house shall become established as a malarious one by virtue of being near enough to a breeding-place to exercise a food taxis on an infected ovipositing anopheles looking for her next meal. Certain species of anopheles leave the house where they have fed immediately after feeding, others remain in it for some hours. There is, however, at least in Europe, Northern America and Brazil, a condition of gonotropic dissociation, when the need to oviposit ceases, while the need to feed does not. Mosquitoes in this condition remain in the house where they have fed, and they are capable of becoming malarious and of transmitting malaria. There is some evidence too that anopheles may become sick of malaria, an added reason for their failure to leave the house where they became infected. The effects of æstivation in this direction are unknown. The kind of blood meal which has been consumed by anopheles caught in houses shows that they are not tied to any particular feeding-place, and an anopheles caught in a house has often had her previous meal from some animal outside it ; as to the converse, there appears to be little evidence, though that is the point which would here be important. There is no

satisfactory evidence that malaria-carrying anopheles prefer the blood of animals to that of man, or that airless animal houses near human habitations necessarily protect man from the bites of anopheles and so from malaria. It is suggested by inference that to house man well is likely to prove a better anti-malarial measure than to house animals badly. There appears a tendency to forget that in the early days of the construction of the Panama Canal, the destruction of replete anopheles in houses was held with good reason by those concerned, from Surgeon-General GORGAS downwards, to have proved a most effective antimalarial measure ; for hibernating mosquitoes this measure has been as emphatically advised ; the success attending the application of these measures stresses the connection between the house and malaria. The value of the screening of houses was established once and for all by the experiment designed by Sir Patrick MANSON in the Roman Campagna to test his mosquito-malaria theory in 1900. Its success showed that, if anopheles were prevented from entering houses, malaria could be avoided ; the work of others has since shown that even imperfect screening is of value in this direction. These experiments are all evidence that it is in the house that malarial infection is essentially obtained. The relationship of house sites be anopheles breeding-places, the manner in which malarial infection can be fostered or hindered by housing men near to or far from such breeding-places is again evidence in the same direction.

These various lines of investigation press with cumulative force the conclusion that the house is a factor of primary importance in the acquisition and spread of malaria.

REFERENCES

TO LITERATURE QUOTED IN "HOUSING AND MALARIA"

(A Critical Summary of Literature)

by Lt.-Col. CLAYTON-LANE, M.D., I.M.S.

ADDY, Sydney, O. 1898. Evolution of the English House. Swan, Sonnenschein & Co., London.

ALCOCK, A. 1925. The Anopheles Mosquito in England. *Lancet* II, 34, 4 July.

ALDERSHOFF, H. KORTEWEG, P. C. 1927. Malaria commissie voor Noord-Holland. Jaarverslag der Wetenschappelijke Malaria-Commissie voor Noord-Holland voor 1926.

BAHR, P. H. 1912. Filariasis and Elephantiasis in Fiji. Supplement N° 1, *Jl. London School Trop. Med.*

BERTARELLI, E. 1914. Wenig erörterte Fragen aus dem Gebiete des Malariaschutzes und der Lehre von der Malaria. *Centralb. f. Bakt.* 1 Abt. Referate 60, 289.

BLACKLOCK, B., and CARTER, Henry F. 1920. Observations on *Anophelis* (*Cœlodiazesis*) *plumbeus* Stephens, with Special Reference to its Breeding-places, occurrence in the Liverpool District, and Possible Connection with the Spread of Malaria. *Ann. Trop. Med. Parasit.* 13, 421.

BOYD, Mark, F. 1926. The Influence of Obstacles unconsciously erected against Anophelines (Housing and Screening) upon the Incidence of Malaria. *Amer. Jl. Trop. Med.* 6, 157.

BOYD, Mark F., and ARIS, F. W. 1929. A Malaria Survey of the Island of Jamaica, B.W.I. *Amer. Jl. Trop. Med.* 9, 309.

BOYD, Mark F., and WEATHERSBEE, Albert, A. 1929. Studies on the Bionomics of North-American Anophelines. V. — Winter Activities of Anopheline imagines in Coastal North Carolina (36° N. Lat.) *Amer. Jl. Hyg.*, 9, 682.

CARTER, Henry F. 1927. Report on Malaria and Anopheline Mosquitoes in Ceylon. *Ceylon, Sessional Paper VII ;* March, Colombo.

CAZENEUVE, H. V. 1920. Le paludisme indigène de Lanester près de Lorient. *Bull. Soc. Path. Exot.* 13, 461.

CELLI, A. 1900. Die neue Prophylaxis der Malaria im Latium. *Cent. f. Bakt. Abt.* I. 28, 696.

CHAGAS, C. 1926. Quelques aspects de l'épidémiologie de la malaria. Nouvelles indications prophylactiques. League of Nations, C. H. Malaria 42, March 16th.

CHALAM, B. S. 1923. Some Notes on a Malaria Investigation on a Sugar Estate in Kamrup, Assam. *Indian Med. Gaz.* 58, 476.

CHRISTIE, Ethel M. 1924. An Account of the Malaria Work done in Buzuluk Ooyezd by the Society of Friends. *Jl. Trop. Med. Hyg.* 27, 107.

CHRISTOPHERS, S. R. 1912. Malaria in the Andamans. Sci. Mem. Off. Med. San. Dept., Govt. of India. Scipt. Govt. Printing, India ; Calcutta.

GOOGLE, C. P. 1927. Preliminary Report of Screening Studies in Leflore County, Miss. *Public Health Rep.* 42, 1101.

COVELL, G. 1927. Report of an Enquiry into Malarial Conditions in the Andamans. Govt. of India Press, Delhi.

DARLING, S. I. 1910. Factors in the Transmission and Prevention of Malaria in the Panama Canal Zone. *Ann. Trop. Med. Parasit.* 4, 218.

DAVIS, Nelson C., and SHANNON, Raymond, C. 1928. The Blood-feeding Habits of *Anopheles pseudo-punctipennis* in Northern Argentina. *Amer. Jl. Trop. Med.* 8, 443.

DEEKS, William E.
1926. Some Aspects of Malaria Control.
Jl. Trop. Med. Hyg. 29, 185.

ESSED, W. F. R.
1925. Malaria at Tandjong Pinang.
Meded. Dienst. d. Volksgezondheis in Nederl. Indie. Pt. 3, p. 301.

EUGLING, Max
1921. Ueber Malaria Bekämpfung : Beobachtungen und Untersuchungen aus dem albanischen Malaria-Gebiet.
Arch. f. Schiffs- u. Trop. Hyg. 25 bei H. 1, 5.

FALCONI, Domenico
1913. Sulla localizzazione della malaria alle abitazioni.
Policl. Sez. pract. 20, 1119.

FRICKS, L. D.
1920. Emergency Measure and Foresight in Malaria Control.
Military Surg. 47, 224.

FROSCH, P.
1903. Die Malaria Bekämpfung in Brioni (Istrien).
Zeitschr. Hyg. Infectionskr. 43, 37.

FRY, A. B.
1922. The Rôle of Cattle in the Epidemiology of Malaria.
Indian Med. Gaz. 57, 1.

GARNHAM, P. C. C.
1929. Malaria in Kisumu, Kenya Colony.
Jl. Trop. Med. Hyg. 32, 207 and 221.

GEIGER, J. G., PURDY, W. C., and TARBETT, R. E.
1919. Control in a Ricefield District.
Jl. Amer. Med. Ass. 72, 844.

GORGAS, William Crawford
1915. Sanitation in Panama.
D. Appleton & Co., New York and London.

HAIGH, W. E.
1925. Malaria in Albania.
League of Nations. Health Organisation C. H. 272.

HANAFIN, J. B.
1928. Further Results in Mosquito-proofing Barracks.
Jl. Roy Army Med. Corps. 51, 127.

HECKENROTH, F.
1923. Mesures capables d'enrayer le paludisme à Dakar.
Bull. Soc. Path. Exot. 15, 1024.

HERON, G. W. 1926. Proceedings of the Twelfth Meeting of the Anti-malarial Advisory Commission, Jerusalem, May 27th, 1926. Manuscript abstracted in *Trop. Dis. Bull.* 23, 832.

HEYDON, G. A. M. 1923. Malaria at Rabaul. *Med. Jl. Australia*, Year 10, Vol. 2, p. 625.

IOFF, I. G. 1926. Comment in *Tropical Dis. Bull.* 23, 138.

JAMES, S. P. 1919 *a*. Malaria contracted in England. *Trans. Soc. Trop. Med. Hyg.* 12, 37.

JAMES, S. P. 1919 *b*. Risks of the Spread of Malaria in relation to Demobilisation. *Reports to the Local Government Board on Public Health and Medical Subjects.* (New series N° 123) *Reports and papers on malaria contracted in England in 1918.*

JAMES, S. P. 1920 *a*. Malaria at Home and Abroad. London.

JAMES, S. P. 1920 *b*. The Risk of the Spread of Malaria in England and the measures necessary to prevent it. *Proceedings Clin. and Scient. Meeting British Medical Association*, p. 254.

JAMES, S. P. 1926. Epidemiological Results of a Laboratory Study of Malaria in England. *Trans. Roy. Soc. Trop. Med. and Hygiene*, 20, 143.

JAMES, S. P. 1927. Communication presented at the October Session of the Malaria Commission of the Health Section of the League of Nations.

JAMES, S. P. 1929 *a*. Remarks on Malaria in Kenya. *Kenya and E. Afr. Med. Jl.* 6, 92.

JAMES, S. P. 1929 *b*. The Disappearance of Malaria from England. *Proc. E. Soc. Med.* 23, 71, (Sect. Epidem. and State Med. p. 1) ; Novemb.

KING, W. V., and BULL, Carroll G. 1923. The Blood-feeding Habits of Malaria-carrying Mosquitoes. *Amer. Jl. Hyg.* 3, 497.

KLIGLER, I. J. 1925. Trans. Fifth Conference of Malaria Field Workers. *Public Health Bull.* Nº 156.

KLIGLER, I. J. LIEBMAN, E. 1928. Studies on Malaria in an Uncontrolled Hyperendemic Area (Hule, Palestine). II. Changes in the Resting-places of Anopheles with Special Reference to Infected Mosquitoes. *Jl. Prev. Med.* 2, 433.

KÜLZ, Dr. 1909. Moskitobekämpfung der Franzosen in West-Afrika durch die Methode der « trous-pièges ». *Arch. f. Schiffs- u. Trop. Hyg.* 13, 645.

LE PRINCE, J. A. 1926. Destroying engorged Anopheles as a Malaria Control Measure. *Public. Health Rep.* 41, 1220.

LE PRINCE, J. A., and GRIFFITHS, I. H. D. 1917. Flight of Mosquitoes. Studies on the Distance of Flight of *Anopheles quadrimaculatus*. *Public Health Rep.* 32, 856.

LE PRINCE, J. A., and ORENSTEIN, A. J. 1916. Mosquito Control in Panama. G. P. Putnam's Sons ; New York & London.

LESLIE, J. T. W. 1909. Malaria in India. *Lancet*, vol. II, p. 1484.

MACARTHUR, W. P. 1929. The Adult Mosquitoes of Shanghai. *Jl. Roy. Army Med. Corps.* 52, 241.

MACGREGOR, Malcolm E. 1927. Mosquito Surveys. A Handbook for Anti-malarial and Anti-mosquito Field Workers. Baillière Tindale & Co. London.

MACKENZIE, Melville D. 1923. Notes on the Epidemiology of Malaria in Russia. *Lancet* II. 1227. 8th Dec.

MANALANG, C. 1928. Notes on Malaria Transmission. *Philippine Jl. Sci.* 37. 123.

MANSON, Patrick. 1900. Experimental Proof of the Mosquito-malaria Theory. *Lancet,* II, 923. and *Brit. Med. Jl.* II. 949.

MAXCY, K. F., and ZIEGLER, M. V. 1923. The malaria problem in South-East Missouri. *Public Health Rep.* 38, 233.

MISSIROLI, A. M., and HACKETT, L. W. 1930. Field Studies on the Cause of the Natural disappearance of Malaria in Certain Regions of Europe. Second International Malaria Congress, Algiers.

MÜHLENS, P. 1902. Beiträge zur Frage der gegenwärtigen Verbreitung der Malaria in Nordwestdeutschland. *Deut. Med. Woche,* 28, 589.

MÜHLENS, P., und SFARCIC, A. 1925. Bericht über Malariaarbeiten in Dalmatien. *Cent. f. Bakt.* 1 Abt. Orig. 94, 326.

PEJU, G., et CORDIER, E. 1919. Epidémie palustre et conditions de l'anophélisme en Argonne. *C. R. Société Biol.* 81. 1039.

ROSS, Ronald 1911. The Prevention of Malaria. John Murray, London.

ROUBAUD, E. 1919. Antagonisme du bétail et de l'homme dans la nutrition sanguine de l'*Anopheles maculipennis.* Le rôle antipaludique du bétail domestique. *C. R. Acad. Sci.* 169. 483.

ROUBAUD, E. et LÉGER, M. 1921. Observations sur le paludisme en Corse (mars-avril 1921). *Bull. Soc. Path. Exot.* 14, 340.

RUTHERFORD, N. J. C. 1928. Mosquito-proofing of Barracks of British Troops in India. *Jl. Roy. Army Med. Corps.* 50, 316.

SCHOO, J. H. M. 1905. Malaria in Noord-Holland. Bohn, Haarlem.

SCHÜFFNER, W., and HYLKEMA, B. 1922. Malaria in Belawan during the Construction of the Ocean-harbour. *Meded. Burgerlijk Geneesk. Dienst in Nederl. Indie* (Foreign Edition) Pt. 1, p. 47.

Schüffner, W., Swellengrebel, N. H., Swellengrebel de Graaf, J. M. H., and Mochtar, A. 1919. On the Biology of M. Lludlowi in Sumatra. *Meded. Burgerlijk. Geneesk. Dienst in Nederl. Indie,* N° 3, p. 65.

Sergent, Ed. et Sergent, Et. 1921. Etudes épidémiologiques et prophylactiques du paludisme (dix-septième, dix-huitième et dix-neuvième campagnes en Algérie, en 1918, 1919 et 1920). *Ann. Inst. Pasteur,* 35, 801.

Sergent, Ed. Sergent, Et., Parrot, L., Foley, H., Senevet, G. et Catanei, A. 1924. Etudes épidémiologiques et prophylactiques du paludisme (vingtième, vingt et unième et vingt-deuxième campagnes en Algérie en 1921, 1922 et 1923). *Ann. Inst. Pasteur,* 38, 775.

Stephens, J. W. W. 1921. Malaria on a Venezuelan Oilfield. *Ann. Trop. Med. Parasit.* 15, 435.

Strachan, Henry 1904. Discussion on the Prophylaxis of Malaria. *Brit. Med. Jl.* II. 637, 17th Sept.

Swellengrebel, N. H. 1925. Le paludisme aux Pays-Bas.

Swellengrebel, N. H. 1929. La dissociation des fonctions sexuelles et nutritives (dissociation gono-tropique) d'*Anopheles maculipennis,* comme cause du paludisme dans les Pays-Bas, et ses rapports avec l'« infection domiciliaire ». *Ann. Inst. Pasteur* 43, 1370.

Swellengrebel, N. H., Schüffner, W., and Swellengrebel de Graaf, J. M. H. 1919. The Susceptibility of Anophelines to Malarial Infection in Netherlands India. *Meded. Burgerlijk. Geneesk. to Nederl. Indie,* N° 3, p. 1.

Symes, C. B. 1926. The Mosquito Problem in Kenya. *Kenya Med. Jl.* 3, 93.

Testi. 1919. Malaria : Risk of Development of Indigenous Foci. Discussion at the fifth meeting of the Fourth Plenary Session of the Sanitary Conference of the Allied Powers held in Paris.

THOMSON, J. G.
1929. Endemic and Epidemic Malaria in Southern Rhodesia.
Proceeding Roy. Soc. Med. 22, 1051.

WALCH, E. W., and SARDJITO, M.
1928. Identification of the Blood-meal of Netherlands Indian Anopheles by means of the Precipitin Test. (First Report).
Meded. Dienst. d. Volksgezondheit in Nederl. Indie, 17, part. 2, 234.

WALCH, E., and WALCH-SORGDRAGER, B.
1921. Een Malaria-Epidemie veroorzaakt door M. sinensis. (In Dutch and English.)
Meded. Burgerlijk, Geneesk Dienst in Nederl. Indie. Pt. 1, p. 2.

WATSON, Malcolm.
1921. The Prevention of Malaria in the Federated Malay States. Second Edition.
John Murray, London.

WENYON, C. B.
1921. The Incidence and Ætiology of Malaria in Macedonia.
Jl. Roy. Army Med. Corps. 37, 172.

WESENBERG-LUND, C.
1920-21. Contributions to the Biology of the Danish Culicidae.
Mém. Acad. R. Sciences et Lettres Danemark (Sect. des Sci.). 8th Series, 7, 1.

WILLIAMS, 1925. Trans. of the Fifth Conference of Malaria Field Workers.
Public Health Bull. 156.

Authorised Agents for the Publications of the League of Nations

ARGENTINE
Librería "El Ateneo", calle Florida 371, BUENOS AIRES.

AUSTRALIA (Commonwealth of)
H. A. Goddard, Ltd., 255A, George Street, SYDNEY.

AUSTRIA
Manz'sche Verlags- und Universitätsbuchhandlung, Kohlmarkt, 20, VIENNA I.

BELGIUM
Agence Dechenne, Messageries de la Presse S.A., 18-20, rue du Persil, BRUSSELS.
Albert Dewit, Rue Royale, 53, BRUSSELS.

BRAZIL
Livraria Vieira Souto, Praça Mauá 7, Sala 620, RIO DE JANEIRO.

BULGARIA
Librairie Française et Etrangère, J. Carasso & Cie, Bd. "Tsar Osvoboditel", No. 8, SOFIA.

CANADA
League of Nations Society in Canada, 389, Wellington Street, OTTAWA.

CHILE
Carlos Niemeyer, Librería Universal, Cas. 293, VALPARAISO.

CHINA
Commercial Press Ltd., 26A, Paoshan Road, SHANGHAI.

CZECHOSLOVAKIA
Librairie F. Topic, 11, Narodni, PRAGUE.

DANZIG (Free City of)
Georg Stilke, Buchhandlung, Langgasse, 27, DANZIG.

DENMARK
Levin & Munksgaard, Publishers, Norregade, 6, COPENHAGEN.

DUTCH EAST INDIES
Algemeene Boekhandel G. Kolff & Co., BATAVIA-WELTEVREDEN.

ECUADOR
Victor Janer, GUAYAQUIL.

ESTONIA
J. G. Krüger, Akt.-Ges., 11, Rüütli t., TARTU.

FINLAND
Akateeminen Kirjakauppa, HELSINKI.

FRANCE
Librairie universitaire J. Gamber S. A., 7, rue Danton, PARIS (VIe).

GERMANY
Carl Heymanns Verlag, Mauerstrasse 44, BERLIN, W. 8.

GREAT BRITAIN, NORTHERN IRELAND and the CROWN COLONIES
George Allen & Unwin, Ltd., 38, Gt. Ormond Street, LONDON, W.C. 1.

GREECE
"Eleftheroudakis", Librairie Internationale, Place de la Constitution, ATHENS.

HAITI
Librairie-Papeterie Mme. D. Viard, Angle des rues du Centre et des Casernes, PORT-AU-PRINCE.

HUNGARY
Librairie Grill, Dorottya utca 2, BUDAPEST.

ICELAND
Peter Halldorsson, REYKJAVIK.

INDIA
The Book Company, Ltd., College Square 4/4 A, CALCUTTA.

IRISH FREE STATE
Eason & Son, Ltd., 79-82 Middle Abbey Street, DUBLIN.

ITALY
Anonima Libraria Italiana, Direzione Generale, Via Palermo, 12, MILAN. Branches: FLORENCE, GENOA, NAPLES, PADUA, PALERMO, PAVIA, ROME, TRIESTE, TURIN.

JAPAN
League of Nations Tokio Office, Marunouchi-C.-13, TOKIO.
Maruzen Co., Ltd. (Maruzen-Kabushiki-Kaisha), 6, Nihonbashi Tori-Nichome, TOKIO.

LATVIA
Latvijas Telegrafa Agentura, K. Barona Iela, 4, RIGA.

LITHUANIA
Librairie de la Société Lithuano-Française, Laisvés Aleja, 22, KAUNAS.

LUXEMBURG (G.-D.)
Librairie J. Heintzé, M. Hagen, Successeur, Place Guillaume, 8, LUXEMBURG.

NETHERLANDS
Martinus Nijhoff, Boekhandelaar - Uitgever, Lange Voorhout, 9, THE HAGUE.

NEW ZEALAND
The Clarté Bookshop, Walter Nash, 126, Vivian Street, P.O. Box 310, WELLINGTON.

NORWAY
Olaf Norli, Universitetsgaten, 24, OSLO.

PARAGUAY
Librería Internaclonal Santiago Puigbonet, Casilla de Correo 581, ASUNCIÓN.

POLAND
Gebethner & Wolff, ulica Zgoda 12, WARSAW.

PORTUGAL
J. Rodrigues & Ca., Rua Aurea, 186-188, LISBON.

ROUMANIA
"Cartea Românească", 3-5, Boul. Academiei, BUCHAREST I.

SAAR BASIN
Gebr. Hofer A.-G., Sortimentsabteilung, SAARBRUCK.

SOUTH AFRICA (Union of)
Maskew Miller, Ltd., 29, Adderley Street, CAPE TOWN.

SPAIN
Centro Editorial "Minerva", Apartado 555, Tudescos 39-41, MADRID, E. 12.

SWEDEN
C. E. Fritze, Hofbokhandel, Fredsgatan 2, STOCKHOLM.

SWITZERLAND
Librairie Payot & Cie., GENEVA, LAUSANNE, VEVEY, MONTREUX, NEUCHATEL, BERNE, BASLE.
Librairie Dr. H. Girsberger & Cie, Kirchgasse 17, ZURICH.

TURKEY
Librairie Anadolou Méarif, Boîte postale 45, ANKARA.

UNITED STATES OF AMERICA
World Peace Foundation, 40, Mt. Vernon Street, BOSTON, 9, Mass.

YUGOSLAVIA (Kingdom of)
Librairie Internationale François Bach, 8, rue Knez Mihailova, BELGRADE.
Librairie de l'Université et de l'Académie Yougoslave, St. Kugli, Ilica 30, ZAGREB.
Knjigarna "Schwentner", Presernova ulica, LJUBLJANA.

For other countries, apply :

Publications Department of the League of Nations, Geneva (Switzerland).

(Complete catalogue sent free on application)