MALARIA IN ENGLAND

WITH SPECIAL REFERENCE TO THE RÔLE OF TEMPERATURE AND HUMIDITY.

By Brevet Lieut.-Colonel C. A. GILL, I.M.S., D.P.H., D.T.M. & H.
Chief Malaria Medical Officer, Punjab.

(With one Map.)

CONTENTS.

I. PRELIMINARY CONSIDERATIONS.

The writer has recently been engaged in India in the study of the part played by meteorology in malaria and in a forthcoming paper a detailed account of the investigation, so far as it has at present gone, is recorded[1].

This communication is solely concerned with the application to English conditions of the following conclusions which are thought to throw light on the malaria problem in England.

(1) Meteorological factors, more particularly the temperature and humidity factors, play an important part in malaria since they are largely concerned in determining the conditions necessary for the transmission of infection.

(2) In any attempt to determine the influence of either temperature or humidity in malaria it is necessary to take into account both the temperature and the humidity factors.

(3) The transmission of malaria in India is mainly confined to periods when the temperature and humidity factors are above a definite height, the lower limits of which are approximately represented by a monthly mean temperature of 61° F. and a monthly mean relative humidity of 63 per cent. (as measured at 8 a.m.).

(4) When both factors are above the "critical" figure a period of potential infection occurs and when either factor is below the "critical" figure a period of interrupted infection supervenes.

(5) Provided both factors are above the "critical" figure, a high mean temperature and a high mean humidity are more favourable to the transmission of malaria than a low mean temperature and a low mean humidity.

[1] Gill, C. A. (x. 1920), The Rôle of Meteorology in Malaria, *Indian Journ. Med. Research.*

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It was also pointed out that in Northern India, where the mean temperature during the greater portion of the year is uniformly above 61° F., the humidity factor, by reason of its marked seasonal variability, exercises a predominant part in determining the season of the year and the duration of the period during which the transmission of infection may take place.

In temperate climates, on the other hand, where a high degree of atmospheric humidity more constantly prevails and where the mean temperature during the hottest months is in the vicinity of the "critical" temperature (61° F.), it was surmised that the temperature factor would be likely to be of major importance in determining the occurrence of periods of potential infection.

In these circumstances it was decided to examine the temperature and humidity conditions prevailing in the United Kingdom with a view to ascertaining whether they confirmed or rebutted the conclusions detailed in the above summary.

As the result of applying this test has afforded evidence suggesting that the temperature and humidity factors play an important part in determining the incidence and distribution of indigenous malaria in England, and that by taking into account the influence exerted by these factors some obscure points in the endemiology of malaria may be explained, it has been thought expedient to consider the subject in some detail.

I desire to take this opportunity of recording my gratitude to the Hon. Major-General W. R. Edwards, C.B., C.M.G., M.D., Director-General, Indian Medical Service, for permitting the publication of this note in England, and also for the encouragement which his interest in the main investigation has occasioned.

II. THE SEASONAL INCIDENCE OF ENDEMIC MALARIA IN ENGLAND.

The first point it was sought to determine has reference to the season of the year in which it is held that meteorological circumstances in the United Kingdom permit of *infection* taking place, which, of course, must be clearly distinguished from the season of the year in which *attacks* of malaria may occur.

Applying to the United Kingdom the conclusion that a mean monthly temperature of not less than 61° F. approximately represents the lower limit of temperature necessary to create a period of potential infection, it is found from a scrutiny of *The Book of Normals*[1] that in respect of the 164 recording stations in the United Kingdom (Scilly and the Channel Islands being excluded), the mean monthly temperature in no part of the kingdom reaches 61° F. except during the months of July and August. There is one exception to this rule, viz. Camden Square, London, N.W., where the mean temperature in June is 61° F. (It is however stated that the thermometer at Camden Square

[1] *The Book of Normals of Meteorological Elements for the British Isles for periods ending* 1915. The Meteorological Office, Kingsway, London, W.C.

is not kept, as elsewhere, in a Stevenson screen and it is thus not protected from indirect radiation.)

A further analysis of the temperature conditions in July and August shows that as a general rule, to which there are a few exceptions, the mean temperature is slightly higher in July than in August. It is also clear that these two months are appreciably hotter than any others, so that under normal conditions it would not be anticipated that the temperature factor would be suitable to the transmission of infection during any other month in the year.

In view of this conclusion, it is of interest to note, in the Reports on Malaria, published by the Local Government Board and the Ministry of Health[1], that the majority of the indigenous cases of malaria recently reported in England have been considered, on clinical and epidemiological grounds, to have been acquired during the months of July or August. A certain number of primary attacks have been attributed to infections acquired in the spring, but it is for consideration whether these cases are not examples, as some authorities are inclined to think, of the tardy appearance of infections acquired in the previous year.

In regard to relative humidity the mean figures for a large number of areas are not available, but I have been referred by the Director of the Meteorological Office, to a paper by W. F. Stacey (1915)[2], from which it appears that the monthly mean relative humidity (at 9 a.m.) in 91 recording stations during the period 1901–1910 never falls below 70 per cent. during any month of the year.

In connexion with the use of monthly mean figures of meteorological elements for the purpose of determining periods of potential infection it is necessary to emphasise certain points.

In the first place it is possible that the meteorological data may not accurately reflect the climatic conditions in every part in each meteorological area, nevertheless, until the contrary be proved, it seems permissible to assume that they do.

Secondly, it is recognised that monthly mean figures do not form entirely satisfactory data, since they fail to take into account the conditions prevailing in exceptional years, whilst they may refer to widely different conditions.

Monthly mean figures therefore form no substitute for, and do not *necessarily* give any indication concerning, the actual conditions of temperature and humidity associated with the transmission of malaria in England, but until the latter have been determined it is thought that the monthly mean figures may be made to serve a useful purpose.

[1] James, S. P., Reports and Papers on Malaria contracted in England in 1918, *Report to the Local Government Board on Public Health and Medical Subjects*, New Series, No. 123. See also *Malaria at Home and Abroad* by the same author. John Bale, Sons and Danielsson, Ltd. London 1920.

[2] Stacey, W. F. (I. 1915), Distribution of Relative Humidity in England and Wales, *Quart. Journ. Royal Meteorol. Soc.* XLI, No. 173.

The following conclusions are drawn in regard to the influence of temperature and humidity on the seasonal incidence of malarial infection in the United Kingdom:

1. Relative humidity being at all times favourable plays little or no part in determining the seasonal incidence of malarial infection in England.

2. The temperature factor exercises an important rôle since it limits the period during which malaria may ordinarily be acquired in the United Kingdom to the months of July and August.

III. THE RECENT DISTRIBUTION OF ENDEMIC MALARIA IN ENGLAND.

It necessarily follows from the part attributed to meteorological factors in determining the required conditions for the transmission of malaria that the distribution of the endemic centres of malaria in the United Kingdom should conform to these conditions, and that, for reasons already stated, a predominant influence should be exerted by the temperature factor.

In order to test the accuracy of this view the accompanying Map 1 has been prepared in accordance with the following plan:

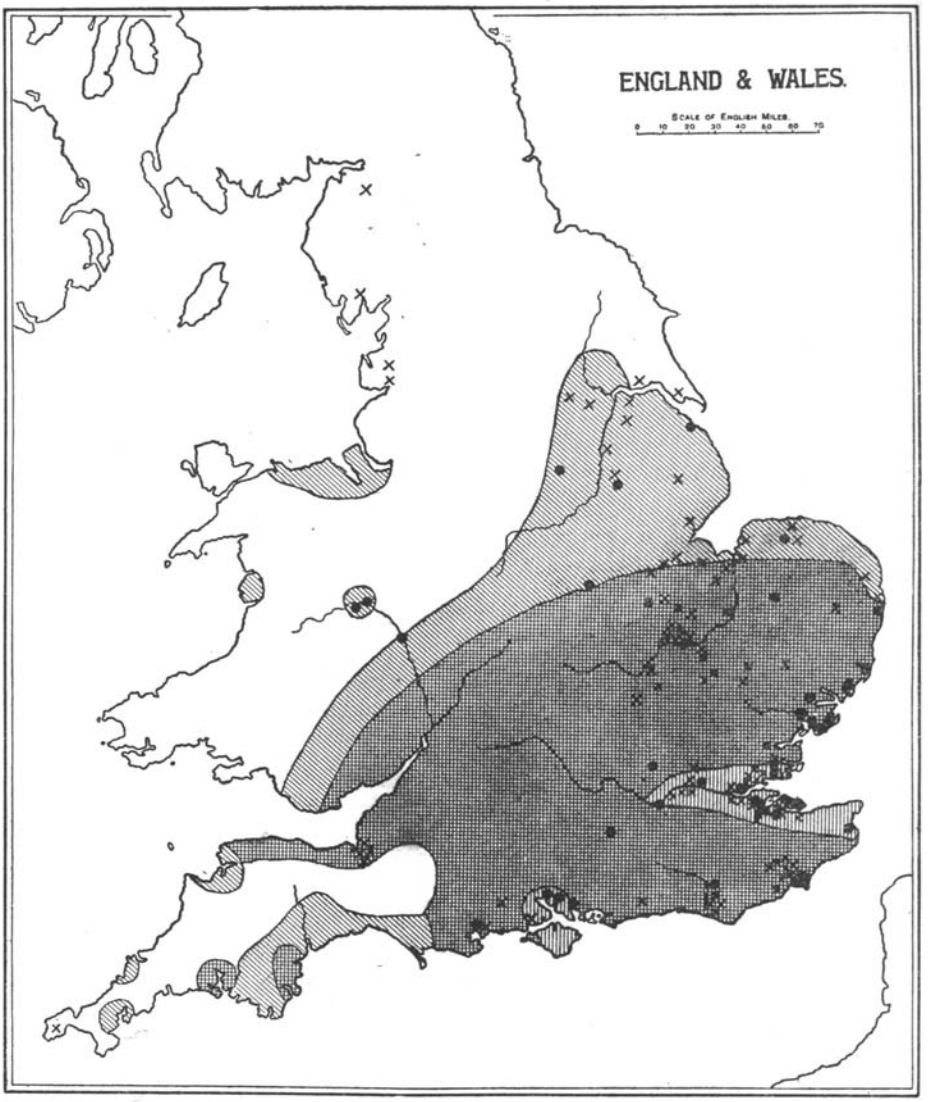
Areas	Mean temperature in areas during July and August	Shown in map
1	62° F. or over	Shaded vertically
2	61–62° F.	Stippled
3	60–61° F.	Shaded obliquely
4	Under 60° F.	Blank

It will be seen that the distribution of temperature during the hottest months in the year (as measured by monthly mean temperature) is in some respects peculiar, and differs from the distribution which on general grounds might have been anticipated.

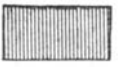
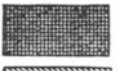
The area showing a mean temperature during July and August of 62° F. or over, which is extremely small in size, comprises a strip of country in Essex and Kent on each side of the estuary of the Thames and the lower portion of the Thames valley. *Area* 1 also includes a strip of country in the south of Hampshire in the vicinity of the New Forest together with the eastern portion of the Isle of Wight. The towns of Brighton and Clifton also belong to Area 1.

Area 2, which is much larger than Area 1, is bounded on the south by the coast-line from the vicinity of Dover to the west of Bournemouth, whilst its northern boundary is formed by a line which runs more or less obliquely across England from a point on the east coast of Norfolk to the Bristol Channel in the vicinity of Cardiff.

Its western boundary is formed by a line which first runs due north from the vicinity of Bournemouth, and then turns west and running parallel to the Bristol Channel, ends on the coast in the neighbourhood of Ilfracombe. Small areas surrounding Torquay, Teignmouth and Plymouth also belong to Area 2.



Explanation.

Zone with mean temperature in July—August
- over 62° F. = 
- 61° F.—62° F. = 
- 60° F.—61° F. = 
- under 60° F. = unshaded

Ancient distribution of endemic malaria = ×

Recent distribution (1917—1919) of endemic malaria = •

NOTE:—A case of malignant tertian malaria believed to have been contracted at Liverpool was reported in *The British Medical Journal*, Nov. 27, 1920. The patient—a girl of 18 years of age—was born in Liverpool and lived there for 10 years, but it is not clear where she lived during the remaining eight years nor whether she always resided in Liverpool during July and August. The proximity of Liverpool to Area 3 may also be noted.

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Area 3 consists of a strip of country lying to the north of and parallel to Area 2 except in the east, where its northern boundary diverges so as to include an area in the south of Yorkshire. The estuary of the Dee and a small area along the north coast of Wales also belong to this area, whilst in England an area around Shrewsbury, the south coast of Devon and three small coastal areas in Cornwall all belong to Area 3.

Area 4. The rest of England and Wales, with the exception of the city of Manchester and the town of Aberdovey in Wales, the whole of Scotland and the whole of Ireland (excluding the city of Dublin) all belong to Area 4, in which the mean monthly temperature during July and August—the hottest months—never normally reaches 60° F.

It is now necessary to determine the relationship of these four areas to the present-day distribution of endemic foci of malaria.

From the reports issued by the Local Government Board—now the Ministry of Health—it appears that during the period 1917–1918 382 indigenous cases of malaria were discovered in 27 different localities in the United Kingdom. Lieut.-Colonel S. P. James, M.D., I.M.S. of the Ministry of Health, has kindly supplied me with the figures for the year 1919 during which 92 additional cases were discovered amongst the civil population and 13 fresh endemic foci. Reliable figures are therefore available regarding 40 endemic foci and 404 indigenous cases of malaria.

If the localities and the number of cases occurring in each be allotted to their respective areas (see Map, p. 324) the result shown in Table 1 is obtained.

Table 1.

The Distribution of Endemic Malaria in the United Kingdom by Areas.

Area	County	Place	No. of Cases	Remarks
Area 1	Kent	Sheppey and *Sheerness**	172	Sea-level (approx.).
		Isle of Grain	59	,, ,,
		Sandwich	78	7 feet
		Queenborough	23	Sea-level (approx)
		Chatham	2	8 feet
		Sittingbourne	3	4 feet
		Iwade	1	32 feet
		Minster	1	Sea-level (approx.)
	Essex	*Tilbury*	3	Sea-level (approx.)
		Purfleet	1	31 feet
	Middlesex	Walton on Thames	2	40 feet
	Hampshire	*Portsmouth*	1	Sea-level (approx.)
		Southampton	1	,, ,,
		Emsworth	1	,, ,,
Area 2	Essex	*Bournes Green*	2	90 feet
		Walton on Naze	7	Sea-level (approx.)
		Dovercourt	6	10 feet
		Shotley	1	Sea-level (approx.)
		Brightlingsea	1	84 feet
		Colchester	2	82 feet, R. Colne

* Localities italicised are situated on the coast.

Table 1—*contd.*

Area	County	Place	No. of Cases	Remarks
Area 2	Suffolk	*Felixstowe*	2	Sea-level (approx.)
		Bawdsey	3	,, ,,
		Southwold	1	,, ,,
	Norfolk	Thetford	2	35 feet, R. Little Ouse
	Huntingdon	St Ives	1	27 feet, R. Ouse
		Fletton	1	27 feet, R. Nen
	Hertford	London Colney	1	225 feet, R. Colne
	Kent	Lydd	3	10 feet
	Sussex	Uckfield	1	43 feet, R. Ouse, Sussex
	Hampshire	Aldershot	9	256 feet
	Dorset	*Parkstone*	1	Sea-level (approx.)
Area 3	Shropshire	Shrewsbury	1	193 feet, R. Severn
		Atcham	1	149 feet, R. Severn
		Coalport	3	200 feet, R. Severn
	Leicester	Leicester	1	200 feet
	Norfolk	Fakenham	2	115 feet, R. Wensum
	Lincoln	Grantham	2	162 feet, R. Witham
		Tetney Lock	1	Sea-level (approx.)
	Nottingham	Chilwell	1	18 feet
Area 4	—	—	—	—

A summary of the above figures gives the result shown in the following table.

Table 2.

	Endemic localities		Cases of malaria	
Areas	Actual	Percentage	Actual	Percentage
Area 1	14	40·0	350	86·6
Area 2	17	40·0	42	10·4
Area 3	8	20·0	12	3·0
Area 4	0	0·0	0	0·0
Total	39	100·0	404	100·0

It is thus seen that 40 per cent. of the endemic localities and no less than 86 per cent. of the cases are included in the extremely small zone in which the mean temperature during July and August—the hottest months—is over 62° F., while 40 per cent. are scattered in a much larger area in which the mean July-August temperature is between 61° F.–62° F.

There are eight localities in the zone exhibiting a mean temperature during July and August of 60° F.–61° F., whilst no endemic localities exist in the rest of the United Kingdom, in which the mean temperature during the hottest months (July–August) is below 60° F.

A consideration of the distribution of mean temperature in the United Kingdom therefore appears to suggest that the temperature factor may play an important part in determining the distribution and incidence of endemic malaria in this country.

But the temperature factor alone does not afford an explanation of the peculiar distribution of the endemic localities *within the above zones* and it

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is thought that by taking into account the humidity conditions some light may be thrown on this point.

Mr Stacey shows (*loc. cit.*) that whilst at no season of the year does the mean monthly relative humidity (as measured at 9 a.m.) fall below 70 per cent., the areas showing the *lowest* mean relative humidity in July and August correspond approximately with the areas exhibiting the *highest* mean temperature.

It is clear therefore that little or no relationship exists between the areas showing relatively high degrees of humidity during the summer and the geographical distribution of endemic malaria; but this lack of correlation would be anticipated, since in many of the areas exhibiting relatively high degrees of humidity, the temperature factor is not favourable to the transmission of malaria.

It is clearly necessary to consider the distribution of the endemic centres *within the area exhibiting a suitable mean temperature* in relation to their mean relative humidity.

Unfortunately so little is known in regard to relative humidity that no precise indications of its distribution can be given, but some conclusions can be reached as the result of a consideration of the following circumstances. In the first place it may be assumed that the atmosphere in low-lying areas, if the latter are situated on the sea-coast or in badly drained riverain tracts, in addition to being relatively warm, will also be relatively humid. Secondly, Mr Stacey gives as one of his four general conclusions that "In summer the air over the interior of the country (England and Wales) is drier than over the coastal regions."

It will be seen from Table 1 (pp. 325, 326) that, of the 39 endemic localities in England, 17 are situated on the coast (names italicised in the Table), whilst, if those which are less than 100 feet above sea-level and are at the same time in close proximity to the coast, be included no less than 26 or 65 per cent. of the endemic localities exhibit the climatic conditions prevailing in coastal regions during the summer.

Of the remaining (inland) endemic centres it is noticeable that they are all located in low-lying situations—none being above 300 feet above sea-level—and they are in close relation with river valleys or marsh land. Thus three are situated in the Fen district, three in the Severn valley and three in the Thames valley.

Whilst therefore no detailed consideration of this subject can be given, the facts suggest that the precise location of the endemic centres of malaria in England, *within the area exhibiting a favourable mean temperature*, may be partly explained by the rôle played by relative humidity.

IV. THE PAST HISTORY OF MALARIA IN ENGLAND.

The bearing of the conclusions regarding the rôle attributed to temperature and humidity in determining the recent distribution of endemic malaria may with advantage be considered in relation to its former distribution in the United Kingdom.

Owing however to the imperfect knowledge prevailing in regard to "fevers" in general (and malaria in particular) up to quite recent times, the past history of malaria is wrapped in obscurity. Nuttall, Cobbett and Strangeways-Pigg (1901)[1] give a detailed account, so far as it could be ascertained, of the conditions prevailing chiefly in the 18th and 19th centuries, and from the map accompanying their paper the endemic localities existing at this period have been added to my Map (p. 324), where they are shown as crosses.

It will be seen that the Thames valley and estuary of the Medway in *Area* 1 were, as now, relatively severely infected, and that in the Fen district many centres of endemic malaria, which are only represented at the present time by St Ives and Fletton, existed.

There is also in *Area* 2 an endemic focus in the vicinity of the Romney marshes, in the neighbourhood of which one endemic centre—Lydd—has recently been detected. Another small endemic area existed near the mouth of the Ouse river in Sussex, whilst recently one indigenous case has been reported from this neighbourhood (Uckfield).

Endemic areas in Hampshire were Lymington, Christchurch, and Lyndhurst, which are again represented by the indigenous cases recently reported from Southampton, Parkstone, Portsmouth and Emsworth.

In *Area* 2, moreover, an endemic centre existed near Bridgwater, where in four villages at the mouth of the Parrett river, malaria was formerly prevalent. No cases have recently been reported from this area, but Lieut.-Colonel James informs me that one case has been reported from Bridgwater, which he did not regard as being of undoubted indigenous origin as the patient had been in north Russia a year previously.

In *Area* 3 there were some 16 endemic localities, mostly in Norfolk and Lincoln which are represented in 1917–1919 by Grantham and Tetney Lock in Lincoln and Fakenham, Thetford in Norfolk and Southwold in Suffolk.

Finally in *Area* 4, in which it would not be anticipated that any endemic localities would occur, except for two places on the Yorkshire coast—Partrington near Spurn Head and Hull, which are on the coast and almost within Area 3—the only endemic areas in Area 4 were Carlisle in Cumberland, Kendal and Ulverston in Westmoreland, Garstang and Kirkham in Lancashire and Penzance in Cornwall.

[1] Nuttall, G. H. F., Cobbett, L., Strangeways-Pigg, T. (1901), Studies in Relation to Malaria. The geographical distribution of Anopheles in relation to the former distribution of ague in England, *Journ. of Hygiene*, I, 4–44, 2 maps.

In regard to these areas Nuttall, Cobbett and Strangeways-Pigg (*loc. cit.*) give the following information on the authority of the observers quoted:

(1) Carlisle: "Ague not endemic. In 1859 of 2580 patients treated at the dispensary only three entered as suffering from intermittent disease" (Whitley 1864).

(2) Kendal: "From 1795–1821 118 cases of intermittent disease occurred amongst 28,700 patients, but between 1813–1821 there were only six cases" (Proudfoot 1795–1821).

(3) Ulverston: "No intermittent disease was seen during 30 years practice but he had heard that a good deal existed at the beginning of the century" (Dickenson).

(4) Garstang: "Some intermittent disease in 1826–1827 but none since" (Bell 1826–1827).

(5) Kirkham: Dr Gradwell reports seeing much ague prior to 1831.

(6) Penzance: Only three cases in a period of 17 years amongst 8,800 patients (Forbes, 1796-1822).

The above authors were unable to obtain any information in regard to the occurrence of endemic malaria in Scotland. They state however that "on the borders of Scotland ague was formerly very prevalent, and very common about Berwick and at Roxborough in 1807."

In regard to Ireland they state that this country "has the reputation of being exempt from ague, the peat bogs being especially stated to be free from the disease, but Wylde speaks of the occurrence of ague in Ireland and of the occurrence of an epidemic in Dublin in 1805[1]."

It is considered that the above-quoted statements cannot be considered as proving the former existence of endemic malaria in either Scotland or Ireland and that it is open to doubt whether the north-west corner of England was ever malarious.

In the case of the south of England and the Midlands the evidence is, on the other hand, entirely convincing that the disease was in certain parts prevalent and relatively severe. Thus Nuttall, Cobbett and Strangeways-Pigg (*loc. cit.* p. 26) conclude that "In England malarial disease seems to have been endemic only in the low-lying, ill-drained swampy districts where there was abundance of stagnant or slowly-flowing shallow water. Among such places the principal were the Fens of Cambridgeshire, Lincolnshire and the surrounding counties, the marshes on either side of the estuary of the Thames in Kent and Essex, the marshes of Romney and Pevensey on the south coast and those around Bridgwater on the Bristol Channel."

The same authors conclude, as the result of a scrutiny of the death-rate from malaria during the years 1850–1858 in the Fen district and in Kent respectively, that the disease was more fatal at that time in the low-lying lands in Kent bordering on the estuary of the Thames than in the Fen country around Huntingdon and Wisbech. They add "And this is in substantial agreement with what Defoe wrote a century earlier."

[1] In a recent book, *The Influence of Man on Animal Life in Scotland*, Professor Ritchie states that malaria was formerly prevalent in parts of Scotland and he shows on a map the location of the endemic localities. Its seasonal incidence is stated to have been vernal rather than autumnal and its disappearance is said in some cases to have followed the cessation of emigration of agricultural labourers from malarious parts of England.

This brief and incomplete review of the past history of malaria in the United Kingdom therefore suggests that, whilst it has during recent years become greatly reduced in incidence and severity, its distribution has not undergone any material change.

It is therefore concluded that the view reached in regard to the part played by temperature and humidity is not rendered untenable by any facts which are forthcoming as the result of a scrutiny of the past history of the disease.

V. CONCLUSION.

It is thought that the adoption of the view attributing an important part to temperature and humidity in determining the distribution of malaria in England affords an explanation of some obscure points in connexion with the endemiology of the disease.

Lieut.-Colonel S. P. James, M.D., I.M.S., draws attention (*loc. cit.*) to one of these points when, in connexion with his recent work in England, he states:

"It was found:

(1) That in a number of places which harboured many carriers and numerous anophelines no new cases of malaria arose.

(2) That some of the new cases recorded arose in areas which harboured only one or two carriers and exceedingly few anophelines."

"The occurrence, in England," he adds, "of these two conditions (sometimes termed 'Paludism *sine* Malaria' and 'Malaria *sine* Paludism' respectively) is of great interest. The problem of defining the particular localities and circumstances in which we may expect an origin of new cases and a spread of malaria would be solved if we could explain these occurrences correctly."

It is thought that in the light of the part ascribed to the temperature and humidity factors an explanation of these two conditions is forthcoming. Thus it is clear, in the case of England, that if the temperature during July and August is unfavourable to the transmission of malaria, the local incidence of the disease will not be affected by the presence of many human carriers and numerous anophelines (Paludism *sine* Malaria).

On the other hand, in areas where the temperature and humidity factors are favourable, the transmission of infection will be apt to occur provided one or two carriers are present together with relatively few anophelines (Malaria *sine* Paludism).

In these circumstances it would not be anticipated that any exact correlation would exist between the distribution of carrier species of anophelines and the distribution of endemic malaria in the United Kingdom, and it is now known that these insects prevail in many parts of England without giving rise to indigenous cases of malaria.

It is possible that the part assigned to the temperature factor may to some degree explain the gradual decline of malaria in England.

The endemic area in this country is situated near the northern limit of

the area in which the mean temperature during the hottest months is favourable to the transmission of the disease. In this area a cold summer—and more especially a succession of cold summers—would be anticipated in the course of time to lead to a gradual decline in the incidence of the disease, for in such circumstances the "recovery-rate" would exceed the "infection-rate."

An interruption of infection, as the result of unfavourable temperature conditions, would necessarily occur more frequently in the Fen district in the north than in Kent in the south, and it would therefore be anticipated (as indeed appears to be the case) that the decline of the disease would take place more rapidly in the former than in the latter area.

Finally, on this view, the main factor in determining an unusual prevalence or a mild epidemic in England would be an unusually hot summer.

In this connexion it is of interest to note that the last occasion on which malaria is known to have prevailed extensively in England was in the years 1858–1859. On consulting the meteorological report for 1858[1] it is found that this year was rendered noteworthy by reason of the exceptionally long and hot summer[2]. The mean temperature in June was extraordinarily high (64·9° F. as compared with a mean of 59·4° F. at Greenwich), and the Registrar-General in his report for the year[3] states: "The heat in June was so great that there was no instance except one since 1771 in which the mean temperature for that month has been exceeded[4]."

It was thought that slight but progressive changes in climate, involving a reduction in the mean temperature during the summer, might also form a contributory factor to the decline of malaria in England, but the meteorological authorities have no knowledge of any secular changes in climate; and, indeed, it is not necessary to postulate their occurrence, in view of the fact that normal oscillations in the climatic conditions prevailing in England suffice to determine a considerable amount of interruption of infection in certain years.

No doubt other circumstances have contributed to the spontaneous decline of malaria in England. Thus the drainage of water-logged areas, and more especially the elaborate system of drainage carried out in the Fen district, must not only have considerably reduced the facilities for the breeding of anophelines, but in addition may have rendered the humidity conditions less favourable than formerly to the transmission of infection.

The intensive cultivation of the soil and the great extension of urban areas have also completely changed the environment in certain malarious tracts.

[1] *Quarterly Weather Reports*, England, 1858.

[2] It is assumed that the prevalence of malaria in 1859 was mainly the result of infections acquired during the previous year.

[3] *Report of the Registrar-General of Births and Deaths*, 1858.

[4] Since this communication was submitted for publication my attention has been called to a report by Angus Macdonald (*War Office Observations on Malaria*, December, 1919) in which the influence of temperature on malaria in England is clearly recognised and emphasised and detailed temperature statistics for the years 1858—1860 are given.

It is thus not difficult to understand the reason why Lambeth and Pimlico in London, which in the 18th century were notoriously malarious, are now free from the disease. Finally, in view of the part played by economic and social conditions in maintaining infection in malarious communities, it would be anticipated that the great amelioration in these conditions which has taken place, more especially during the past 100 years, must have been a further factor in favouring the spontaneous decline of the disease.

In view of the operation of all these factors—amongst which an important part is assigned to the meteorological factors—it is possible to offer an explanation of the gradual disappearance of malaria from England, and to hazard the opinion that the introduction from abroad of human carriers is not likely to interfere materially with its final extinction.

SUMMARY.

(1) The study of the meteorological circumstances prevailing in the United Kingdom confirms the conclusions reached in India that the combined influence of temperature and humidity plays an important part in determining the conditions necessary for the transmission of malaria.

(2) The part assigned to temperature and humidity points to the conclusion that the period of active infection in England is ordinarily limited to the months of July and August.

(3) The part attributed to temperature accounts for the geographical distribution of the endemic area of malaria in the British Isles and explains its limitation to certain parts of England.

(4) The combined influence of temperature and humidity appears to afford an explanation of the precise location of the endemic centres of malaria within the above area.

(5) The part assigned to temperature and humidity elucidates certain points in connexion with the endemiology of malaria in England, and it offers an explanation of the conditions known as "Malaria *sine* Paludism" and "Paludism *sine* Malaria."

(6) The part played by the meteorological factors throws light on the past history of malaria in England and it helps to explain its gradual decline.