STUDIES ON THE ARNETH COUNT

IN A HOT CLIMATE.

Thesis submitted for the

M.D. Glasgow

by

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CONTENTS.

1. Introduction.

Arneth (1904) was the first to suggest that the ordinary total and differential counts did not give a sufficiently delicate indication of haematological changes. He demonstrated that there was significant change in the nucleus of the polymorphonuclear leukocyte in patients suffering from infectious diseases and that the severity of toxaemia could be gauged from this. The Arneth count has been developed along different lines by other workers, notably Cooke and Ponder (1927) and Schilling (1911), who formulated standards for clinical application in health and in certain diseases.

It has recently been recognised that in tropical countries, the Arneth count standards both in healthy and diseased people differ from those accepted in European countries. These differences are found to be particularly striking in 'Iraq. While investigating this problem it was found that by correlating the Arneth count with the number of neutrophils in the differential count, a factor was obtained which was of use in differentiating certain diseases. The results are considered of sufficient interest for presentation.

The work was carried out chiefly in the summer months of 1935 and 1936 while the author was attached as pathologist to the R.A.F. General Hospital, Hinaidi (Baghdad) and to the R.A.F. Station, Basrah.

Although geographically in the subtropics, 'Iraq is an inland desert

country and in summer the heat reaches tropical intensity. As in tropical countries one of the problems of the physician is the differential diagnosis of the many febrile conditions grouped together by the Service medical officer as "Pyrexias of Uncertain Origin". In the hot weather in 'Iraq most of the pyrexias are due to malaria, phlebotomus fever and acute pyogenic infections. These groups of diseases were therefore chosen for detailed study. For comparison and contrast the results of the blood examination in leprosy, a chronic (and usually apyrexial) condition, are included.

Cooke and Ponder's modification of the Arneth count was used throughout.

Material.

To set up standards of normality for 'Iraq, 234 British airmen and officers at Hinaidi and Basrah were examined. Such a population is eminently suitable for study since it gives uniformity of age, sex and environment. All had been in 'Iraq for at least six months and many for over a year. The health standard was singularly high. Recruitment to the Royal Air Force involves a stringent medical examination. Before posting overseas all cases of obvious sepsis (teeth, tonsils, sinuses, etc.) are treated. All personnel are periodically examined, medically and dentally, and all are under continual medical supervision.

The airmen pilots and the officers included had shortly before

undergone the pilot's annual medical board, to pass which requires a high standard of physical fitness. None were included who had, during the three weeks previous to sampling, suffered from minor ailments such as colds, headaches or diarrhoea. Cases deviating considerably from the mean, either in the Arneth or the differential count were re-examined for helminth infection, malaria and septic foci, and only included after repeated negative findings.

The age range was 19 to 30. Environmental conditions, food, habitation and working conditions were uniform.

The phlebotomus fever cases (74 in number) were also obtained from British airmen and officers in Hinaidi and Basrah. Incidence of this disease is high amongst British residents in 'Iraq, especially Air Force personnel. One attack confers immunity for ten years or longer, but the R.A.F. tour of duty in 'Iraq is one of two years and the population is constantly changing, with a steady influx of non-immune subjects. On the other hand the diseases is seldom encountered in the native population since the natives contract the disease in childhood and immunity is maintained by subsequent sub-infective doses of the virus.

In malaria and in the acute pyogenic infections material was collected from natives in addition to British subjects. As will be shown later, in 'Iraq the leukocyte counts in the British population in health and in disease do not differ significantly from those in the indigenous population. Malaria

is endemic throughout 'Iraq, but amongst airmen the incidence is not high as a result of mosquito control in the R.A.F. cantonments. In 1936 however, because of unusually heavy spring floods, the Tigris and the Euphrates burst their banks at many points. The extensive flooding which resulted, favoured mosquito breeding and during June and July malaria reached epidemic proportions throughout the country. It was at this time that the blood counts were done, 47 of them in British airmen.

The remainder of the material (79 cases) was obtained from Arabs serving in the 'Iraq Levies, a native force raised for the protection of Air Force aerodromes. These Arabs, who are recruited from the marshlands around Amara are of good physique and train readily as soldiers. But among them malaria is common and most of them suffer from periodic relapses. Relapses occur at two well-defined periods; the first at the onset of the cold weather during November and December and the second during July and August.

Of the cases of acute pyogenic infection eight cases were also obtained from 'Iraq Levies, the remainder (33 cases) from British airmen.

Material from lepers was obtained from the isolation hospitals at Baghdad (numbering 70) and Basrah (26). The patients were Arabs, 9 female and 87 male; the age range was 12 to 60.

The presentation of masses of figures in a study such as this is difficult, and may even be misleading unless the figures are subjected to

accurate statistical analysis. It has long been the criticism levelled against the medical research worker that he seldom applies accurate mathematical methods in the analysis of his results. But of recent years there has been an increasing tendency among medical men to make use of statistical methods in examining the results of scientific and even of clinical investigations. In the present study the results of the leukocyte counts are considered as population attributes and analysed accordingly, using the simpler statistical methods as explained by Woods and Russell (1921.).

In treating biological attributes mathematically many difficulties are encountered. For clinical diagnosis cannot be regarded as a science. It must always be a question of elimination, the weighing up of possibilities and probabilities. For example it is true that the Arneth index gives a measure of toxaemia. Also in those diseases usually associated with a neutrophil leukocytosis the number of polymorphs in the circulation gives an indication of the severity of infection. By correlating these two variables one finds that the distance of travel from the ranges of normality gives a fair measure of the severity of illness. There are obvious exceptions; as when the virulence of infection is so severe or resistance so low that there is no leukocytic reaction. Thus in such a case of pneumonia, for example, a marked left-handed shift in the Arneth index may be associated with a leukopaenia.

However it will be shown that by charting these two variables, the

Arneth index and the percentage number of polymorphs in the differential count, a haemogram is obtained which is of value in the diagnosis of certain diseases. As has been stated in acute pyogenic infections a low Arneth index is associated with leukocytosis. In phlebotomus fever it is associated with a leukopaenia. Malaria lies between these two. In leprosy, a chronic infection, the shift in the Arneth index is less marked, and there is also a relative fall in the number of polymorphs in the circulation since the disease is typified by a mono-nuclear leukocytosis.

Historical note.

That deflection of the Arneth count occurs in most acute infections has now long been recognised. Ponder (1926) showed that parenteral administration of thyroid extract in rabbits also caused deviation to the left. Similar results were obtained by Ponder and Flint (1927) using thyroxine, colchicine and nucleic acid. Kennedy and Thompson (1927) produced deviation of the count by ultra-violet radiation, as did Clemenko (1930) by the parenteral administration of irradiated ergosterol. Danzer (1930) came to the conclusion the count deviation was the effect of tissue proteins, liberated in the case of disease by the break down of body tissues, or experimentally by chemical or other agents.

The first to observe that the polynuclear count was affected by locality were Chamberlain and Vedder (1911). Using Arneth's original method they found a marked left hand shift in Filipinos. Breinl and Priestley

(1914-15; 1915; 1916-17) had similar results in children of European descent living in Queensland, in native adults and children of New Guinea and in aboriginal children of Northern Australia. These authors concluded the deflection of the count was due to climatic effects. Macfie (1915) recorded a left handed shift in the Arneth count in European residents and natives of the Gold Coast but concluded that the shift was due to malaria and that it persisted for a considerable time after convalescence. Bannerjee (1924) found in normal Bengalese the mean was less than Arneth's mean for Europeans and Lyndhurst Duke (1920) had similar results in Uganda.

These workers all used Arneth's original method. More recently similar left handed deviations were found using Cooke's polynuclear count by Kennedy (1935) in Arabs, Kurds and Jews in 'Iraq; by McLeod (1935) in small numbers of cases from scattered localities throughout the world; by Pai (1935 and 1936) in Mukden, China; by Kennedy and MacKay (1935) in British airmen in 'Iraq; by Shanklin (1936) in the natives of Syria; and by Bernard Shaw (1936) in British and Egyptians resident in Egypt.

2. <u>The Neutrophil Picture</u>.

<u>Technique</u>. The usual technique was followed in making blood smears. Blood was obtained by pricking the finger or the lobe of the ear. In the normal series sampling was done at the same time each morning, between

10.00 and 12.00 hours. In a number of cases intravenous blood was used but no added advantage was found. Using oxalated blood it was found more difficult to prepare satisfactory films and unless spread immediately, clumping of the white cells and irregularity of distribution were apt to occur. Particular attention was paid to cleanliness of the slides. A spreader such as is shown in Figure 1, was used. This was made by

Figure 1. Blood film spreader.

cutting off two angles of an ordinary microscope slide. It made a film with two margins clear of the edge of the slide, an advantage in examining the blood in leukopaenic diseases, since the white cells tend to accumulate along these margins.

At first it was found difficult to obtain satisfactory staining results especially during hot weather. This was due to rapid deterioration of the stains, unreliability of the distilled water and the fine penetrating dust with which the atmosphere is laden during the summer. The chief faults were poor granule staining, precipitation of stain and inconsistency of results even in the same batch of smears. Wright's, Leishman, Jenner, Giemsa, May-Grunwald Giemsa, Fadicit and other stains were tried and the following buffered Giemsa method ultimately adopted for routine work:-

1. Dry slide in air (under glass cover).
2. Fix in acetone-free methyl alcohol for not less than 10 minutes.
3. Filter on to slide freshly mixed solution of stain - one part Giemsa in five of Haden's solution.
4. Stain for 20 to 25 minutes.
5. Wash rapidly in Haden's solution; blot dry.

It should be noted that 3 to 5 minutes the time frequently given for fixation of blood films is in methyl alcohol not sufficiently long for thorough fixation. Calmette (1933) recommends 30 minutes, and immersion for 24 hours does not damage the smears. Also, Giemsa stain after dilution rapidly losses its staining power. The Haden's solution was prepared from the following formula as recommended by Osgood and Haskins (1931):-

Recrystallised acid potassium phosphate....6.63g.
Andydrous basic sodium phosphate.....2.56g.
Chloroform.....1cc.
Distilled water to 1 litre.

This method was found satisfactory for routine work, for batches of twenty slides or more may be stained at a time. It stains well the granules of the granulocytes and also the azurophil granules of the mononuclear cells. Nuclear material overstains slightly, but this is an advantage in doing the polynuclear count, since the fine filamentous strands

of nuclear material are prominently shown.

Where permanent preparations were required, "Caedax", a neutral mounting agent which does not cause fading of the preparation, was used.

In the course of these studies some unusual microscopical appearances were encountered of which it was thought advisable to make a permanent record. Stained blood films form a very suitable subject for photomicrography and the advantages of the photograph over diagrams and sketches are many and obvious. Using a high magnification there are some technical difficulties to be overcome; especially in a country like 'Iraq where supplies of photographic materials are unreliable and rapidly deteriorate. But it was found possible, using a simple and inexpensive microcamera, to produce photographs sufficiently clear for reproduction in print.

The apparatus isshown in Figure 2.. The "Pointolite" lamp was first used and found satisfactory but was later discarded in favour of a 200 Volt, 500 Watt, Ediswan vertical filament lamp. Between the course of light and the microscope condenser is placed a Chance-Watson green filter (No. 5.). For high power work the lens used is a Watson's "Versalic" 1/12" oil immersion. This with a tube length of 170 cms. and a x10 eyepiece gives a magnification of 1000 diameters which is a convenient standard. The camera is a Leitz Micro Camera Attachment

of fixed focus, taking plates or film pack of 9 by 12 cms. A periscopic view-finder is incorporated.

It was found more convenient to use the microscope in the horizontal position than in the vertical, as is recommended by the makers. The apparatus is more stable in this position and the mirror can be dispensed with, thus cutting out one source of light loss. One possible disadvantage is that the oil may flow from under the oil immersion lens during a long exposure; this can be overcome by using thicker oil. The lamp is adjusted to have the filament level with the microscope condenser. An objective and the eyepiece are removed and the microscope adjusted to obtain the maximum intensity of even illumination as is done in the dark-ground illumination method. This permanent microscope position is marked on the bench.

The subject to be photographed is focussed using the ordinary microscope lamp and the slide is clamped to the substage. The microscope is placed in position, the eyepiece removed, and the camera, loaded and with the slide withdrawn, is inserted in its place. It is advisable to have the camera ready for actual exposure at this stage in order to reduce to a minimum adjustments liable to move the subject out of focus. Final focussing and centering is done using the periscopic viewfinder of the camera. During the exposure all possible sources of vibration must be eliminated. An assistant walking across the room or the slamming of a

Figure 2. Layout of photomicrography apparatus.

door in another part of the building may be sufficeint to throw the microscope out of focus.

Using the lamp and filter described the exposure time varied from 30 to 40 seconds according to the thickness of the film and the staining. Increased intensity of illumination shortens the exposure but is hurtful to the eye in making the adjustments; diminished light lengthens the exposure with resulting fogging of the negative.

The best results were obtained with panchromatic plates but for a series of photographs a film pack has the advantage of convenience and one such as the Kodak "Verichrome" is satisfactory.

A hydrokinone-caustic developer was used for depth and hardness of the negative. In printing, since the aim is maximum contrast compatible with detail, the hardest and most "contrasty" paper available was used.

Photographs taken using this technique are shown in Figures 4 and 5.

For the purpose of this study only the neutrophil cells are being considered, but in all cases complete differential white cell counts were done, 200 cells being counted in each smear examined.

On consulting standard text-books on general medicine, physiology and pathology, one is struck by the variation in the figures given as normal in the differential count. A few are quoted in Table 1. In none of the books consulted were figures given to which statistical criteria had been applied. It is also of interest to note that text-books on tropical medicine such as that of Manson-Bahr give figures similar to the accepted

British standards.

T A B L E 1.

Text-book and Author.	Polymorphs in differential count
Medicine. Beaumont (1937).	50 - 65 %
Synopsis of Medicine. Tidy (1934).	50 - 75%
Principles of Human Physiology. Lovatt Evans (1936).	68 - 70%
Text Book of Pathology. MacCullum (1936).	60 - 70%
Manson's Tropical Disease. Manson-Bahr (1935).	60 - 70% av. 67%

On the other hand Houghton (1936) goes so far as to say:- "There are, of course, no fixed normal figures for the total or differential leukocyte counts, owing to the wide variations which may be found in different healthy individuals". This view we consider to be extreme. For if we cannot lay down standards for health now can we place any stress on the value of leukocyte counts in disease when we know that the variability of physical attributes increases when complicated by the disease processes.

In 'Iraq in collaboration with Kennedy (Kennedy and MacKay) (1936) the following results in the differential count were obtained in a series of British and 'Iraqi subjects examined during the summer:-

T A B L E 2.

	Mean	σ	Standard error	Coefficient of variation	Minimum	Maximum
Neutrophils	56.6	7.27	±0.421	12.5	35	75.5
Eosinophils	3.8	2.39	±0.138	62.9	0	13
Lymphocytes	25.9	7.31	±0.423	28.1	9	48
Monocytes	13.7	4.89	±0.283	35.6	4	29.5

It is seen that the coefficient of variation of the mean percentage of neutrophils is 12.5%. The variability of an attribute of a standard population such as body weight is usually about 10%. Thus the measure of the variability of the neutrophil cells is little in excess of this figure, although the variability of the other cells is considerably greater. In other words, in the series of cases considered the level of the neutrophil count is more constant than that of the other cells.

In Table 3. are shown the statistical constants with their Probable Errors for the percentage of polymorphs in the present series of healthy airmen in 'Iraq

T A B L E 3.

Mean.	Standard deviation.(σ).	Coefficient of Variation.
56.49 ± 0.32	7.39 ± 0.225	13.06 ± 0.40

The detailed calculation of the mean, standard deviation and coefficient of variation is shown below along with the calculation of the constants for the Arneth count. For in this case it is simpler to consider

together the analysis of both these attributes of the polymorph by making use of a correlation table. But we may consider here the significance of the statistical constants and their probable errors.

The mean is not calculated by summing the observations and dividing the sum by the number of observations. It is less laborious to calculate it from the grouped frequency distribution and the error involved is insignificant, provided suitable group intervals are used.

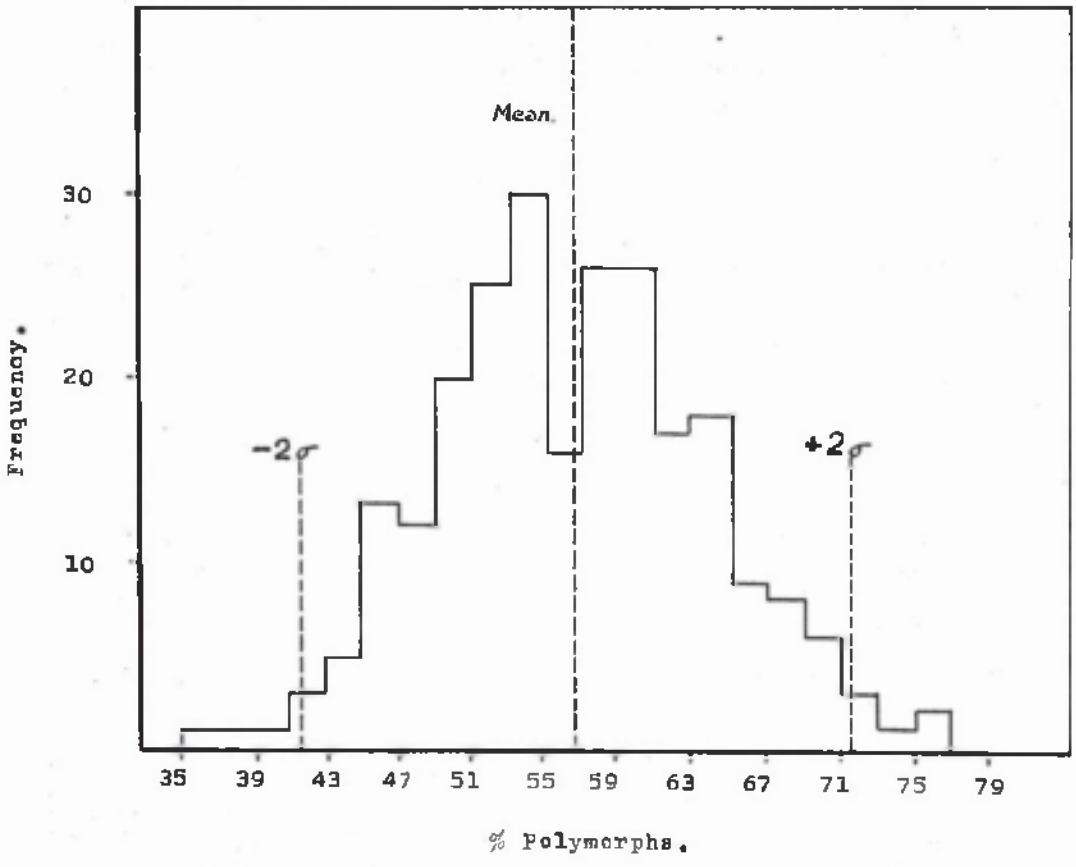
The standard deviation or root-mean-square deviation gives a measure of the scatter of the observations around the mean. Making use of the range is unsatisfactory for its extent is dependent on the size of the two extreme values and it gives no idea as to the form of the distribution. A small standard deviation shows that the observations are closely concentrated round the mean. In the normal frequency curve it is found that the distance between twice the standard deviation on either side of the mean includes about 96% of the observations in the series. It is customary to regard any observation which falls outside of the limits of -2σ to $+2\sigma$ as differing significantly. Thus in the percentage of polymorphs series, any observation which is less than 41.7, and more than 71.27 may be considered abnormal.

That is, taking it for granted that the cases chosen represent a fair sample of the whole population. Should we take another random sample of the population it is unlikely that the mean of the second sample

would be identical with that of the first but it should approximate closely to it. If we took a large number of such samples and estimated the mean for each, these means would all differ slightly from one another. A frequency distribution would form a normal curve centred on the true mean of the population with the majority of the observations concentrated round the true mean. Thus provided we know the true mean for the population, we can tell if a given sample is within normal limits. But, if as in the present instance, we do not know the mean for the whole population we must make use of the limited knowledge derived from a single sample. As a measure of the variability of this sample we use the standard error (S.E.) whose formula is $\frac{\sigma}{\sqrt{N}}$ or the probable error (P.E.) $\frac{.67449}{\sqrt{N}}$ where N is the number of observations in the sample. If M is the mean percentage of polymorphs of the present sample the mean for the whole population is likely to fall within the limits of $M \pm 2 \times S.E.$ or of $M \pm 3 \times P.E.$ since the probable error equals the standard error multiplied by .67449. That is, the population mean percentage of polymorphs is likely to fall within the limits $56.49 \pm 3 \times 0.32$, i.e. between 55.53 and 57.45 %. Similarly for the standard deviation and coefficient of variation. The formula for the probable error of the standard deviation is $\frac{.67449\sigma}{\sqrt{2N}}$ and the probable error of the coefficient of variation $\frac{.67449}{\sqrt{2N}} \cdot V \cdot \left(1+2\left(\frac{V}{100}\right)^2\right)^{\frac{1}{2}}$.

Figure 3. is a frequency polygon of the percentage of polymorphs grouped at intervals of 2%. The position of the mean, -2σ and $+2\sigma$ are indicated by cross lines.

Figure 3.



Frequency polygon of

percentage of polymorphs in health.

The mean percentage of polymorphs of 56.49 is at least 10% less than the standard accepted as normal in Britain. Poindexter (1935) states that in normal coloured Alabama people he found a lower percentage of neutrophils than that quoted in text-books. Osgood and Haskins (1931) from their experience in Oregon concluded that a range of 55-75% is from 5-15% too high. We have no evidence to show that there is an absolute decrease in the number of neutrophils in the circulation. The fall in the percentage is probably relative, due to an increase in the number of other cells, chiefly monocytes.

A striking feature of the differential count in 'Iraq is the large number of "abnormal" cells that appear in the circulation even in health. By "abnormal" we mean those cells known to occur occasionally but infrequently, such as myeloblasts, lymphoblasts, promyelocytes, myelocytes, macropolycytes, Türck cells, Reider cells, etc. Myelocytes, including metamyelocytes, occur in health in more than 50% of cases to the extent of ½ to 3%. There is a further increase in the number of these cells in infection. The presence of relatively large numbers of primitive neutrophil cells is probably associated with the left-handed shift which occurs in the Arneth count.

One also finds in the circulation larger numbers of degenerate cells than occur in Britain. Frequently degeneracy is marked by increased fragility and early rupture of the cell which affects not only the older

multi-nucleated cells but also the more primitive type with a simple nucleus. This seems to indicate the occurrence of premature senility. Other indications of degeneracy which occur are vacuolation of the cytoplasm and a foamy appearance of the nucleus, as if it were lacking in chromatin. Occasionally the nuclear material remains after the rest of the cell has disappeared forming a "smear cell" or the type described by Whitby and Britton (1935) as the "basket" cell. The development of the basket cell is illustrated in Figure 4.. It is of interest to record that in one case of severe smallpox in a native child aged six months, 53% of all cells present in the blood were degenerate basket type cells.

It was also found that in many cells the granules were larger and coarser than normal. That this was not due to artefact could be deduced from the fact that cells with coarse granules frequently lay beside cells that were normal. Also the incidence of such cells increased greatly in infections such as malaria. Panton (1930) has described such coarse granules in toxic and inflammatory conditions and in aplastic anaemia. He considers that they may be an indication of extra work thrown on the cell ferments.

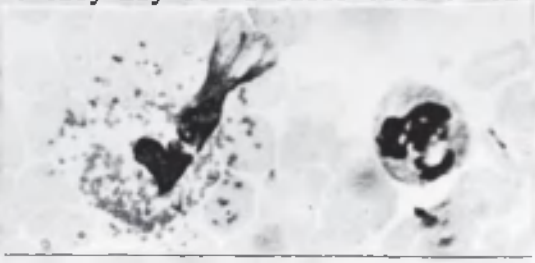


Figure 4.

Degenerate cell showing the early stage of formation of "basket" cell. On the right is a normal polymorph.

Among the abnormal cells metnioned is the macropolycyte. The occurrence of this cell in 'Iraq has been reported on by Kennedy and MacKay (1937). The name was first suggested by Sir Humphry Rolleston to describe a giant type of polymorphonuclear leukocyte of 16μ or over. The cell has been studied extensively by Cooke (1927, 1933-34) who distinguishes three types. In Type I. the staining reactions of the nuclei and cytoplasm are identical with those of the other polymorphs in the blood film. The nuclei are frequently hypersegmented; ten or more lear lobes may be present. The cell diameter may be 16μ to 25μ. Type II. is called the megakaryocyte type since it resembles in size and in nuclear configuration the megakaryocyte of the marrow. The granules are coarse and azurophil as well as neutrophil granules are present. Type III. is intermediate between Types I. and II. having fine neutrophil granules and nuclear configuration as in Type II., but the nuclear structure is distinctive. There is a very open reticulum suggesting a deficiency of basichromatin and the bulk of the nucleus is large compared with the cytoplasm. Cooke states that Types II. and III. only occur in pernicious anaemia. Type I. he describes as occurring in health, in tuberculosis, cancer, the acute pyogenic infections, the exanthemata, pernicious anaemia and in myelogenous leukaemia.

Among the chief points of interest of the macropolycyte are its distinctive characters and its rarity. According to Cooke (1927) macropolycytes

are encountered perhaps twice or three times a year by anyone constantly examining blood films. In the literature mention is made of only one case, in Britain, occurring in health. Usually they are associated with a neutrophil leukocytosis and the presence of myelocytes in the peripheral blood.

Figures (2) to (12) in Plate Figure 5. are photomicrographs of the macropolycytes found in the present series of cases. Of these 3 occurred in healthy people, 1 in acute sepsis, 1 in phlebotomus fever, 3 in malaria, and 3 in leprosy. They have also, in 'Iraq been found in tuberculosis, ascariasis, ascites and pernicious anaemia.

and a small lymphocyte.

Fig. 9. Macropolycyte in malaria. Diameter 21μ; 8 lobes. The granules are coarse.

Fig. 2. Macropolycyte of megakaryocyte type from case of [illegible]. Diameter 22 x 18μ; nucleus single and massive; granules coarse. The other cell is a metamyelocyte.

Figs. Macropolycytes from leprosy. Diameter 17 x 21μ; 12 [illegible]

Description of Plate.

Fig. 1. Two normal polymorphs.

Fig. 2. Small macropolycyte from normal individual. Diameter 16μ; 8 lobes; granules fine.

Fig. 3. Macropolycyte in health. Size, 23 x 18μ; 9 lobes; granules fine.

Fig. 4. Macropolycyte in health. Diameter 22μ; 11 lobes; granules normal. The surrounding red cells are rather distorted.

Fig. 5. Macropolycyte from case of acute osteomyelitis. Diameter 20μ; 7 lobes. The granules are coarser than normal.

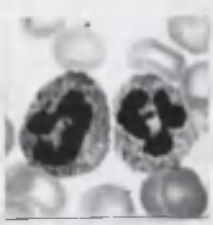
Fig. 6. Macropolycyte from case of malaria. Diameter 17μ; 8 lobes; granules normal.

Fig. 7. Macropolycyte in malaria. Diameter 22μ; 10 lobes; granules normal. Also present in the picture are two normal polymorphs and a small lymphocyte.

Fig. 8. Macropolycyte in malaria. Diameter 17μ; 8 lobes. The granules are coarse.

Fig. 9. Macropolycyte of megakaryocyte type from case of phlebotomus fever. Diameter 22 x 18μ; nucleus single and massive; granules coarse. The other cell is a metamyelocyte.

Figs. 10,11,12. Macropolycytes from lepers. Diameters 17 x 21μ; 19μ, 18μ respectively. The granules in Fig. 12 are of the coarse type.



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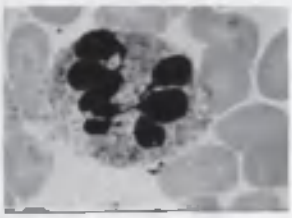

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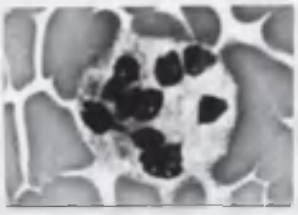

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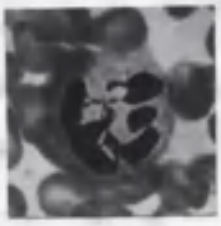

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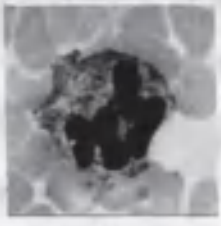

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Figure 5.

Magnification : 1000 diameters (approx.).

Of the function of the macropolycyte or of its mode of development we know little. As Cooke (1933-34) suggests these large hypersegmented cells may be normal polymorphs which have escaped the physiological mechanism for the removal of old leukocytes from the circulation and acted on by pathological stimuli, have developed beyond their normal span. Or they may be the result of abnormal stimuli on the haemocytoblast of the bone marrow. The latter is probably the more likely explanation. In view of its distinctive morphology it is inconceivable that the macropolycyte could be produced by mere ageing of an otherwise normal polymorph. The conditions in which it appears are accompanied by the presence in the circulation of "abnormal" cells such as myelocytes. This is especially true of pernicious anaemia, the disease in which macropolycytes are most frequently found. In 'Iraq where these cells are apparently less uncommon than elsewhere their appearance even in health is associated with other "abnormal" cells in the blood stream and as is discussed below with a marked left hand shift in the Arneth count. This would seem to indicate either abnormal bone marrow stimulation or the upset of the mechanism which regulates the equilibrium between the output of the bone marrow and the removal of white cells from the circulation.

3. The Polynuclear Count in Health.

Arneth divided the polymorph into five classes, starting from the admitted fact that leukocytes with a round or slightly indented nucleus are less mature than leukocytes with segmented nuclei. In Class I. he included myelocytes (M), cells with a slightly indented nucleus (W), and with a more deeply indented nucleus (T). In Class II. were placed nuclei of two lobes; with two round pieces (2K); with two bent pieces (2S); and with one round and one bent piece (1K and 1S). Similarly in Class III. were classified nuclei of three lobes; (3K); (3S); (2K and 1S) and so on. In Classes IV. and V. were placed nuclei with four and five lobes respectively, subgrouped as in Classes II. and III.. Thus the more complex the lobulation, the greater the number of possibilities of different combinations of nuclear lobes. Arneth, however, did not state sufficiently clearly the characteristics by which the various lobes could be recognised. His classification was too complex for ready clinical use and the interpretation of it varied greatly with different workers.

In 1914 Cooke modified Arneth's method and later in conjunction with Ponder (Cooke and Ponder, 1927) amplified it calling it the "polynuclear count". Like Arneth, Cooke divided the polymorphonuclear leukocytes into five classes. Those with an undivided nucleus he placed in Class I.; those with two lobes in Class II.; those with three, four and five or more lobes in Classes III., IV. and V. respectively. The difficulty of deciding whether the nucleus is divided or merely convoluted is solved by a simple,

criterion, depending on the fact that division is never complete but that the lobes are united by fine threads of nuclear material. "If there is any band except this chromatin filament connecting the different parts of a nucleus that nucleus cannot, for the purpose of the count be said to be divided.". This is illustrated in Figure 6.

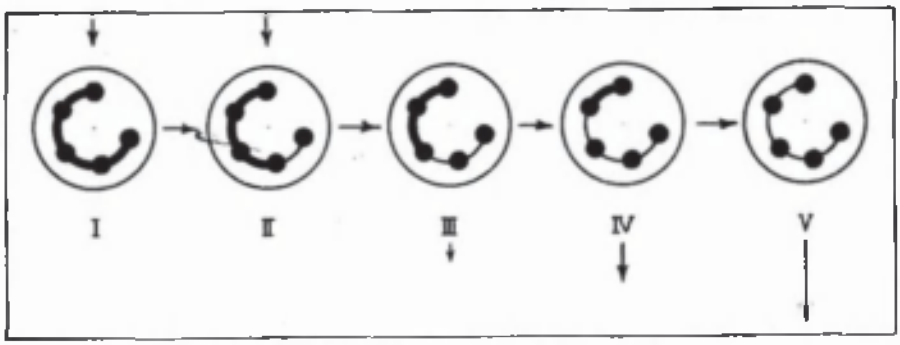


Figure 6. Diagram illustrating the development of the polymorph. The arrows indicate the entrance into and exit from the circulation of the cells.

Diagram I. in Figure 6. represents a polymorph with five lobes in its nucleus connected by thick strands of nuclear material. Although the nucleus has five distinct masses the cell is placed in Class I. because the connecting strands are too thick for true division to have occurred. In Diagram II. one of the thick bands is replaced by a fine filament and the cell is placed in Class II., one lobe consisting of one mass and the other of four masses connected by thick strands, and so on in diagrams III., IV. and V.

Polymorphs which are distorted or degenerate should not be counted. Where the nucleus has become folded on itself it may be difficult to follow

the fine nuclear filaments and to decide to which class the cell belongs. The rule is, if it is a question as to whether the cell belongs to Class III. or to Class IV. to place it in Class III.; in Class IV. if the doubt is between IV. and V.. If there is a doubt between Classes II. and III. the cell should not be counted.

Cooke and Ponder established a normal polynuclear count or "health standard". They took 90 persons of both sexes between the ages of twelve and twenty-five and excluded any focus of infection at the time of sampling by examination of teeth, nose, ears, chest, abdomen and the urine, and in many cases taking a radiograph of the chest and the teeth. In this series the average count was:-

I.	II.	III.	IV.	V.
12	25	44	15	4

The lowest extreme was:-

I.	II.	III.	IV.	V.
15	34	40	11	0

and the highest extreme:-

I.	II.	III.	IV.	V.
9	24	47	17	3

It is more convenient to express the result as a single index. The simplest method is to draw a line between Classes II. and III. and to total

the cells on either side of the line as follows:-

I.	II.	III.	IV.	V.
12	25	44	15	4
37		63		

in which case the index may be taken as 37. If Classes I. and II. are termed left-handed and Classes III., IV. and V. right-handed, an increase of the cells in Classes I. and II. is called a "shift to the left" and the reverse a "shift to the right".

A more delicate measure of the state of the count is obtained by making use of the weighted mean. This factor is found by multiplying the number of cells in Class I. by one, in Class II. by two, in Class III. by three and so on, and expressing the sum of these as a percentage. Thus the weighted mean of the average count is 2.74, and of the lowest and highest extremes 2.47 and 3.11 respectively. If a cell should move from one class to the class above or below it, the move is reflected in the weighted mean by unit difference in the second decimal place.

Other indices have been used. Houghton (1936) and others make use of a figure which they call the "Bonsdorff" count. This figure is merely the total number of nuclear lobes in a count of 100 cells; this figure if expressed as a percentage is identical with the weighted mean.

Hamilton Black (1913) described a phagocytic index. Working with tuberculous patients he showed that the power of ingesting tubercle bacilli

increased with the complexity of the polymorph nucleus; that the phagocytic powers of cells with one, two, three, and four or more lobes are in the ratio of 10 : 18 ; 22 : 25. Thus by multiplying the number of one-lobed nuclei by 10, two-lobed by 18, three lobed by 22 and the more complex by 25, the total sum gives the index. The normal index is about 2000.

Kennedy (1933) was of the opinion that the Cooke and Ponder standard of health was too stringent for clinical purposes and that the majority of people in "ordinary health" did not attain to it. He selected 90 medical students men and women, who were in good health and had no obvious focal sepsis of teeth or tonsils. In this series the range of weighted means was 2.18 to 3.05 with an average of 2.628; which figures show a small but significant shift to the left as compared with Cooke and Ponder's standard.

Cooke and Ponder (1927) state that a satisfactory polynuclear count can be obtained by counting as few as 50 cells, and it is unnecessary to count more than 100. In the present series 100 polymorphs were counted in each case. In doing the differential white cell count it is not much more laborious and takes but little longer to do the polynuclear count at the same time. A simple method is to use 100 beans or glass beads and five dishes, one for each polymorph class, while the other cells are charted in the usual manner.

RESULTS.

1) In health.

In the index are tabulated the detailed results for two hundred and

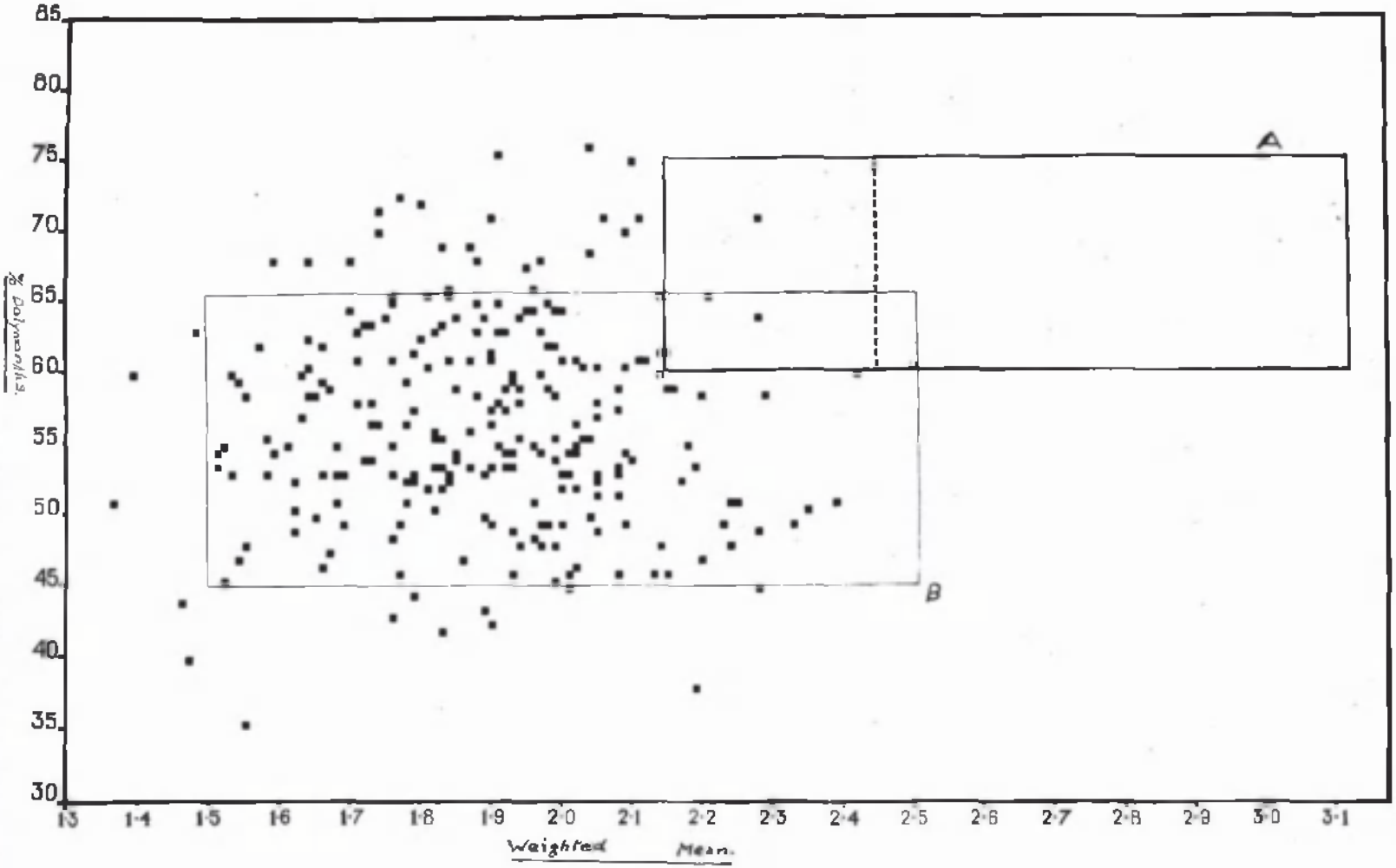
forty-three cases in normal health, giving in each case the percentage of polymorphs, the polynuclear count and its weighted mean.

Figure 7. is a spot diagram in which each result is shown by plotting the percentage of polymorphs (ordinate) against the weighted mean (abscissa). The rectangle 'A' represents for each of these two variables the ranges accepted as normal in Great Britain.

In the percentage of polymorphs the commonly accepted figure of 60 - 75% is taken. In the weighted mean Kennedy's range of 2.15 - 3.15 is used. The dotted line represents the lower border of normality in the Cooke and Ponder series, the value being 2.45. It is seen that of the 'Iraq series only five cases (2.1%) fall inside the British area of normality and if the more stringent Cooke and Ponder standard is adhered to, only one case (0.4%). Inspection of the figure shows that this is due to a marked left handed shift in the polynuclear count and to a fall in the relative number of polymorphs in the differential count.

The scatter of the points plotted is regular and there is no obvious drift in any direction i.e. superficial examination reveals no apparent correlation between the two variables plotted. The possibility of there being statistical correlation between these two attributes of the neutrophil cell, i.e. between the relative number in circulation and the complexity of the cell nucleus is investigated mathematically below. Table 4. is a double entry correlation table and from it are calculated the statistical constants,

Figure 7.



Correlation diagram for normal health series. Rectangle A represents British area of normality. Rectangle B arbitrary normality area for ' Iraq.

the Arithmetic Mean, the Standard Deviation, the Coefficient of Variation and the Coefficient of Correlation. The range of percentage of polymorphs is 35 - 75% and for grouping, a convenient class interval is 2% giving 21 groups. Similarly the weighted mean range is 1.35 to 2.50 and taking a class interval of .05 as a unit it gives 24 class intervals.

The individual results are now entered or plotted as in the case of the spot diagram, except that the results are grouped in class intervals. Inspection of this table shows no line of trend, the area of greatest density being towards the centre of the table. As arbitrary origins the class intervals 55 - on one scale, and 1.90 - on the other, are chosen.

Table 4.

% Polymorphs.

Weighted Means.		-9 35-	-8 37-	-7 39-	-6 41-	-5 43-	-4 45-	-3 47-	-2 49-	-1 51-	0 53-	1 55-	2 57-	3 59-	4 61-	5 63-	6 65-	7 67-	8 69-	9 71-	10 73-	11 75-	I f	II d	III fxd	IV fxd²
-11	1.35								1					1									2	-11	-22	242
-10	1.40																						0	-10	-	-
- 9	1.45			1		1									1								3	- 9	-27	243
- 8	1.50						2			1	3			2									8	- 8	-64	512
- 7	1.55	1						1		1	1	1	1		1			1					8	- 7	-56	392
- 6	1.60							1	1	1	1	1	2	2	1			1					11	- 6	-66	396
- 5	1.65						1	1	3	3	1		1	1	1								12	- 5	-60	300
- 4	1.70										2	2	2	1	1	3		1	1	1			14	- 4	-56	224
- 3	1.75				1	1	1	1	1	4	1	1	2	2	1	2	1			1			20	- 3	-60	180
- 2	1.80				1				1	4	2	3		2	2	2	3	1		1			22	- 2	-44	88
- 1	1.85					1	1			1	2	1	2	1	1	3	1	1					15	- 1	-15	15
0	1.90				1		1	2	1		6	2	6	3	3	2			1			1	29	0	-470	0
1	1.95						1	3	3		3	1	3	1	3	4	1	2					25	1	25	25
2	2.00					1	1		2	4	3	3		3		1		1				1	20	2	40	80
3	2.05						2		1	5	2	1	3	2					2				18	3	54	162
4	2.10						1	1			1			3	1		2		1		1		11	4	44	176
5	2.15		1				1			1	2		2		1								8	5	40	200
6	2.20						1	1	2				1				1						6	6	36	216
7	2.25					1		1	1				1			1			1				6	7	42	294
8	2.30								1														1	8	8	64
9	2.35								2														2	9	18	162
10	2.40													1									1	10	10	100
11	2.45																						0	11		
12	2.50													1									1	12	12	144
I.	f	1	1	1	3	5	13	12	20	25	30	16	26	26	17	10	9	8	6	3	1	2	243		329	4415
II.	d	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11				
III.	fxd	-9	-8	-7	-18	-25	-52	-36	-40	-25	-220	17	52	78	68	20	54	56	48	27	10	22	522			
IV.	fxd²	81	64	49	108	125	208	108	80	25	-	17	104	234	272	100	324	392	384	243	100	242	3610			

Correlation table for weighted means

and percentage polymorphs in health.

Consider the columns of figures on the right hand side of the table. Column I. represents the frequency distribution in the class intervals of .05. This is obtained by summing the numbers, in each horizontal column, e.g. in the first interval of 1.35 - there are two cases and in the interval 1.90 - there are twenty-nine. It happens in this case that the chosen arbitrary origin coincides with the mode of the distribution. The frequency distribution thus obtained is shown in Figure 9. as a frequency polygon. In the next column II. the groups are numbered according to their distance from the arbitrary origin which is '0', the values below being negative and the values above positive. Column III. which gives a measure of the moment of the frequency, is a product of the frequency and the deviation from the mean. The sum of the negative moments is -470 and of the positive 329; i.e. the total sum of the deviations from the arbitrary origin is -141 and the mean deviation from the arbitrary origin ($\bar{x}$) is $-\frac{141}{N} = \frac{-141}{243}$

$= -.58$ class interval units.

$= -.58 \times .05 = -.0290.$

The true mean is obtained by subtracting .0290 from the mid point of the group of arbitrary origin.

i.e. the true mean is 1.925 - .029 = 1.896.

Column IV. gives the product of frequency and the deviations squared ($f \times d^2$)

i.e. the weighted squares, which summed give in this case a total of 4415. Thus the standard deviation about the arbitrary mean (x) is obtained from the formula $x^2 = \frac{fd^2}{N} = \frac{4415}{243} = 1817$ where N is the total number of observations.

The standard deviation about the true mean (x) is, therefore,

$$\sigma x = \sqrt{x^2 - \bar{x}^2}$$

$$= \sqrt{18.17 - .3367}$$

$$= \sqrt{17.73} \quad \text{class interval units.}$$

$$= 4.211 \times .05 = .21055.$$

As an estimate of the effect on the value of the mean due to errors of random sampling we may use the Standard Error obtained by the formula

$$S.E. = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{.21055}{\sqrt{243}} = \pm 0.0135$$

or the Probable Error $= \frac{.67449\sigma}{\sqrt{N}} = .0091.$

The variability may be expressed as a percentage of the mean, the Coefficient of Variation. which is a convenient method for comparison of attributes of various populations,

$$\text{i.e. C.V.} = \frac{100\sigma x}{\text{Mean}}$$

$$= \frac{100 \times .21055}{1.896} = 11.10\%$$

Similarly we may consider the frequency distribution of the percentage of

polymorphs as shown in column I. of Table 4.. This frequency distribution is reproduced a frequency polygon in Figure 3.. Column II. represents (d) or the deviation of the class intervals from the arbitrary mean in this case taken as the centre of the class 53%.

Column III. gives the products of 'f' and 'd', the sum of these being

522 - 200 = 302

∴ The variation of the arbitrary mean from the true mean $(\bar{y})$

$$= \frac{\Sigma fd}{N}$$

$$= \frac{302}{243} = 1.243 \text{ class intervals.}$$

$$= 1.243 \times 2$$

$$= 2.486$$

∴ The true mean = mid point of group + $\bar{y}$

= 54.0 + 2.486

= 56.49%

Column IV. gives the products of f and d^2 and

$$\Sigma fd^2 = 3610$$

If y is the standard deviation from the arbitrary mean

$$y^2 = \frac{\Sigma fd^2}{N} = \frac{3610}{243} = 14.85$$

and $\bar{y}^2 = 1.545$ class interval units.

If σy is the standard deviation from the true mean

$$\sigma y = \sqrt{y^2 - \bar{y}^2}$$

$$= \sqrt{14.85 - 1.545}$$

$= \sqrt{13.305}$

$=$ 3.649 class interval units

$=$ 3.649 X 2

$=$ 7.398

Standard Error $= \frac{\sigma y}{\sqrt{N}} = \frac{7.398}{\sqrt{243}} = .474$

Probable Error $= \frac{.674496}{\sqrt{N}} = .3198$

And coefficient of variation

$= \frac{100 \sigma y}{\text{mean}}$

$= \frac{100 \text{ X } 7.398}{56.49}$

$= 13.06\%$

If X and Y represent two variables in grouped series the Coefficient of Correlation (r) may be calculated from the formula

$$r = \frac{x_i y_i - \bar{x}\,\bar{y}}{\sigma x\, \sigma y}$$

where σx = standard deviation of the X's around their true mean.

σy = standard deviation of the Y's around their ture mean.

$\bar{x}$ = difference between arbitrary mean and true mean of X's.

$\bar{y}$ = difference between arbitrary mean and true mean of Y's.

$x_i y_i$ = mean product deviations around arbitrary means of X and Y.

The values for these constants are taken in working or class interval units and not in actual values.

The constants $x, y, \bar{x}, \bar{y}$ are already calculated. The calculation of $x_1 y_1$ is made from the correlation table as follows. Consider the percentage polymorphs in the class interval 35 - 37. There is one entry in this column in the square at the intersection with the weighted mean class interval 1.55 - 1.60 . The product deviation for this observation is

$$1 \text{ X}(-9 \text{ X } -7) = +63$$

In the class interval 41 - 43 there are three observations and the total product is 1 X (-3 X -6) + 1 X(-2 X -6) + 1 X (0 X -6) = +30; and so on. To simplify the calculation, Table 5. has been used. Column I. gives the deviation of classes from the arbitrary mean; Column II. the frequency; Column III. the sum of the products of the individual observations and weighted mean deviations. The total product is obtained by multiplying this first product by the percentage polymorph deviation (Column I.). Thus the sum of the total products is 408 - 438 = -30, and the mean product deviations around the arbitrary means = $\frac{-30}{243}$ Thus

$$r = \frac{-\frac{30}{243} - (-.58 \text{ X } 1.234)}{4.211 \text{ X } 3.694} = .04558.$$

It is now to be decided whether r differs significantly from zero, i.e. no correlation at all between the two variables. A preliminary statistical test is made by comparing r with the value of $\frac{1}{N-1}$ where N is the number of variables in the group. If the value of the coefficient of correlation does not exceed twice the value of $\frac{1}{N-1}$ it may be regarded as likely

Table 5.

% Polymorphs.			
I.	II.	III.	IV.
Deviation from arbitrary mean in working units.	Frequency.	First product.	Total Product Column I X Column III.
-9	1	-7	+63
-8	1	+5	-40
-7	1	-9	+63
-6	3	-5	+30
-5	5	-4	+20
-4	13	-1	+ 4
-3	12	-1	+ 3
-2	20	+18	-36
-1	25	-29	+29
0	30	-30	0
1	16	-21	-21
2	26	- 5	-10
3	26	- 2	- 6
4	17	-27	-108
5	18	-12	-60
6	9	+ 5	+30
7	8	-16	-112
8	6	+13	+104
9	3	- 9	- 81
10	1	+ 4	+ 40
11	2	+ 2	+ 22
		TOTAL	-30

that there is no correlation between the two variables. In this case $\frac{1}{\sqrt{N-1}}$ = .0643 so that the value of r does not reach this figure far less exceed twice its value. That is, statistically there is no correlation either positive or negative, in health, between the relative number of neutrophils in the circulation and the weighted mean of the polynuclear count.

Another method which may be used in examining the figures for correlation is to subgroup the observations of one variable and calculate the mean of the other variable for each subgroup, as is shown in Table 6.

Table 6.

Weighted Mean	Mean % Polys.
under 1.65	54.7
1.65 -	57.4
1.80 -	57.1
2.05 -	56.2
2.25 and over	54.9
Total	56.6

Inspection shows that for each weighted mean subgroup the percentage polymorph mean varies little throughout. In Table 7. the percentage polymorph figures are grouped according to magnitude and the mean polynuclear count calculated for each subgroup.

Table 7.

% Polys.	I.	II.	III.	IV.	V.	W.M.
Under 51	36.4	40.0	19.3	4.1	0.3	1.92
51 - 63	36.9	41.0	18.9	3.2	0.2	1.89
Over 63	35.5	40.8	19.6	3.9	0.1	1.92
Total	36.5	40.6	19.1	3.6	0.2	1.91

Again it is seen that there is little variation in the polynuclear count figures for each subgroup.

As is shown below there occurs in acute septic conditions correlation between a high percentage of polymorphs in the differential count and a low weighted mean in the polynuclear count. In the normal health series since there is no correlation present it helps us to eliminate latent focal sepsis as a factor causing the left hand shift which is present.

The statistical constants for the normal health series are shown in Table 8.

Table 8.

	Mean	Standard deviation.	Coefficient of variation	Coeff. of correlation.
% Polys.	56.49 $\pm$ 0.32	7.39 $\pm$ 0.225	13.06 $\pm$ 0.40	.04558
W.M.	1.896 $\pm$ 0.0090	0.208 $\pm$ 0.0066	10.95 $\pm$ 0.35	

The limits of Mean - 2σ to Mean + 2σ are

% Polys. 42.7 - 71.3

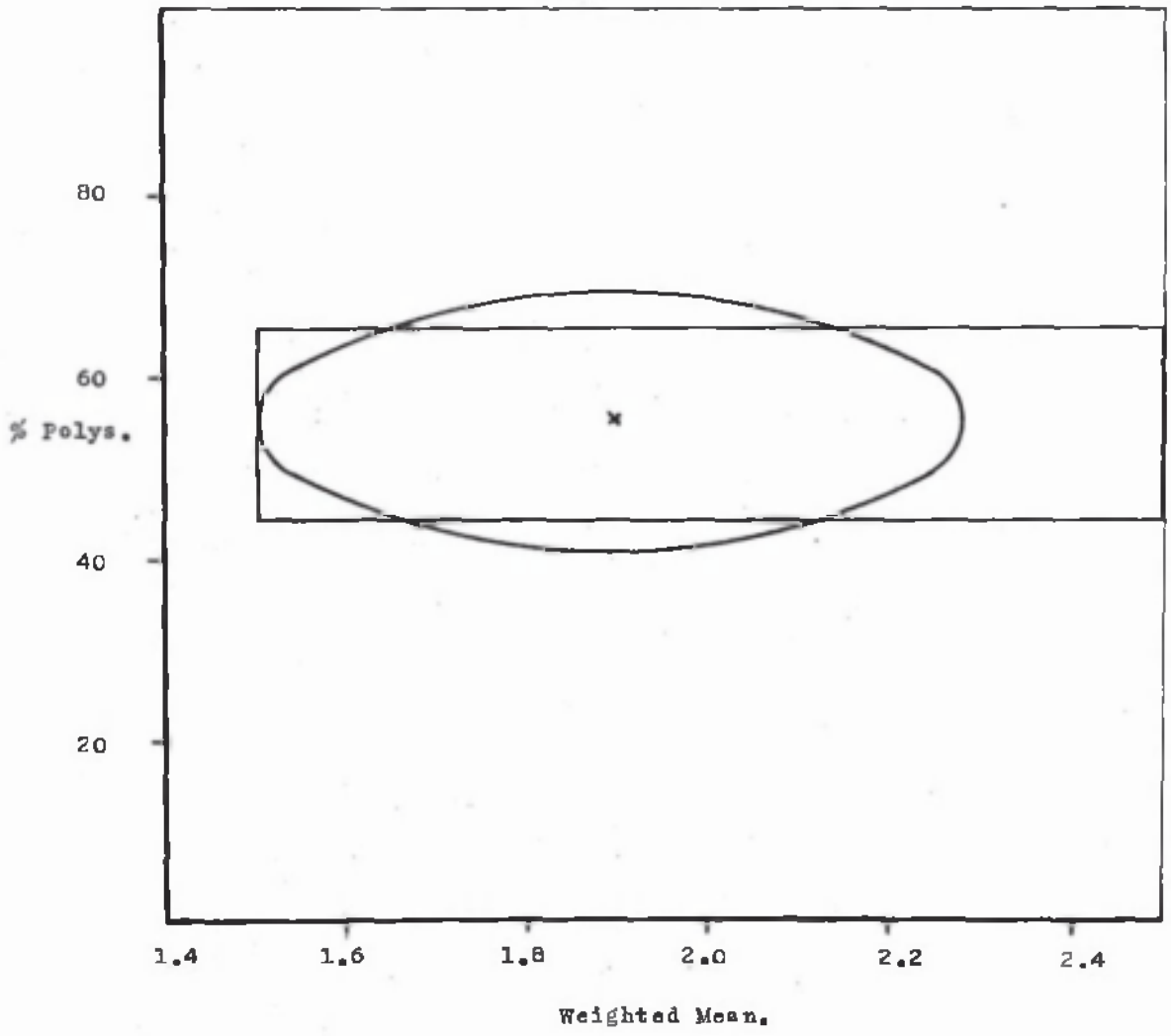
W.M. 1.46 - 2.30

Considering both variables together the area of normality may be charted as shown in Figure 8, as an elipse with axes corresponding in extent to each of these limits. Since there is no correlation between the variables the regression line is horizontal. The majority of the observations are concentrated around the means i.e. around the centre of the elipse.

For clinical application these statistical limits are somewhat unwieldy and for preliminary comparison with pathological results we have used the arbitrary limits shown as rectangle B. in Figure 7.. The arbitrary range of 45 - 65% polymorphs incoudes 86% of the observations. In the weighted means there appears to be at 1.50 a fairly definite line of cleavage between normal and pathological. The upper limit is extended to 2.50 to include the highest observation for in disease a shift to the right is extremely uncommon.

Kennedy (1935) investigated the polynuclear count in 121 'Iraqi nationals (Kurds, Jews and Arabs) in apparent good health. His results are shown in Table 9. and reproduced as a frequency polygon B. in Figure 9. In the same figure polygon A. represents the frequency of the present series of British airmen in 'Iraq, and C., Cooke and Ponder's British series. For ready comparison the frequencies are expressed as percentages of the total number of cases in each series. It is seen that both the 'Iraq polygons lie

Figure 8.



Elipse with axes Mean $\pm 2\sigma$ represents area of normality.
Centre of elipse is the intersection of the two means.
Rectangle marks arbitrary normality limits.

much to the left of the British polygon and that their similarity in form and extent is striking. By calculating the difference between the British airmen resident in 'Iraq and the indigenous population there is statistically no significant difference.

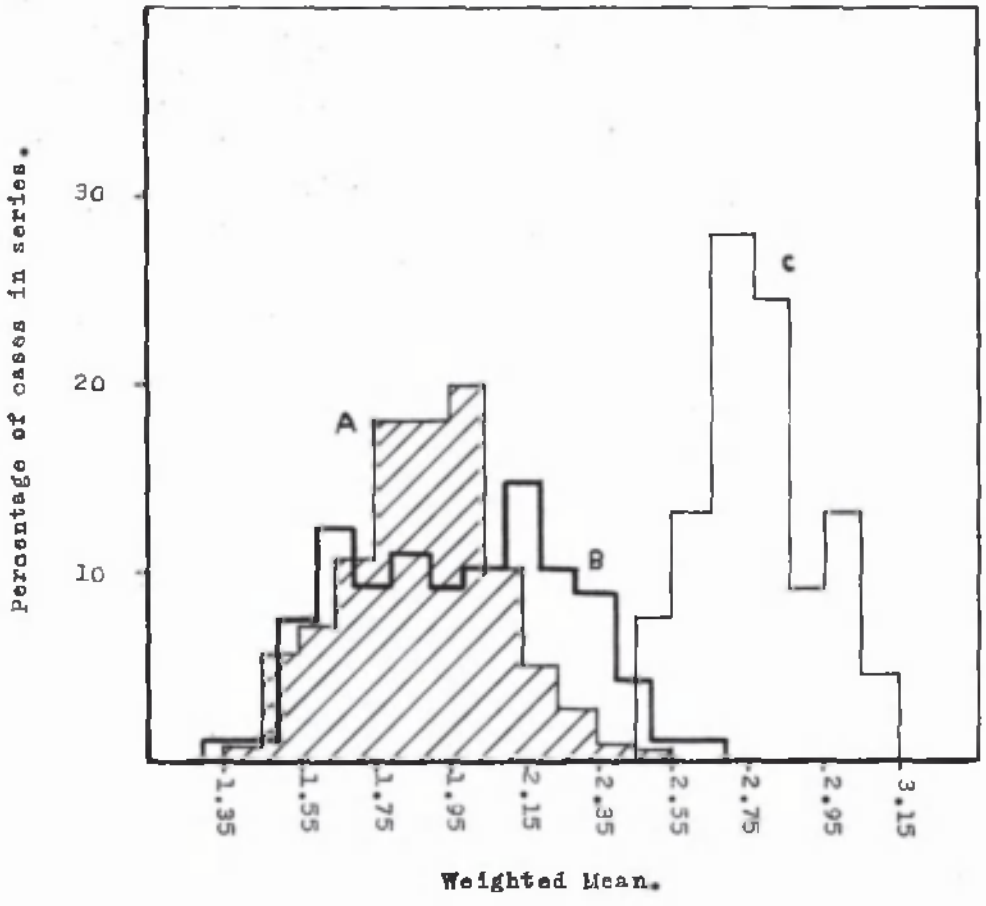
The effect of locality on the Arneth count has been studied by other workers using Cooke's technique. Some of the results are shown in Table 9.. Abels (1933-34) in 100 persons in New York found the results differed significantly from those of Cooke and Ponder and of Kennedy in Britain. MacLeod (1935) examined 25 cases each from Melbourne, Wigan, Florida, California, Alberta, Colorado, Pretoria, New York, Japan, China and Greece, and found the average weighted means arranged themselves in that order of magnitude, the highest being Melbourne and the lowest Greece.

Pai (1935 & 1936) found that in China the count of British residents approximated to that of the Chinese, and that Chinese going to Britain assumed the British type of count.

Similarly in Egypt, Shaw (1936) demonstrated that the polynuclear count of the British did not differ significantly from that of the local population and that both groups showed a shift to the left as compared with British standards. This change occurred within a few weeks of arrival in the country of residence. These facts would appear to indicate that the condition is due to environment and not to race.

British residents abroad adhere as closely as circumstances permit to

Figure 9.



Frequency polygons of weighted means:-

A. British airmen in Iraq.

B. Kennedy's Iraqi nationals.

C. Cooke and Ponder's health series.

Table 9.

Locality.	Average W.M.	Standard Error	Standard deviation
Britain (Cooke & Ponder.)	2.74	±0.019	0.18
Britain (Kennedy)	2.628	±0.02	0.19
New York (Abels)	2.30	-	-
Egyptians in Cairo (Shaw)	2.128	±0.021	0.148
British in Egypt (Shaw)	2.077	±0.024	0.135
China (Pai)	2.073	±0.027	0.178
'Iraq (Kennedy)	1.994	±0.024	0.273

home habits and customs. The food in Egypt, 'Iraq and even in China does not differ greatly from that in England. In hot weather, however, the effect of increased fluid intake with its concomitant salt loss must be remembered; as also the possibility of some unsuspected vitamin deficiency.

The other environmental agency which may affect the count is climate. 'Iraq is an arid country and in summer is intensely hot and dry. The following are official meteorological figures for August, 1935:-

Temperature		Humidity	
Av. Max.	Av. Min.	Av. Max.	Av. Min.
112.3°	78.0°	37.7	10.2

The atmosphere is laden with very fine dust whose effect on solar radiation is not yet fully investigated.

That intense heat per se is a powerful bone marrow stimulant is known. Beerman (1934) by short wave radiations raised the body temperature to 104 - 106 for three to four hours and found an initial leukopaenia followed by a leukocytosis chiefly of immature neutrophils. Exposure to ultra-violet rays has been shown, in animals (Kennedy and Thompson, 1927-28) and in infants (Sanford, 1929) to produce a left hand deviation of the count.

Recovery from the deviation caused by a single exposure takes about three weeks, but results during the recovery period in an unsteady type of count marked by double maxima. Continued stimulation would result in a leukocytosis.

unless compensated by an increased removal of cells from the circulation. In hot climates it would appear that this is what happens for we have no evidence of the occurrence of leukocytosis. That the count is in a state of equilibrium has been shown by repeated counts in the same individuals and by the absence of double maxima in any count. Since ultra-violet radiations are not deeply penetrating it is likely that they act not direct on the leukogenic centres, but by the destruction of white cells whose break-down products produce marrow stimulation.

That increased intensity of solar radiation is the only causal factor is unlikely. For in China during the cold of winter the Arneth count is deviated compared with that of Britain. Whatever the cause of the deviation the evidence seems to show that in hot climates the life of the neutrophil leukocyte is shortened. While the mechanism which controls the equilibrium of white cells in the circulation seems to remain efficient, that bone marrow stress occurs is shown by the presence of minor abnormalities in the leuko-cytes themselves, by the presence of myelocytes in increased numbers in the circulation and by the occurrence of abnormal cells such as macropolycytes.

The neutrophil picture in certain diseases in 'Iraq.

a. Acute Pyogenic Infections.

A series of forty-one blood counts were done in British personnel (33 cases) and in natives (8) in the following acute pyogenic conditions. Acute appendicitis (14 cases), pneumonia (11), osteomyelitis (5), sepsis,

following burns (3), cholecystitis (3), peritonsillar abscess (2), erysipelas (2) and perinephric abscess (1). The detailed results of the percentage of neutrophils in the differential count and the polynuclear counts are shown in Index II..

It should be noted that only these cases are included in which one has a well-marked systemic reaction. This is to demonstrate the further shift to the left that occurs in 'Iraq in acute sepsis and the increase in neutrophils in the diseases in which one normally gets a leukocytosis. The number of cases is small but the group is sufficiently large to demonstrate the points in its statistical analysis. In estimating the value of the results the fewness of the cases must be borne in mind.

Table 10. is a correlation table showing the cases grouped as in Table 4. Inspection of this table shows a line of trend in the grouping of the observations, the latter being concentrated in the bottom left hand corner and in the top right hand corner of the diagram. That is, superficial inspection shows that there may be some degree of correlation between low values of X (Weighted Mean) and high values of Y (percentage of polymorphs.). The values of the statistical constants are shown in Table 11.

Table 11.

	Mean.	Standard deviation	Coefficient of variation
% Polys.	76.01 ± .94	8.87 ± .66	11.67 ± .89
W.M.	1.398 ± .074	.1643 ± .012	12.01 ± .91

Table 10.

% Polymorphs.

Weighted Means.

		-8 61-	-7 63-	-6 65-	-5 67-	-4 69-	-3 71-	-2 73-	-1 75-	0 77-	1 79-	2 81-	3 83-	4 85-	5 87-	6 89-	7 91-	I d	II f	III fxd	IV fxd^2
-7	1.05												1				1	-7	2	-14	98
-6	1.10												1					-6	1	- 6	36
-5	1.15														1			-5	1	- 5	25
-4	1.20		1					1				1			1			-4	4	-16	64
-3	1.25															1		-3	1	- 3	9
-2	1.30					1		1								2	1	-2	4	- 8	16
-1	1.35						1	1		2	1							-1	5	- 5	5
0	1.40				1		1	1	1	3			1			1	1	0	10	-57	-
1	1.45							1										1	2	2	2
2	1.50		1					1			1							2	3	6	12
3	1.55				1	1	1						1					3	3	9	27
4	1.60	1			1													4	2	8	32
5	1.65		1		1						1							5	3	15	75
I	f	1	3	0	4	2	3	5	1	5	1	1	5	0	3	4	3		41	40	401
II	d	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7				
III	fxd	-8	-21	0	-20	-8	-9	-10	-1	-77	1	2	15	0	15	24	21	78			
IV	fxd^2	64	147	0	100	32	27	20	1		1	4	45	0	75	144	147	807			

Correlation table for

acute pyogenic infections.

In this case the calculation of the coefficient of correlation is given in detail since there proves to be statistical correlation between the two variables under consideration. For this reason, since it will be referred to later in calculating the Coefficient of Regression, Table 12. is included, i.e. the table used in calculating x_1y_1 the mean product deviation round the arbitrary means of X and Y.

Table 12.

Deviation from Arbitrary Mean.	Frequency.	1st Product.	2nd Product.
-8	1	+ 4	-28
-7	3	+ 3	-21
-6	0	0	0
-5	4	+12	-60
-4	2	+ 1	- 4
-3	3	+ 2	- 6
-2	5	- 2	+ 4
-1	1	0	0
0	5	- 2	0
1	1	- 1	- 1
2	1	- 4	- 8
3	5	- 7	-56
4	0	0	0
5	3	- 7	-35
6	4	- 7	-42
7	3	- 9	-63
	Total 41		Total -320

$$\therefore \quad x_1y_1 = \frac{-320}{41}$$

Coefficient of Correlation (r) $= \dfrac{x_1 y_1 - \bar{x}\,\bar{y}}{x\ y}$

$$= -\frac{\frac{320}{41} - (-.4146 \times .02439)}{3.286 \times 4.436}$$

$$= -.5353$$

and $\dfrac{1}{\sqrt{N-1}} = .1580$

i.e. r exceeds twice the value of $\dfrac{1}{\sqrt{N-1}}$ therefore we may say that there is negative correlation between the constants, low values of X being associated with high values of Y.

The Coefficient of Regression, i.e. the expression of the association of one variable in terms of the other is given by

$$\frac{\text{Standard Deviation of W.M.}}{\text{Standard Deviation of \% Polymorphs}} \times r$$

$$= \frac{.1643}{8.072} \times -.1643$$

$$= .009913 = \text{Coefficient of Regression.}$$

i.e. for every increase of 1% in polymorphs in the differential count there is a fall in the Weighted Mean of the polynuclear count of .01 (approx.). Knowing this value we may now draw the Regression Line, by calculating the value of X for each midpoint group value of Y. In doing this we make use of Table 13. Column I. gives the midpoint value for each group of the Y series (percentage polymorphs), Column II, the frequency; Column III. the sum deviation in working units. Column II. and III. are the same as columns II. and III. in Table 12.

Table 13.

I.	II.	III.	IV.	V.
Midpoint group % polymorphs.	No. of observ. % polymorphs.	Sum of deviation in working units.	Cw or average deviation from mean in Working units.	Actual W. M.
61.5	1	+4	+4	1.60
63.5	3	+3	+1	1.45
65.5.	0	0	0	0
67.5	4	+12	+3	1.55
69.5	2	+1	+.5	1.42
71.5	3	+2	+.66	1.43
73.5	5	-2	-.4	1.38
75.5	1	0	-1	0
77.5	5	-2	-4	1.38
79.5	1	-1	-1.4	1.35
81.5	1	-4	0	1.20
83.5	5	-7	-2.3	1.33
85.5	0	0	-1.7	0
87.5	3	-7	-3	1.28
89.5	4	-7		1.31
91.5	3	-9		1.25

Column IV. gives Cw or the average deviation in working units. Cw in this case multiplied by .05, the group value for Weighted Means gives the actual average deviation from the arbitrary mean. Column V. gives the actual means of weighted means corresponding to the midpoint of the groups of percentage polymorphs.

Plotting these values gives us the observed regression line shown in Figure 10. The line shows a steady downward trend, but is somewhat irregular, probably because of the small number of variables in the series. It may be noted that the dip corresponding to 81.5% polymorphs is due to the fact that there is only one observation in this group.

The calculated regression line is obtained as follows. We know that the corresponding mean values for the two variables are percentage polymorphs 76.01 and weighted mean 1.398. But the values charted are mid group values of percentage polymorphs. The value associated with the nearest mid group point of 75.5% is 1.406,

at 65.5% is 1.506,

and at 85.5% is 1.306,

taking it that there is a fall of .01 (actually .009913) in the weighted mean for every 1% increase in polymorphs. These values when plotted will be seen to lie on a straight line - the line of best fit to the observed values, the equation for which is -

$$y = r \frac{\sigma y}{\sigma x} x$$

Figure 10.

Regression lines for acute pyogenic infections.

Calculated Regression Line ———
Observed Regression Line ———

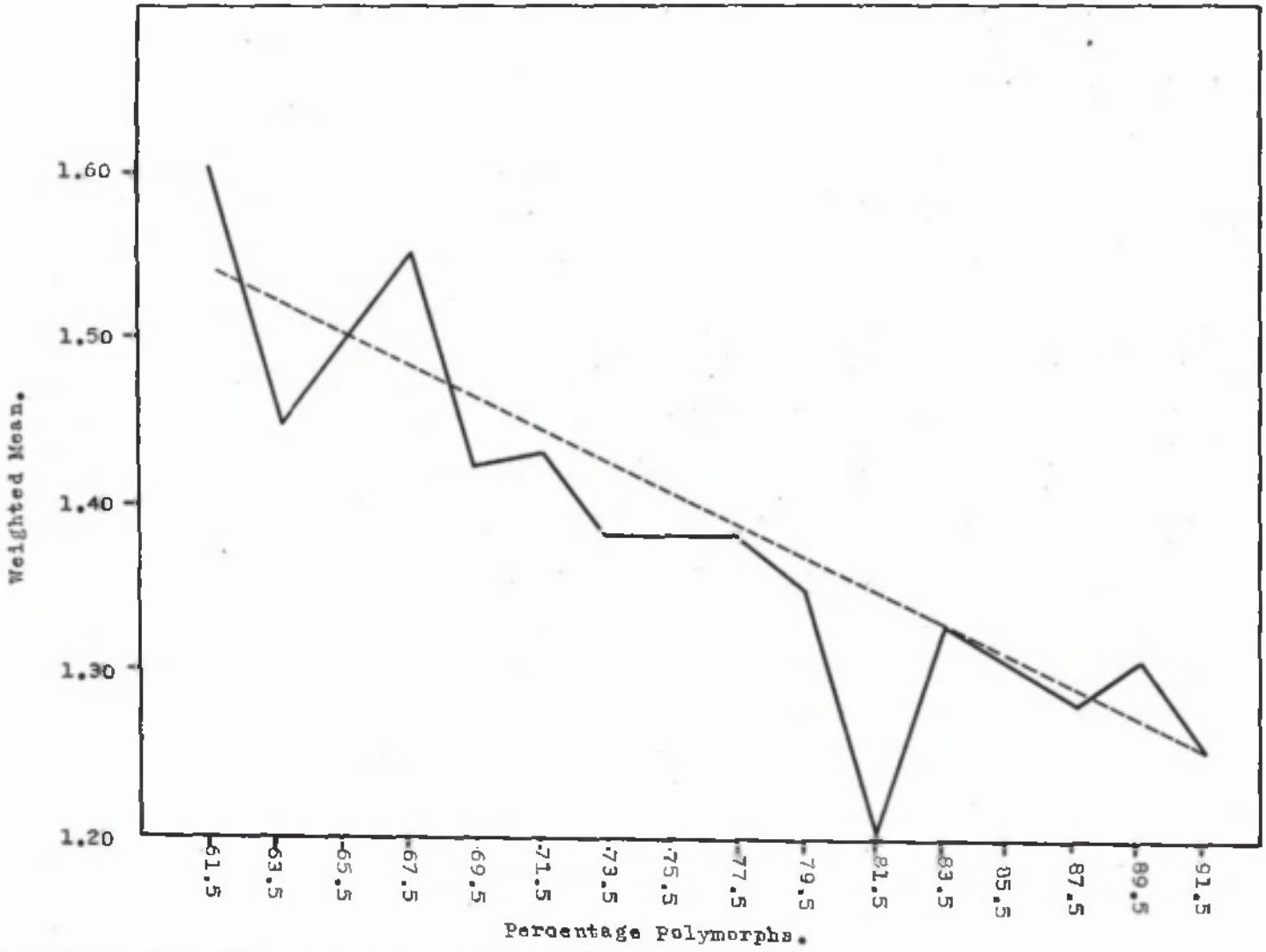
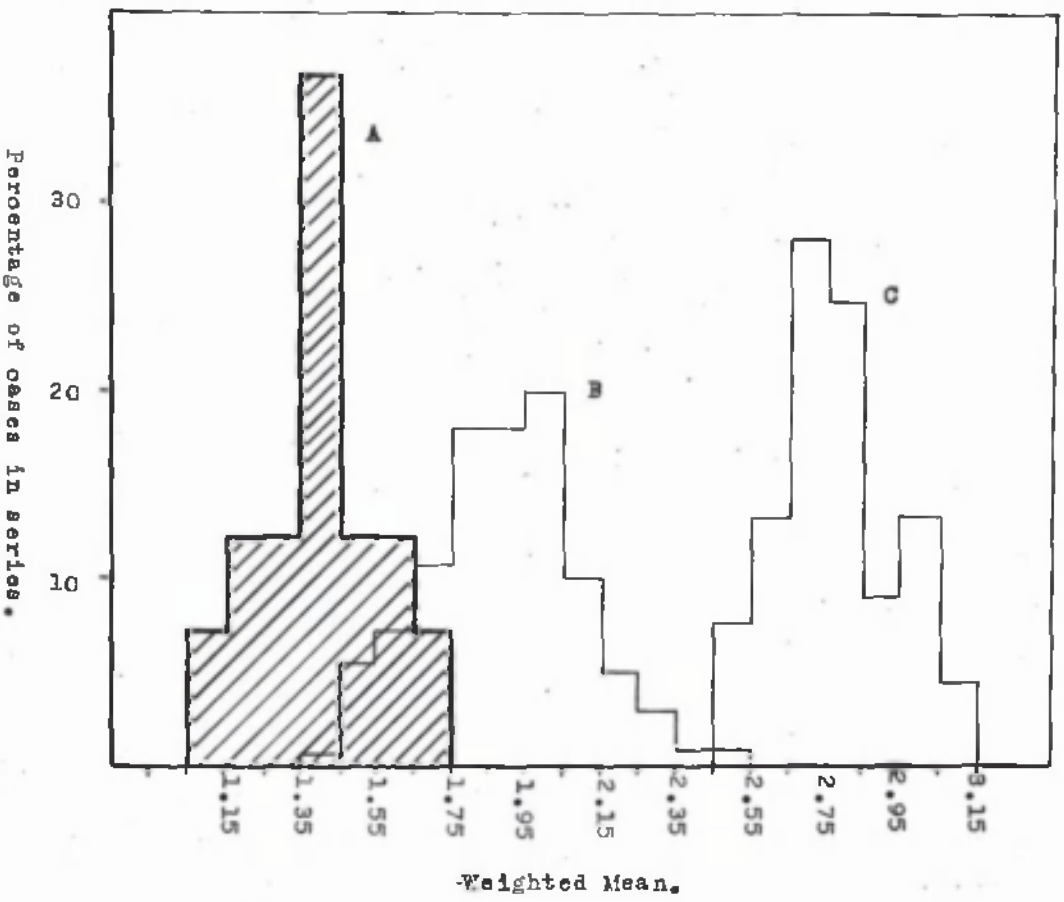


Figure 11.



Frequency polygons of weighted means.

A. Acute pyogenic infections.

B. British airmen in 'Iraq.

C. Cooke and Ponder's British series.

Figure 11. shows the frequency polygons of the acute sepsis group (A) with, for comparison, the health series (B) and the Cooke and Ponder series (C). The diagram illustrates the further shift to the left that occurs in acute pyogenic diseases.

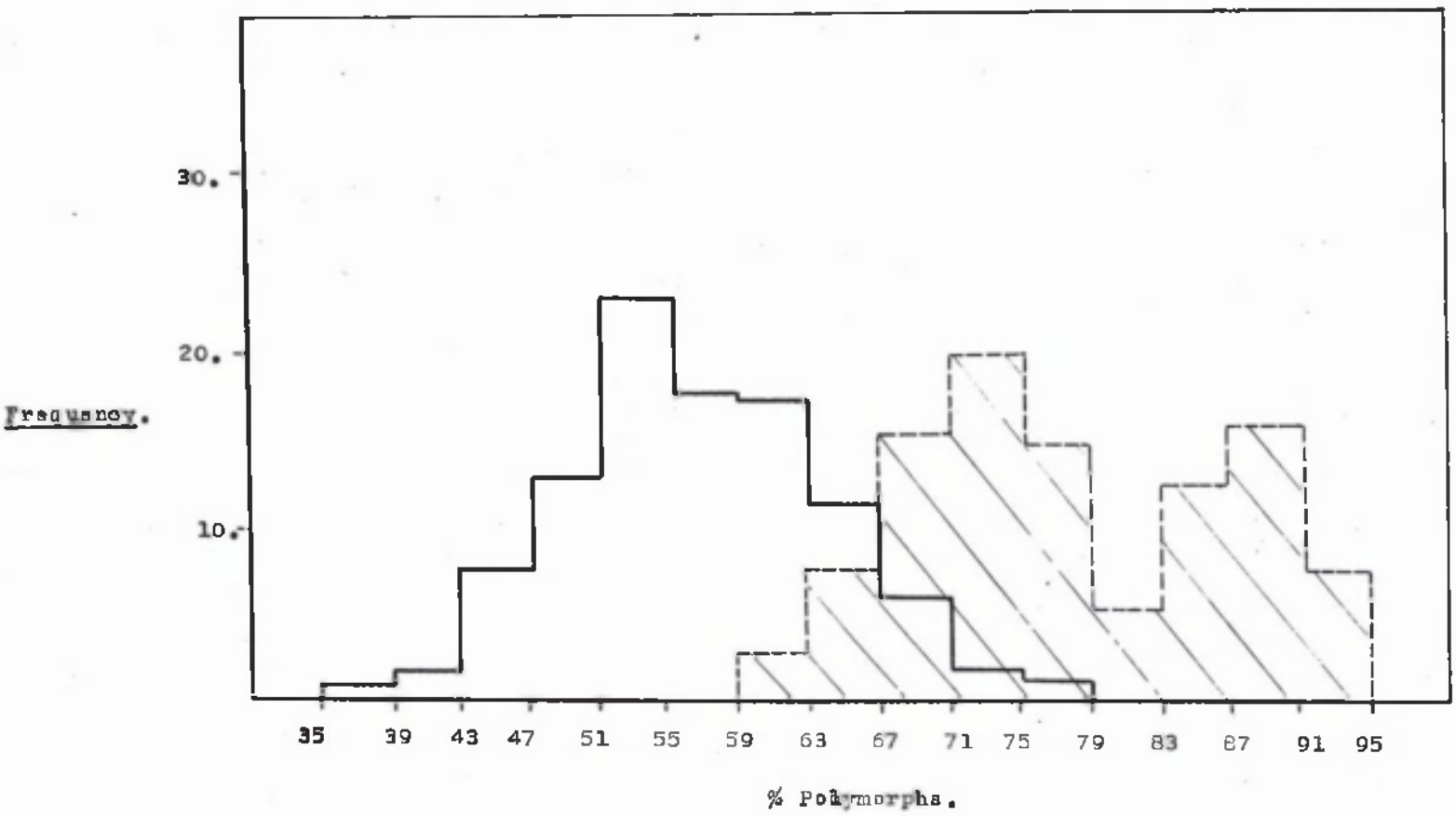
It also illustrates an interesting statistical fallacy caused by too coarse grouping of the series. It is seen from Table 10. that using grouping of 1.05 - 1.10; 1.10 - 1.15 and so on, the frequency is quite irregular. But grouping - 1.15; 1.15 - 1.25; 1.25 - 1.35 and so on, as is done in the diagram, the frequency is found to be 3,5,5,15,5,5,3 giving a perfectly symmetrical polygon. This is entirely due to chance and is in no way significant. In the figure the frequencies are expressed, not in actual numbers, but as percentages of 41, the total number in the series.

The increase in neutrophils in acute sepsis is similarly illustrated by a frequency polygon in Figure 12., with the polygon for the normal series. In this case the frequencies are grouped at intervals of 4%, and the observations expressed as percentages of the total number in each series.

b. Phlebotomus Fever.

Manson-Bahr (1935) defines phlebotomus fever as a "specific fever of short duration and no mortality, caused by a germ introduced by the bite of the sandfly (phlebotomus)". The usual duration of the pyrexia is three days and there may be associated upper respiratory or gastro-intestinal complications. The pyrexial stage is followed by a convalescent period of three to four weeks

Figure 12.



Frequency Polygons for Percentage Polymorphs

in Normal series and Acute Pyogenic Infections (shaded).

during which time there is marked physical debility with, frequently, extreme mental depression.

In 'Iraq the incidence of the disease is seasonal, reaching its height between May and September. At this time malaria also is rife and since these two diseases are very similar in the early stages, differential diagnosis is of importance. Phlebotomus fever also resembles clinically both dengue fever and influenza and as in these diseases the blood picture is leukopaenic. This has been reported by McCarrison (1906) and Birt (1913). More recently Whittingham (1923) working in Malta investigated in detail the leukocyte picture in phlebotomus fever as did Shortt, Poole and Stephens (1934) in the disease experimentally induced.

Whittingham records a leukopaenia for the first three to five days of the disease, occasionally followed about the tenth day by a moderate leukocytosis. He found the lowest average count of this series on the first day of illness, the lowest individual count being 2700 cells per c.mm. The leukopaenia chiefly affected the neutrophil leukocytes.

In the present series of 74 cases, total white cell, differential, and polynuclear counts were made; the detailed results are tabulated in Index III. As a preliminary investigation the leukocyte counts were done in 11 cases daily for 7 days i.e. the duration of stay in hospital, and thereafter weekly for further three weeks. It was found that the most typical blood picture occurred on the second or the third day of disease. At this stage there is still a marked leukopaenia. Indeed in a few cases the maximum fall in the total white

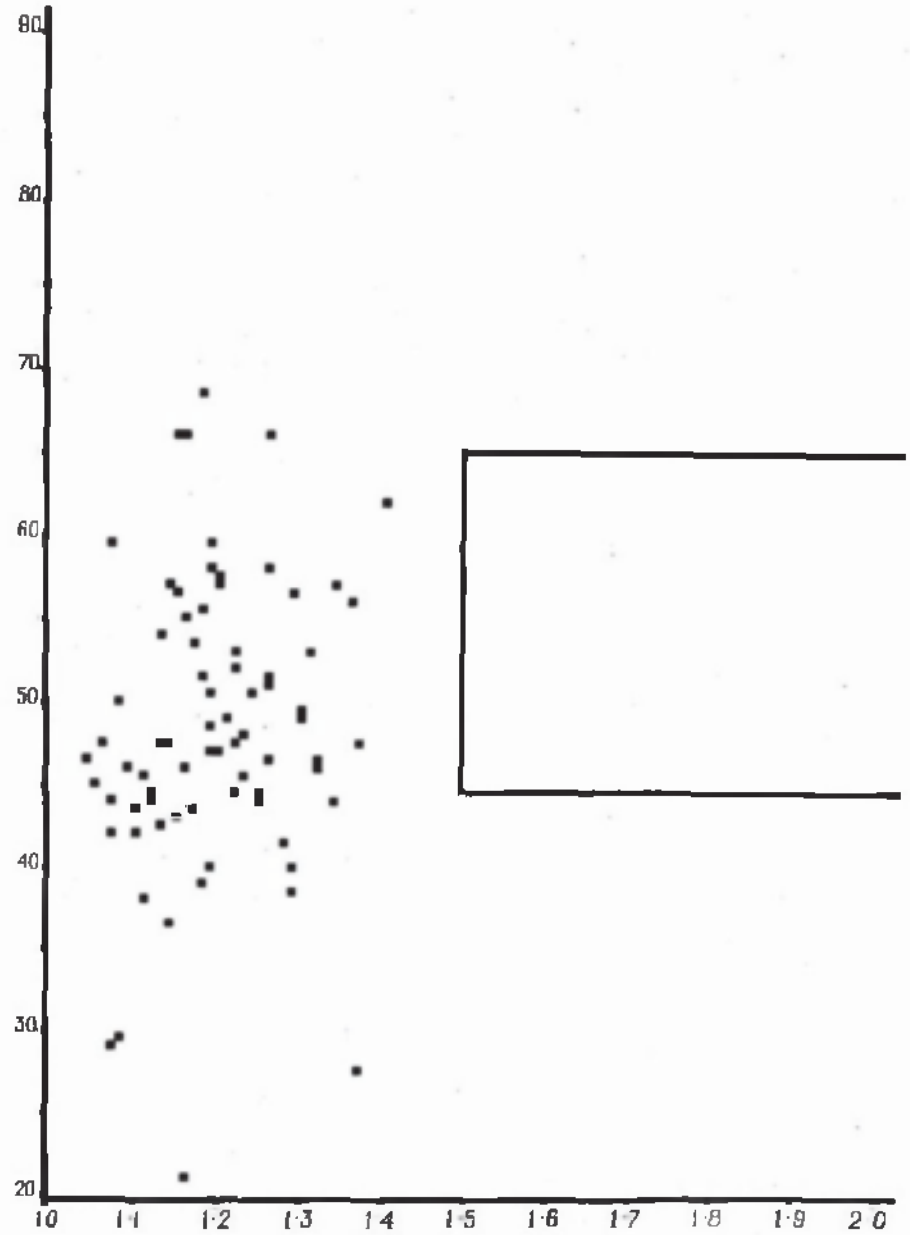


Figure 13. Correlation diagram for Phlebotomus Fever.

Table 14.

% Polymorphs.

Weighted Mean.	-13 21	-12 23	-11 25	-10 27	-9 29	-8 31	-7 33	-6 35	-5 37	-4 39	-3 41	-2 43	-1 45	0 47	1 49	2 51	3 53	4 55	5 57	6 59	7 61	8 63	9 65	10 67	f	d	fxd	fxd^2
1.00													1												1	-3	-3	9
1.05					2						1	1	2	1	1					1					9	-2	-18	36
1.10								1	1		2	3	1	2			1		1						12	-1	-12	12
1.15	1									2		2	1	2	1		1	3	1	1			2	1	18	0	-33	
1.20												1	1	3	2	2	1		2						12	1	12	12
1.25									1	1	1	2	1			2		1	1				1		11	2	22	44
1.30												1	2		2		1		1						7	3	21	63
1.35				1										1				1							3	4	12	48
1.40																					1				1	5	5	25
f	1	0	0	1	2	0	0	1	2	3	4	10	9	9	6	4	4	5	6	2	1		3	1	74		72	249
d	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10				
fxd	-13	0	0	-10	-18	0	0	-6	-10	-12	-12	-20	-9	-0	6	8	12	20	30	12	7		27	10	132			
fxd^2	169	0	0	100	162	0	0	36	50	48	36	40	9	0	6	16	36	80	150	72	49		243	100	1402			

Correlation table for

phlebotomus fever.

count was found as late as the third day, and it is about this time that the greatest deviation of the polynuclear count occurs. Of the 74 counts recorded, 58 were made on the second day of disease and the remainder on the third.

These cases complicated by superadded infection (sore throat, etc.) are not included, since even a mild septic condition may alter the blood picture.

In Figure 14. are charted the temperature, the total white count, the percentage of polymorphs and the weighted mean of the polynuclear count daily for seven days in one case in which the course of the disease was typical. It happened that this patient had a blood examination done while in good health a fortnight previous to the onset of the illness. The results in health are charted for comparison. It is seen that with the fall in temperature on the fourth day the total white count and the number of polymorphs return to normal but the weighted mean is still only 1.47 the normal being 1.84 . In this case the weighted mean did not reach normal until four weeks after the onset of the disease. A similar result was obtained in the other cases followed up during convalescence. It is of interest to note that it is at this time that occur the sequelae of phlebotomus fever such as acute depression and neurosis.

In Figure 13. are plotted the correlated results of the percentage polymorphs and the weighted means of the 74 cases. For comparison the left-hand end of rectangle B. in Figure 7. is included, defining the lower border of

Figure 14.

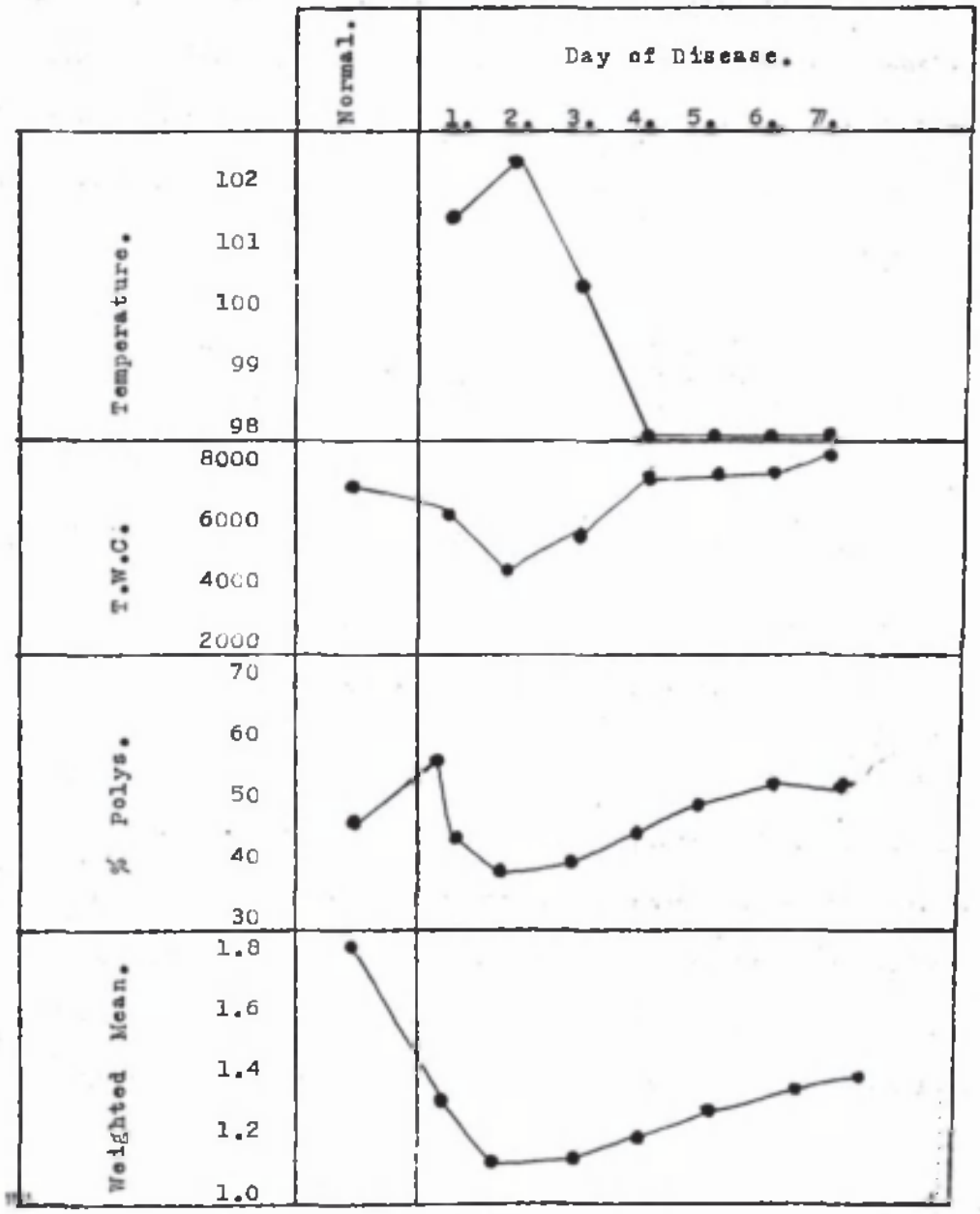


Chart showing the relation between temperature and the leukocyte picture in phlebotomus fever.

normality of the weighted mean. The charted results show remarkably close grouping of the plotted points, with a downward tendency in the percentage of polymorphs and a marked shift to the left in the Arneth count.

The results are also grouped in the correlation table, Table 14. from which are calculated the statistical constants tabulated below.

Table 15.

	Mean.	Standard deviation	Coefficient of variation
% Polys.	48.59 ± .68	8.68 ± .481	17.87 ± 1.02
W.M.	1.398 ± .074	.1643 ± .012	12.01 ± .91

The coefficient of correlation is .1743 and since the value of $\frac{1}{\sqrt{N-1}}$ is .117, there is no correlation between the two variables.

c. Malaria.

In the investigation of the neutrophil picture in malaria 126 cases were examined. Of these 47 were British airmen and 79 Arab Levies. All are considered together because there was found to be no significant difference between the two groups either in the percentage of polymorphs or the weighted mean. Of the cases 36 were benign tertian infections and 90 malignant tertian.

Much work has been done on the differential count in malaria and the consensus of opinion appears to be that just before the attack there is often

a pronounced leukopaenia, while at the height of the paroxysm and just after, there is usually a moderate degree of leukocytosis. No attempt was made to obtain blood films at any particular phase of the malarial cycle. The films used were, for the most part, those sent to the laboratory for the purpose of diagnosis. For inclusion in this series the only criteria insisted on were that the patient should have a temperature of over 100° at the time of sampling and that parasites be present in the slide counted.

The individual results are diagrammatically shown in Figure 15. Scrutiny of the diagram shows that the scatter of the plotted results is wider than in the case of phlebotomus fever. In view of the cyclical variation in the number of neutrophils known to occur during the course of a malarial attack this is to be expected. It is also seen that the cases of benign tertian infection (hollow squares) show a more consistent left-handed shift than do the malignant tertian cases (solid squares). This is also to be expected when one remembers that in the early stages the illness of benign tertian infection is more acute than that of malignant. Although the fatality rate is higher in the latter, the onset is often very insidious. It was observed that those cases most seriously ill clinically showed the most marked deviation of the polynuclear count.

Table 16. is a correlation table from which are calculated the statistical constants tabulated overleaf.

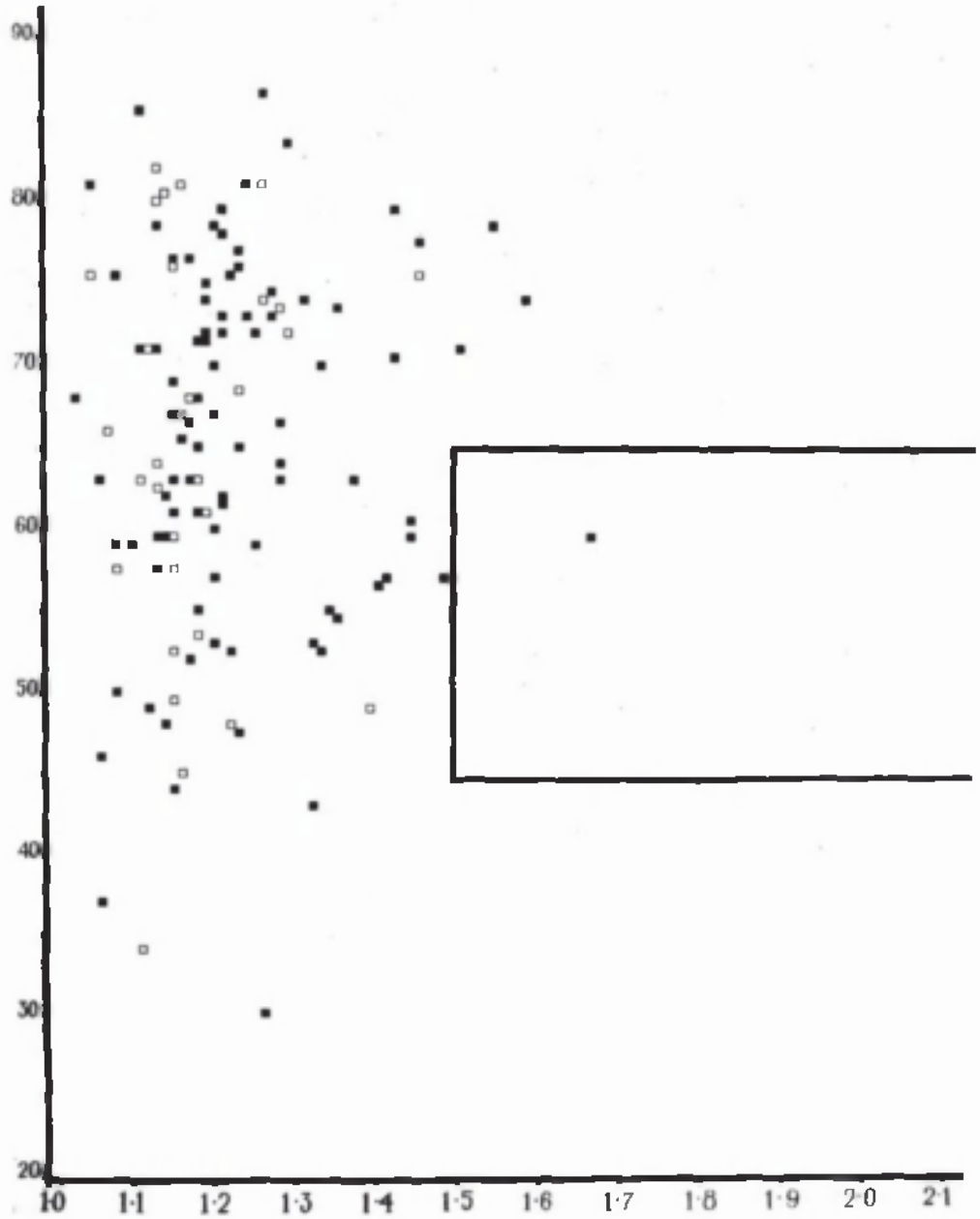


Figure 15. Correlation diagram for malaria.

■ Malignant Tertian.
□ Benign Tertian.

Table 16.

% Polymorphs.

	−17 29	−16 31	−15 33	−14 35	−13 37	−12 39	−11 41	−10 43	−9 45	−8 47	−7 49	−6 51	−5 53	−4 55	−3 57	−2 59	−1 61	0 63	1 65	2 67	3 69	4 71	5 73	6 75	7 77	8 79	9 81	10 83	11 85	f	d	fxd	fxd²
1.00																				1										1	−4	−4	16
1.05					1				1		1				1	1		1	1					2			1			10	−3	−30	90
1.10			1							1	1				1	3	2	2				2			1	2	1		1	18	−2	−36	72
1.15				1				1	1		1	1	1	1	1	1	3	3	3	4	1	3	1	4			1			32	−1	−32	32
1.20		1								1		1	1	1	1	1	2			2	1	2	2	2	3	1	1		1	24	0	−102	0
1.25	1															1		2	1			2	5				1	1	1	15	1	15	15
1.30								1		1			1	1							1		1							6	2	12	24
1.35											1		1					1					1							4	3	12	36
1.40														1	1	2			1		1					1				7	4	28	112
1.45															1								1	1	1					4	5	20	100
1.50																						1			1					2	6	12	72
1.55																							1							1	7	7	49
1.60																																	
1.65																1							1							2	9	18	162
f	1	1	1	1	1	0	0	2	2	3	4	2	4	4	6	10	7	9	6	7	4	10	13	9	6	4	5	1	3	126		124	780
d	−17	−16	−15	−14	−13	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1	0	1	2	3	4	5	6	7	8	9	10	11				
fxd	−17	−16	−15	−14	−13	0	0	−20	−18	−24	−28	−12	−20	−16	−18	−20	−7	−258	6	14	12	40	65	54	42	32	45	10	33	353			
fxd²	289	256	225	196	169	0	0	200	162	192	196	72	100	64	54	40	7		6	28	36	160	325	324	294	256	405	100	363	4519			

Weighted Mean.

Correlation Table for Malaria.

Table 17.

	Mean.	Standard deviation	Coefficient of variation
% Polys.	65.08 ± 0.71	11.88 ± 0.51	18.26 ± 0.80
W.M.	1 234 ± .0075	0 124 ± .0053	10.06 ± 0.43

Coefficient of correlation = .0987; $\frac{1}{\sqrt{N-1}}$ = .0895.

c. Leprosy.

The blood was examined in 96 Arab lepers, 9 female and 87 male, the age range being 12 to 60. The patients at the time of examination were under treatment in the isolation hospitals at Baghdad and Basrah. All were advanced cases in which diagnosis had been confirmed by the finding of the leprosy bacillus. All suffered from the nodular type of leprosy, many in addition having nerve lesions.

The Baghdad cases were under treatment by intra-venous methylene blue but the Basrah cases were being treated along general lines only. There was no significant difference in the leukocyte count findings of the two groups.

The results, the percentage of polymorphs and the polynuclear count, are plotted as a spot diagram in Figure 16. and are grouped in the correlation table, Table 19.. Inspection of Figure 16. shows that compared with the normals or the other disease groups there is a wide scatter of the plotted points. There is also observed a drift to the left in the polynuclear count

and a fall in the percentage of polymorphs. This is confirmed by the statistical constants tabulated below.

Table 18.

	Mean.	Standard deviation	Coefficient of variation.
% Polys.	46.75 ± 0.87	12.63 ± 0.62	27.03 ± 1.41
W.M.	1.524 ± .0150	0.218 ± .0106	14.43 ± 0.71

Coefficient of correlation = -.1206; $\frac{1}{\sqrt{N-1}}$ = .1021

The variability both of the percentage of polymorphs and of the weighted mean is greater than of any of the other groups considered. This is what one would expect in a population such as this. The general condition of the lepers in 'Iraq even while undergoing hospital treatment is very poor. Most of them are chronic malaria carriers and only receive anti-malarial treatment during febrile attacks. In five of the blood smears counted malarial parasites were actually present in fair numbers. The majority of the cases also suffer from helminth infection, many from chronic gonorrhoea and a few from active syphilis or tuberculosis. The blood examination of this group, therefore, cannot be regarded as typical of leprosy; it is merely the picture obtained in a leprous population where multiple chronic infection is rife, and is of value for comparison with the health group and other pathological groups.

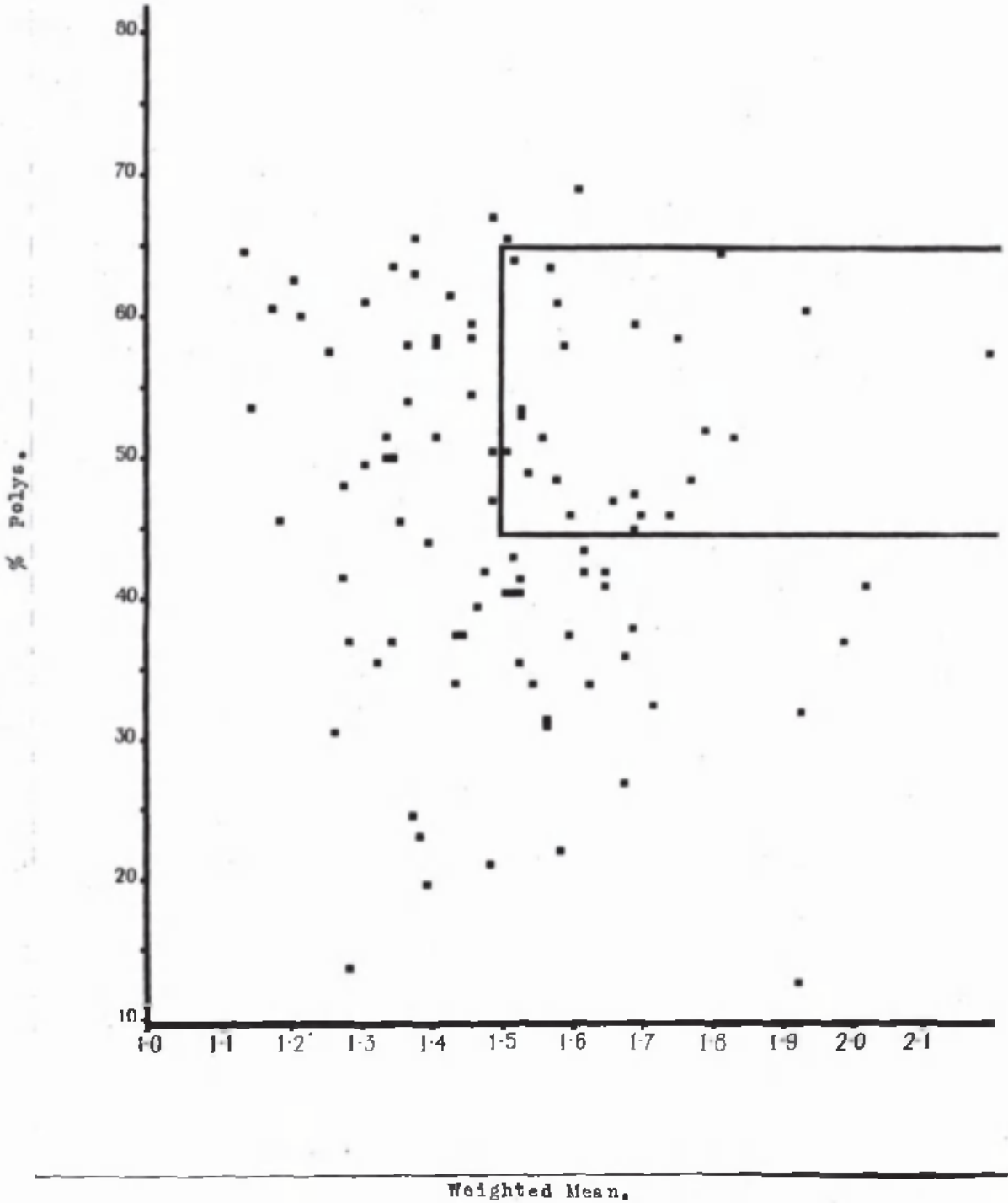


Figure 16. Correlation diagram for Leprosy.

Table 19.

% Polymorphs.

Weighted Mean.

	−15 11	−14 13	−13 15	−12 17	−11 19	−10 21	−9 23	−8 25	−7 27	−6 29	−5 31	−4 33	−3 35	−2 37	−1 39	0 41	1 43	2 45	3 47	4 49	5 51	6 53	7 55	8 57	9 59	10 61	11 63	12 65	13 67	14 69	f	d	fxd	fxd²
1.10																						1					1				2	−10	−20	200
1.15																		1							1						2	−9	−18	162
1.20																									1	1					2	−8	−16	128
1.25		1								1				1		1			1					1							6	−7	−42	294
1.30													1	1							3	1				1	1				8	−6	−48	288
1.35					1		2										1	1				1		1			1	1			9	−5	−45	225
1.40												1		1	1						1			2		1					7	−4	−28	112
1.45						1									1	1			1	1		1		1	1				1		9	−3	−27	81
1.50												1	1		3	1	1			2		2				1	1				13	−2	−26	52
1.55						1					2			1			1	1	1		1			1		1	1				11	−1	−11	11
1.60												1				3														1	5	0	−201	0
1.65									1				1	1				2	2					1	1						8	1	8	8
1.70											1							1						1							3	2	6	12
1.75																			1		1										2	3	6	18
1.80																					1					1					2	4	8	32
1.85																															0	5	0	0
1.90	1										1														1						3	6	18	108
1.95														1																	1	7	7	49
2.00																1															1	8	8	64
2.05																															0	9	0	0
2.10																															0	10	0	0
2.15																								1							1	11	11	121
2.20																															0	12	0	0
2.25																															0	13	0	0
2.30																															0	14	0	0
2.35															1																0	15	0	0
2.40															1																1	16	16	256
																															96		80	2221
f	1	1	0	0	1	2	2	0	1	1	4	3	3	6	6	7	3	6	6	6	5	5	0	8	5	4	6	2	1	1				
d	−15	−14	−13	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14				
fxd	−15	−14	0	0	−11	−20	−18	0	−7	−6	−20	−12	−9	−12	−6	150	3	12	18	24	25	30	0	64	45	40	66	24	13	14	378			
fxd²	225	196	0	0	121	200	162	0	49	36	100	48	27	24	6	0	3	24	54	96	125	180	0	512	405	400	726	288	169	196	4372.			

Correlation Table for

LEPROSY.

In phlebotomus fever the fall in the number of polymorphs is due to leukopaenia. But in the lepers the diminution is a relative one, there being an actual increase of other cells, chiefly mononuclears and also of eosinophils, the eosinophilia being due to helminth infection

Comparison may now be made of the two variables, percentage of polymorphs and weighted mean, in respect of the five groups of individuals; normals, cases of acute sepsis, of phlebotomus fever, malaria and leprosy. Constants descriptive of the groups, the mean, standard deviation and coefficient of variation together with their probable errors are shown in Tables 20. and 21.

Table 20.

	Percentage Polymorphs		
	Mean	Standard deviation	Coefficient of Variation.
Normals.	56.49 ± 0.32	7.39 ± 0.225	13.06 ± 0.40
Acute sepsis.	76.01 ± 0.94	8.87 ± 0.66	11.67 ± 0.89
Phlebotomus F.	48.59 ± 0.68	8.68 ± 0.48	17.87 ± 1.02
Malaria.	65.08 ± 0.71	11.88 ± 0.51	18.26 ± 0.80
Leprosy.	46.75 ± 0.87	12.63 ± 0.62	27.03 ± 1.41

Table 21.

Weighted Mean.

	Mean	Standard deviation	Coefficient of Variation
Normals.	1.896 ± .0091	0.208 ± .0066	10.95 ± 0.35
Acute sepsis.	1.398 ± .0173	0.164 ± .012	12.01 ± 0.91
Phlebotomus F.	1.201 ± .0069	0.088 ± .0049	7.31 ± 0.41
Malaria.	1.234 ± .0075	0.124 ± .0053	10.06 ± 0.43
Leprosy.	1.524 ± .0150	0.218 ± .0106	14.43 ± 0.71

The mean percentage of polymorphs of the healthy group is 56.5. This value is exceeded by those means for the groups malaria and acute sepsis, the latter being the highest value of the series, while those for phlebotomus fever and leprosy are lower than normal. Arranged in order of highest to lowest they are:-

Acute sepsis

Malaria

Normals

Phlebotomus Fever

Leprosy.

The variability in individuals in each group is fairly wide as can be seen by inspection of either of the moments of variation given in Table 20. Contrary to expectation the coefficient of variation is less in the sepsis disease group than in health; but there is wider dispersion among the other

disease groups. Of the latter the greatest relative variablility is seen in leprosy. This has been explained by the occurrence of multiple infection in the lepers examined.

As will be seen from Table 22, there is statistically significant difference between each of the groups, for in each case the difference between the means is greater than the recognised constant (three times the probable error of the difference).

Table 22.

Differences between groups.

	% polymorphs	Weighted mean.
Normals - acute sepsis	+19.62 ± 0.993	-0.408 ± .0195
. . - phlebot. fev.	-7.90 ± 0.752	-0.695 ± .0116
. . - malaria	+8.59 ± 0.782	-0.662 ± .0119
. . - leprosy	-9.74 ± 0.926	-0.372 ± .0176
Acute sepsis - phleb. f.	-27.42 ± 0.998	-0.197 ± .0186
. . - malaria	-10.93 ± 1.096	-0.164 ± .0261
. . - leprosy	-29.26 ± 1.279	+0.126 ± .0229
Phlebot. f. - malaria	+16.48 ± 0.987	+0.033 ± .0102
. . - leprosy	-1.85 ± 1.105	+0.323 ± .0165
Malaria - leprosy	-18.33 ± 1.125	+0.290 ± .0168

The weighted mean of the polynuclear count differs substantially in each group. The highest value is that of the normals, the mean being 1.986, while

the means of the disease groups are appreciably below this figure. Arranged in order of magnitude they are as follows:-

Normal

Leprosy

Acute sepsis

Malaria

Phlebotomus Fever.

The excess of the mean of the normals over each of the disease groups is definitely significant in a statistical sense. Similarly the differences between the disease groups themselves are all statistically significant, as is seen from inspection of Table 22.

The relative measure of variability shows, however that the weighted mean is less variable than the percentage of polymorphs. This is true of all the groups except acute sepsis. In respect of the normal group, it does not show as is usually found a lower variability than the pathological groups. The coefficient of variation for normals is 10.95 and for malaria and phlebotomus fever 10.06 and 7.31 respectively. The explanation of this apparent inconsistency is a simple one. The two diseases mentioned are those in which one finds the most marked shift to the left i.e. the lowest average weighted mean. The range of the weighted mean is limited at the lower end by the absolute extreme of 1.00. And since all the cases examined showed a marked systemic reaction, with the majority of weighted means below

the lower limit of normality of 1.50 the possible range is much less extensive than that of the normal group where deviation is possible either to the right or to the left.

What is the relationship between the percentage of polymorphs in circulation and the weighted mean of the polynuclear count?. For each group are tabulated below the value of the coefficient of correlation and of the constant $\frac{1}{\sqrt{N-1}}$.

Table 23.

	Coefficient of correlation	$\frac{1}{\sqrt{N-1}}$
Normals	.04558	.0643
Acute sepsis	- .5353	.1580
Phlebotomus F.	.1743	.1170
Malaria	.0987	.0895
Leprosy	- .1206	.1021

The only group in which there is statistical relationship between the two variables is acute sepsis, where a high percentage of polymorphs is associated with a low weighted mean. It would appear that in the other three disease groups the percentage of polymorphs is not affected by the weighted mean or vice versa. In these groups this is appreciated more readily by inspection of Table 24., where are set forth the polynuclear counts classified in three categories; below 51% polymorphs; 51 - 63% polymorphs; over 63% polymorphs.

It might therefore be argued that in any population the occurrence of statistically significant negative correlation between these two variables would be fair presumptive evidence of the presence in the population of pyogenic infection.

Table 24.

Group	% Polys.	I	II	III	IV	V	W.M.	No.
Phleb.F.	Under 51	82.6	15.8	1.3	-	-	1.18	48
	51 - 63	79.6	18.7	1.7	-	-	1.22	22
	Over 63	82.7	15.8	1.5	-	-	1.19	4
	Total	81.7	16.7	1.4	-	-	1.21	74
Malaria	Under 51	83.7	14.4	1.6	0.3	-	1.18	16
	51 - 63	79.1	18.4	2.3	0.2	0.03	1.24	33
	Over 63	79.8	16.9	2.7	0.2	0.01	1.23	77
	Total	80.1	17.0	2.5	0.2	0.02	1.22	126
Leprosy	Under 51	57.0	32.4	9.1	1.2	0.1	1.54	59
	51 - 63	61.0	30.6	7.2	1.1	0.1	1.49	27
	Over 63	63.3	28.5	7.3	1.1	0.1	1.46	10
	Total	58.8	31.5	8.4	1.1	0.1	1.52	96

The clinical application of the statistically analysed data may now be considered. As has been explained, for each group the limits of twice the standard deviation about the mean includes approximately 96% of the

observations. The value of mean - 2σ and + 2σ for both variables in the normal and the pathological groups is shown below.

Table 25.

	% Polymorphs.		Weighted mean	
	Mean-2σ	Mean+2σ	Mean-2σ	Mean+2σ
Normal	41.7	71.3	1.40	2.32
Acute sepsis	58.2	93.8	1.08	1.72
Phlebotomus fever	31.2	65.0	1.03	1.37
Malaria	41.2	89.0	1.00	1.46
Leprosy	21.4	72.2	1.08	1.96

The values of these limits are charted in diagrammatic form in Figure 17. For each series an elipse is drawn, the axes of the elipses extending from mean-2σ to mean+2σ for percentage of polymorphs and weighted mean respectively. The centre of the elipses i.e. the point of intersection of the two means is marked by a cross. One therefore has a diagrammatic representation of the neutrophil picture in health and in four common types of infection; 1, acute pyogenic; 2, protozoal; 3, virus; 4, chronic bacterial.

In the areas outlined there is considerable overlap, but statistically each can be differentiated from the others. The areas for the three pyrexial conditions are distinctly separate from the normality area there being only slight overlap between acute sepsis and normal. The area for phlebotomus fever is distinct from that of acute sepsis, but malaria overlaps both. In interpreting the diagram it must be remembered that the frequencies in the groups

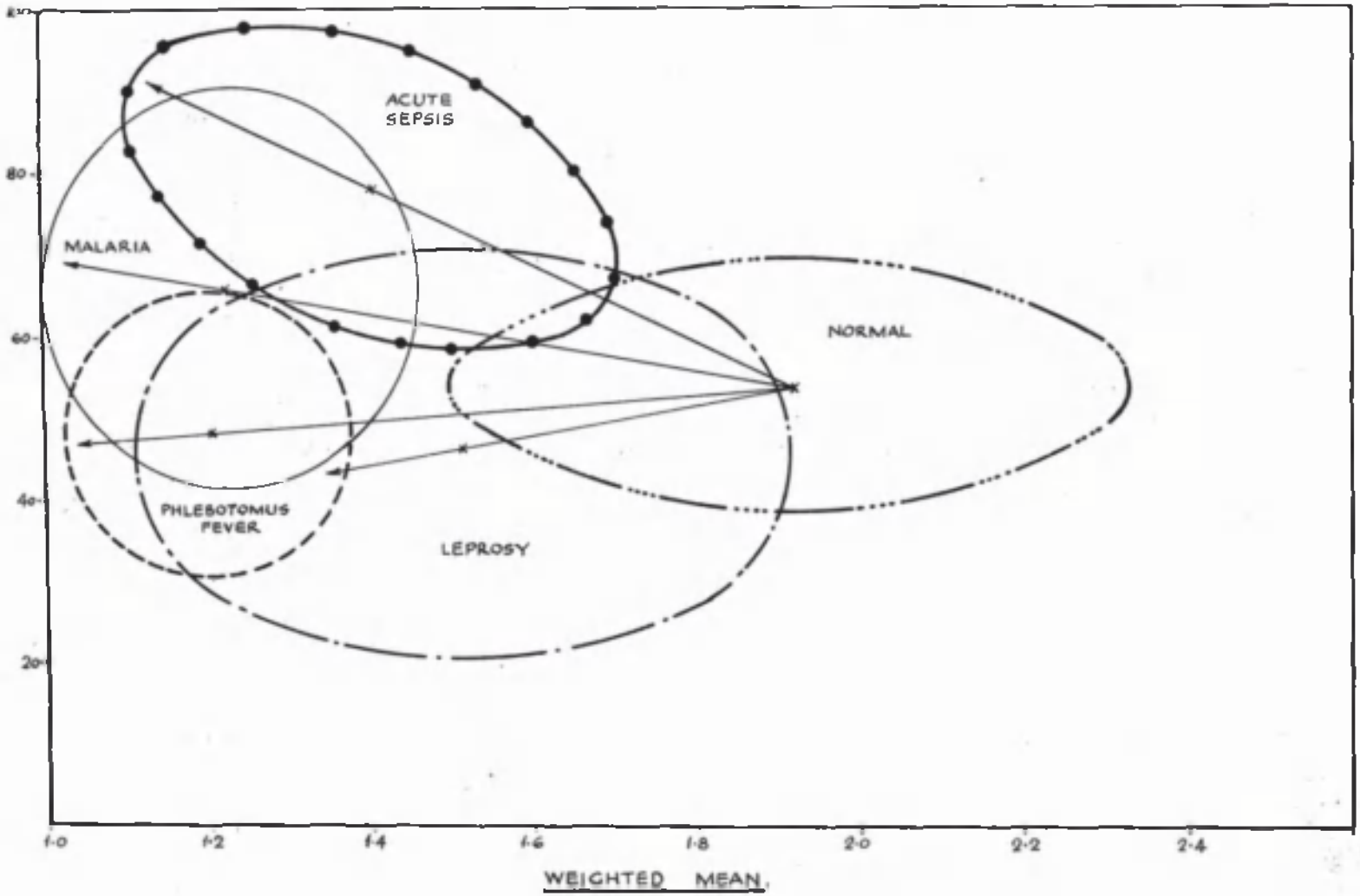


Figure 17. Correlation chart of percentage polymorphs and weighted mean for normals, acute sepsis, malaria, phlebotomus fever and leprosy. Intersection of means of each group marked by a cross. Arrows indicate average direction of drift for each disease.

are not indicated. The bulk of the observations are concentrated round the means and the amount of overlap in the groups is much less than the diagram would indicate.

By drawing a line from the normal mean to the mean of each of the disease groups one obtains an approximate indication of the drift of the average case in each type of infection. Since the deviation of the polynuclear count is an indication of the degree of systemic reaction one obtains a fair indication of the severity of illness in the individual case by the measure of the extent of drift along this line.

The value of leukocyte counts in the diagnosis of pyogenic infections has long been recognised. In 'Iraq as has been stated the two other common causes of pyrexia are phlebotomus fever and malaria. In the early stages clinical differentiation is not always easy. Both diseases at the onset may produce abdominal symptoms and may simulate an acute surgical condition or a basal pneumonia. As in acute sepsis the blood picture in phlebotomus fever is typical. So much so that one was able with confidence to make a diagnosis frequently before the full clinical syndrome had developed and in many cases when the onset was atypical.

That other infections cause a leukopaenic reaction with marked deviation of the Arneth count, we know. Influenza and dengue fever are two examples, like phlebotomus fever both probably virus diseases, and both producing remarkably similar clinical manifestations. In 'Iraq, however, dengue fever is unknown and influenza occurs only in winter.

The leukocyte picture in malaria is as a rule of little value for in most cases the parasite is easily found. But in those cases, such as cerebral malignant tertian infection, where parasites in the peripheral circulation are scanty or absent typical leukocyte counts may be of great value to the physician, and will certainly stimulate one to more intensive search for the parasite.

The neutrophil picture in leprosy is of no diagnostic value but is of interest for comparison and contrast with the acute infections.

5. Summary.

The results are presented and analysed statistically of the neutrophil counts in 'Iraq of five groups of individuals; healthy airmen, cases of acute sepsis, phlebotomus fever, malaria and leprosy.

Haematological technique suitable for routine work in the tropics is described and a simple method for photomicrography. Some results of the latter are demonstrated, including photographs of giant polymorphs known as macropolycytes. The significance of the macropolycyte is discussed.

Cooke and Ponder's modification of the Arneth count is explained and the use of the weighted mean as an index. The results of the percentage of polymorphs in the differential count and of the polynuclear count are presented for 243 healthy British airmen, 41 cases of acute pyogenic infection, 74 cases of phlebotomus fever, 126 of malaria and 96 of leprosy. These results are analysed statistically and demonstrated on a correlation chart.

Conclusions.

1. In Iraq, in health, there is a marked shift to the left in the Arneth count and a relative fall in the percentage of neutrophils in the differential count.

2. These changes are probably due to climatic conditions.

3. In acute sepsis, phlebotomus fever, malaria and leprosy there is further deviation in the Arneth count and the extent of the deviation differs in each disease.

4. There is a neutrophil leukocytosis in acute sepsis and in malaria, less marked in the latter. There is an absolute neutrophil leukopaenia in phlebotomus fever and a relative neutrophil leukopaenia in leprosy.

5. In acute sepsis there is significant correlation between the percentage of neutrophils in the differential count and the weighted mean of the polynuclear count.

6. The neutrophil counts are of value in the differential diagnosis of pyrexial diseases in the tropics.

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[illegible]. Phlebotomus fever.

[illegible]. Malaria.

[illegible]. Leprosy.

7. Appendix of Tabulated Counts.

1. In health.

2. Acute pyogenic infection.

3. Phlebotomus fever.

4. Malaria.

5. Leprosy.

1. In Health.

No.	% polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
1.	53.5.	24.	46.	26.	4.	-	2.10.
2.	54.5.	41.	42.	15.	2.	-	1.76.
3.	65.	16.	39.	32.	11.	2.	2.21.
4.	60.	47.	43.	9.	1.	-	1.64.
5.	51.	40.	45.	13.	1.	1.	1.78.
6.	60.	25.	50.	20.	5.	-	2.05.
7.	58.	25.	32.	33.	9.	1.	2.29.
8.	50.	16.	39.	39.	6.	-	2.35.
9.	49.	29.	47.	19.	5.	-	2.00.
10.	64.	26.	50.	23.	1.	-	1.99.
11.	59.	26.	44.	27.	2.	1.	1.78.
12.	54.5.	23.	40.	33.	4.	-	2.18.
13.	53.	35.	40.	22.	3.	-	1.93.
14.	56.	46.	39.	11.	4.	-	1.73.
15.	59.	30.	51.	15.	4.	-	1.93.
16.	51.5.	36.	40.	18.	8.	-	2.00.
17.	57.5.	31.	50.	13.	6.	-	1.94.
18.	43.5.	59.	37.	3.	1.	-	1.46.
19.	52.	38.	43.	16.	3.	-	1.84.
20.	54.	30.	49.	20.	1.	-	1.92.
21.	65.5.	30.	38.	25.	6.	1.	2.10.
22.	61.5.	47.	41.	11.	1.	-	1.66.
23.	52.5.	28.	40.	26.	6.	-	2.08.
24.	57.5.	37.	39.	19.	5.	-	1.92.
25.	62.5.	34.	45.	17.	4.	-	1.91.
26.	60.	26.	45.	23.	6.	-	2.09.
27.	55.5.	36.	45.	15.	4.	-	1.87.
28.	64.5.	33.	46.	18.	3.	-	1.91.
29.	58.5.	36.	37.	21.	5.	1.	1.98.
30.	44.5.	38.	34.	25.	4.	-	2.01.
31.	60.5.	28.	38.	29.	5.	-	2.11.
32.	53.	21.	47.	26.	4.	2.	2.19.
33.	49.	22.	40.	31.	7.	-	2.23.
34.	52.	41.	42.	14.	3.	-	1.79.
35.	52.	42.	42.	12.	4.	-	1.78.
36.	60.5.	31.	42.	21.	6.	-	2.02.
37.	58.5.	20.	53.	20.	6.	1.	2.15.
38.	61.	40.	44.	14.	1.	1.	1.79.
39.	46.5.	36.	45.	16.	3.	-	1.85.
40.	42.5.	42.	40.	14.	4.	-	1.76.
41.	53.	43.	33.	14.	-	-	1.51.
42.	75.	33.	46.	18.	3.	-	1.91.
43.	52.	28.	43.	25.	4.	-	2.05.
44.	61.	28.	37.	28.	6.	1.	2.15.
45.	75.5.	27.	49.	17.	7.	-	2.04.
46.	51.5.	39.	41.	18.	2.	-	1.83.
47.	50.	43.	37.	18.	5.	-	1.82.
48.	52.5.	59.	29.	12.	-	-	1.53.
49.	58.5.	30.	49.	18.	3.	-	1.94.
50.	64.	28.	41.	24.	7.	-	1.70.

1. In Health. (2).

No.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
51.	55.	29.	44.	22.	5.	–	2.03.
52.	62.	32.	46.	16.	1.	–	1.80.
53.	48.5.	48.	42.	10.	–	–	1.62.
54.	64.	24.	57.	15.	2.	–	1.95.
55.	72.	48.	32.	15.	3.	–	1.77.
56.	53.5.	51.	30.	15.	4.	–	1.72.
57.	52.5.	34.	45.	19.	2.	–	1.89.
58.	61.5.	29.	46.	23.	2.	–	1.98.
59.	57.	28.	41.	26.	5.	–	2.08.
60.	64.	37.	36.	21.	6.	–	1.96.
61.	45.5.	28.	37.	28.	6.	1.	2.15.
62.	61.5.	26.	51.	21.	2.	–	1.99.
63.	56.5.	27.	44.	26.	3.	–	2.05.
64.	58.	51.	37.	9.	3.	–	1.64.
65.	62.5.	35.	37.	24.	4.	–	1.97.
66.	50.5.	25.	36.	28.	11.	–	2.25.
67.	60.5.	42.	41.	16.	1.	–	1.76.
68.	39.5.	60.	34.	5.	1.	–	1.47.
69.	45.	36.	34.	25.	5.	–	1.99.
70.	58.5.	50.	37.	13.	1.	–	1.67.
71.	45.5.	45.	40.	16.	1.	–	1.77.
72.	67.5.	30.	45.	23.	2.	–	1.97.
73.	61.5.	54.	38.	5.	3.	–	1.57.
74.	62.5.	43.	44.	12.	1.	–	1.71.
75.	71.	45.	38.	15.	2.	–	1.74.
76.	60.	16.	35.	34.	13.	2.	2.50.
77.	50.5.	20.	34.	35.	9.	2.	2.39.
78.	70.5.	26.	44.	23.	7.	–	2.11.
79.	51.	27.	42.	27.	4.	–	2.08.
80.	46.5.	57.	33.	9.	1.	–	1.54.
81.	60.	36.	32.	25.	7.	–	2.03.
82.	49.	27.	44.	22.	7.	–	2.09.
83.	54.	29.	50.	16.	5.	–	1.97.
84.	70.5.	36.	40.	22.	2.	–	1.90.
85.	51.5.	25.	48.	23.	4.	–	2.02.
86.	35.	51.	44.	4.	1.	–	1.55.
87.	48.5.	27.	51.	16.	4.	–	1.93.
88.	54.	35.	46.	19.	3.	1.	2.01.
89.	64.5.	36.	42.	20.	2.	–	1.88.
90.	48.5.	18.	42.	34.	6.	–	2.28.
91.	47.5.	22.	43.	24.	11.	–	2.24.
92.	48.	44.	40.	13.	2.	1.	1.76.
93.	53.5.	44.	31.	22.	2.	1.	1.85.
94.	53.	27.	42.	27.	4.	–	2.08.
95.	67.5.	38.	38.	22.	2.	–	1.88.

1. In Health. (3)

No.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
96.	54.	32.	39.	27.	2.	–	1.93.
97.	71.5.	43.	36.	19.	2.	–	1.80.
98.	63.	41.	45.	14.	–	–	1.73.
99.	43.	39.	36.	22.	–	–	1.89.
100.	56.	43.	43.	12.	2.	–	1.73.
101.	57.	39.	34.	25.	2.	–	1.90.
102.	45.5.	30.	38.	27.	4.	1.	2.08.
103.	53.5.	37.	44.	19.	–	–	1.72.
104.	57.5.	48.	34.	15.	3.	–	1.73.
105.	68.	31.	38.	27.	4.	–	2.04.
106.	44.5.	22.	43.	22.	11.	2.	2.28.
107.	58.	21.	44.	30.	4.	1.	2.20.
108.	65.	23.	48.	21.	8.	–	2.14.
109.	59.5.	25.	39.	33.	3.	–	2.14.
110.	50.5.	25.	36.	30.	8.	1.	2.24.
111.	54.	53.	35.	12.	–	–	1.59.
112.	46.5.	23.	43.	29.	5.	1.	2.20.
113.	70.5.	17.	44.	33.	6.	–	2.28.
114.	55.	27.	48.	20.	5.	–	2.03.
115.	42.	30.	51.	18.	1.	–	1.90.
116.	59.5.	15.	43.	36.	7.	1.	2.42.
117.	52.	49.	40.	11.	–	–	1.62.
118.	54.5.	27.	51.	21.	1.	–	1.96.
119.	58.5.	25.	46.	25.	4.	–	2.08.
120.	63.5.	19.	39.	37.	5.	–	2.28.
121.	52.5.	29.	44.	25.	2.	–	2.00.
122.	52.5.	44.	29.	14.	3.	–	1.66.
123.	47.5.	31.	35.	23.	11.	–	2.14.
124.	53.	35.	40.	25.	–	–	1.90.
125.	49.	19.	38.	35.	7	1.	2.33.
126.	57.	40.	41.	18.	1.	–	1.79.
127.	64.5.	45.	39.	11.	5.	–	1.76.
128.	47.5.	56.	33.	11.	–	–	1.55.
129.	56.5.	51.	36.	12.	1.	–	1.63.
130.	65.5.	35.	48.	15.	2.	–	1.84.
131.	45.5.	20.	57.	17.	6.	–	1.93.
132.	45.5.	29.	41.	19.	11.	–	2.13.
133.	57.	32.	47.	18.	3.	–	1.92.
134.	53.	34.	52.	12.	2.	–	1.82.
135.	53.	58.	36.	6	–	–	1.51.
136.	41.5.	33.	53.	12.	2.	–	1.83.
137.	58.5.	29.	53.	13.	6.	–	1.98.
138.	64.5.	46.	31.	20.	2.	1.	1.81.
139.	46.	31.	40.	25.	4.	–	2.02.
140.	37.5.	28.	38.	23.	9.	2.	2.19.

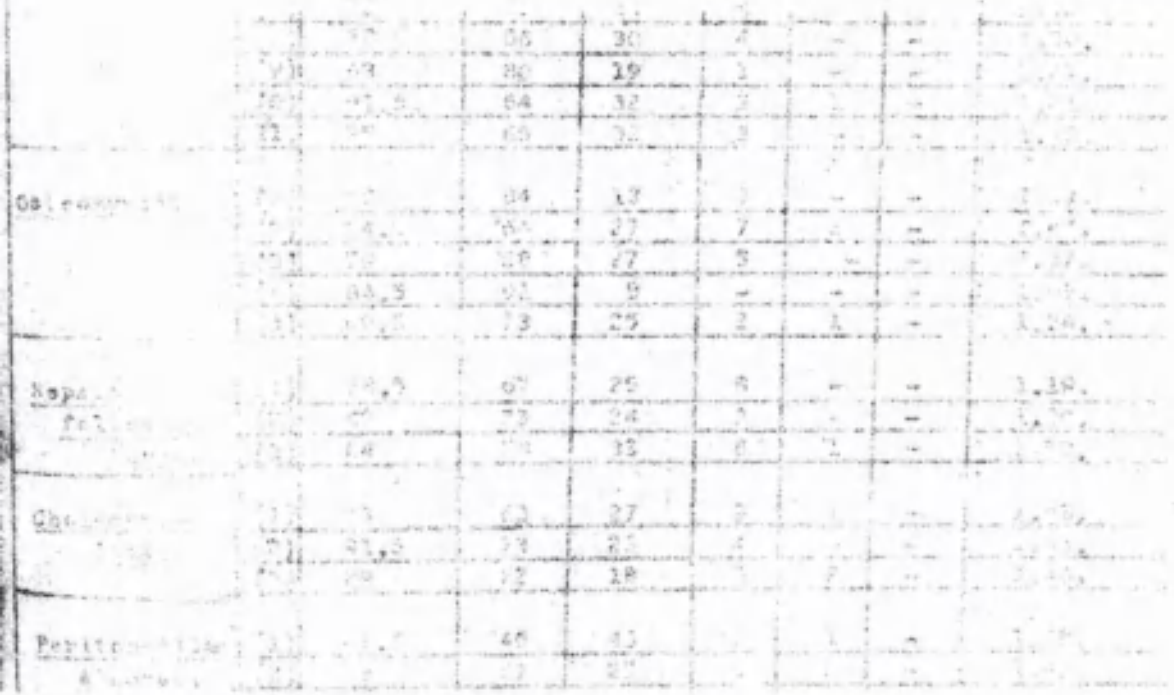
No.	% Polymorphs.	Polynuclear Count.					W.M.
		1.	2.	3.	4.	5.	
141.	56.	41.	43.	13.	3.	-	1.78.
142.	68.5.	37.	41.	20.	2.	1.	1.87.
143.	74.5.	26.	45.	22.	7.	-	2.10.
144.	54.	30.	42.	24.	4.	-	2.02.
145.	45	57.	35.	7.	1.	-	1.52.
146.	48.5.	24.	52.	20.	3.	1.	2.05.
147.	58.5.	38.	41.	19.	2.	-	1.85.
148.	55.	40.	40.	18.	2.	-	1.82.
149.	58.5.	38.	40.	19.	3.	-	1.87.
150.	64.	35.	37.	21.	7.	-	2.00.
151.	52.5.	48.	37.	14.	1.	-.	1.68.
152.	67.	34.	39.	25.	2.	-	1.95.
153.	61.	24.	42.	31.	2.	1.	2.14.
154.	49.5.	45.	42.	13.	-	-	1.65.
155.	44.	47.	29.	22.	2.	-	1.79.
156.	50.5.	69.	26.	5.	-	-	1.36.
157.	46.	46.	44.	8.	2.	-	1.66.
158.	55.	28.	49.	19.	4.	-	1.99.
159.	52.5.	53.	27.	9.	1.	-	1.58.
160.	59.5.	56.	36.	7.	1.	-	1.53.
161.	49.	46.	40.	13.	1.	-	1.69.
162.	63.	41.	47.	11.	1.	-	1.72.
163.	47.5.	33,	39.	26.	2.	-	1.97.
164.	62.5.	41.	37.	20.	1.	-	1.82.
165.	67.5.	50.	34.	13.	3.	-	1.59.
166.	59.5.	66.	29.	5.	-	-	1.39.
167.	60.5..	34.	42.	20.	4.	-	1.90.
168.	65.	41.	41.	14.	4.	-	1.81.
169.	63.	39.	43.	14.	4.	-	1.83.
170.	59.	56.	36.	6.	2.	-	1.54.
171.	60.	41.	40.	6.	3.	-	1.81.
172.	54.5.	50.	40.	9	1.	-	1.61.
173	62.	48.	41.	10.	1.	-	1.64.
174.	65.	39.	41.	17.	3.	-	1.84.
175.	60.5.	41.	34.	23.	1.	1.	1.87.
176.	62.5.	60.	32.	19.	6.	-	1.48.
177.	63.5.	37.	38.	19.	6.	-	1.94.
178.	55.	38.	43.	18.	1.	-	1.82.
179.	52.5.	40.	44.	16.	-	-	1.76.
180.	62.5.	39.	41.	19.	3.	-	1.88.
181.	57.5.	44.	37.	18.	1.	-	1.70.
182.	59.5.	53.	34.	10.	3.	-	1.63.
183.	49.	34.	40.	20.	6.	-	1.98.
184.	60.5.	41.	36.	21.	2.	-	1.84.
185.	52.5.	44.	42.	13.	1.	-	1.69.

1. In Health. (5)

No.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
186.	59.	49.	38.	11.	2.	-	1.66.
187.	57.5.	30.	41.	23.	6.	-	2.05.
188.	69.5.	46.	36.	16.	2.	-	1.74.
189.	58.	57.	31.	16.	2.	-	1.55.
190.	52.5.	28.	44.	23.	5.	-	2.05.
191.	62.5.	27.	40.	18.	4.	1.	1.92.
192.	51.	27.	46.	22.	5.	-	2.05.
193.	58.	53.	33.	11.	3.	-	1.64.
194.	57.5.	41.	41.	16.	2.	-	1.79.
195.	68.5.	43.	35.	19.	2.	1.	1.83.
196.	60.5.	29.	49.	15.	7.	-	2.00.
197.	65.5.	29.	49.	19.	3.	-	1.96.
198.	63.5.	39.	38.	18.	5.	-	1.89.
199.	63.5.	39.	39.	20.	2.	-	1.85.
200.	49.	39.	47.	12.	2.	-	1.77.
201.	70.5.	32.	37.	24.	7.	-	2.06.
202.	53.	40.	41.	17.	7.	1.	1.82.
203.	47.	49.	37.	12.	2.	-	1.67.
204.	57.5.	49.	31.	16.	3.	-	1.71.
205.	61.	35.	43.	19.	3.	-	1.90.
206.	56.	34.	36.	24.	6.	-	2.02.
207.	52.5.	33.	40.	21.	6.	-	2.00.
208.	54.5.	59.	32.	7.	2.	-	1.52.
209.	56.	39.	35.	23.	3.	-	1.90.
210.	54.	28.	40.	27.	5.	-	2.09.
211.	55.	51.	40.	9.	-	-	1.58.
212.	52.	23.	47.	20.	10.	-	2.17.
213.	60.5.	22.	54.	16.	7.	1.	2.11.
214.	60.5.	46.	39.	13.	2.	-	1.71.
215.	59.5.	37.	38.	21	3.	1.	1.93.
216.	64.5.	32.	43.	20.	5.	-	1.98.
217.	55.	34.	43.	18.	5.	-	1.94.
218.	53.5.	33.	44.	14.	9.	-	1.99.
219.	48.	34.	44.	16.	4.	2.	1.96.
220.	54.5.	48.	39.	11.	1.	1.	1.68.
221.	51.5.	44.	34.	19.	3.	-	1.81.
222.	67.5.	55.	30.	12.	2.	1.	1.64.
223.	49.59.	29.	46.	18.	6.	1.	2.04.
224.	47.5.	35.	39.	23.	3.	-	1.94.
225.	63.5.	48.	32.	17.	3.	-	1.75.
226.	55.	35.	48.	16.	1.	-	1.83.
227.	59.5.	36.	54.	17.	3.	-	1.97.
228.	54.5.	37.	31.	26.	5.	1.	2.02.
229.	58.5.	22.	45.	28.	5.	-	2.16.
230.	49.	34.	39.	23.	4.	-	1.97.

1. In Health. (6).

No.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
231.	50.5.	33.	42.	22.	2.	1.	1.96.
232.	47.5	33.	40.	23.	3.	1.	1.99.
233.	54.	38.	40.	21.	1.	-	1.85.
234.	49.	36.	42.	18.	4.	-	1.90.
235.	58.5.	34.	42.	22.	2.	-	1.92.
236.	50.5.	47.	40.	11.	2.	-	1.68.
237.	52.5.	37.	43.	19.	1.	-	1.84.
238.	53.	35.	46.	12.	6.	1.	1.92.
239.	58.	31.	44.	20.	5.	-	1.99.
240.	54.5.	34.	41.	25.	-	9	1.91.
241.	65.	43.	30.	15.	2.	-	1.76.
242.	69.5.	29.	42.	20.	9.	-	2.09.
243.	50.	50.	39.	10.	1.	-	1.62.



2. ACUTE PYOGENIC INFECTIONS.

Diagnosis		% Polymorphs.	I	II	III	IV	V	W.M.
Acute Appendicitis.	(1)	67	51	37	11	1	-	1.62.
	(2)	78.5	66	27	7	-	-	1.41.
	(3)	82	79	19	2	-	-	1.23.
	(4)	89	76	18	6	-	-	1.30.
	(5)	73.5	58	33	8	-	1	1.52.
	(6)	64.5	45.	41.	12	2	-	1.71.
	(7)	83	87	13	-	-	-	1.13.
	(8)	68.5	66	27	5	2	-	1.43.
	(9)	74	69	26	4	1	-	1.37.
	(10)	87.5	58	33	8	1	-	1.52.
	(11)	69.5	59	29	8	3	1	1.58.
	(12)	74.5	80	17	3	-	-	1.23.
	(13)	71	74	17	9	-	-	1.35.
	(14)	75.5	66	26	8	-	-	1.42.
Pneumonia.	(1)	67	55	33	11	1	-	1.58.
	(2)	89	70	28	2	-	-	1.32.
	(3)	83.5	64	33	2	1	-	1.40.
	(4)	62	50	40	9	1	-	1.61.
	(5)	91	92	8	-	-	-	1.08.
	(6)	87.5	83	11	6	-	-	1.23.
	(7)	72	62	34	4	-	-	1.42.
	(8)	78	66	30	4	-	-	1.38.
	(9)	63	80	19	1	-	-	1.21.
	(10)	91.5.	64	32	3	1	-	1.41.
	(11)	78	65	32	3	-	-	1.38.
Osteomyelitis.	(1)	88	84	13	3	-	-	1.19.
	(2)	84.5	64	27	7	2	-	1.47.
	(3)	79	68	27	5	-	-	1.37.
	(4)	84.5	92	8	-	-	-	1.08.
	(5)	69.5	73	25	3	1	-	1.34.
Sepsis following burns.	(1)	78.5	67	25	8	-	-	1.19.
	(2)	89	73	24	3	-	-	1.30.
	(3)	64	58	33	8	1	-	1.52.
Cholecystitis.	(1)	73	63	27	9	1	-	1.48.
	(2)	91.5	73	23	4	-	-	1.31.
	(3)	89	72	18	8	2	-	1.40.
Peritonsillar Abscess.	(1)	67.5	45	43	11	1	-	1.68.
	(2)	73	67	25	6	2	-	1.43.
Erysipelas.	(1)	83	46	41	12	1	-	1.68.
	(2)	78	66	25	9	-	-	1.43.
Perinephric Abscess.	(1)	72	56	33	7	4	-	1.58

3. Phlebotomus Fever.

No.	T.W.C.	% Polymorphs	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
1.	5.000.	46.	84.	16.	0.	0.	0.	1.16.
2.	6.200.	66.	84.	16.	0.	0.	0.	1.16.
3.	5.400.	47.5.	66.	31.	3.	0.	0.	1.37.
4.	4.200.	38.	89.	11.	0.	0.	0.	1.11.
5.	8.600.	62.	66.	28.	6.	0.	0.	1.40.
6.	7.100.	45.5.	89.	11.	0.	0.	0.	1.11.
7.	6.400.	56.5.	85.	15.	0.	0.	0.	1.15.
8.	6.300.	49.	80.	19.	1.	0.	0.	1.21.
9.	6.300.	57.5.	82.	16.	2.	0.	0.	1.20.
10.	6.200.	52.	81.	16.	3.	0.	0.	1.22.
11.	8.800.	41.5.	75.	22.	3.	0.	0.	1.28.
12.	6.900.	40.	82.	17.	1.	0.	0.	1.19.
13.	4.000.	66.	86.	13.	1.	0.	0.	1.15.
14.	4.500.	21.	87.	10.	3.	0.	0.	1.16.
15.	4.500.	66.	78.	18.	4.	0.	0.	1.26.
16.	6.700.	56.	68.	28.	4.	0.	0.	1.36.
17.	7.800.	44.5.	78.	22.	-	-	-	1.22.
18.	6.300.	45.	95.	5.	-	-	-	1.05.
19.	6.300.	57.	80.	20.	-	-	-	1.20.
20.	4.600.	36.5.	88.	10.	2.	-	-	1.14.
21.	8.300.	52.	79.	20.	1.	-	-	1.22.
22.	5.200.	44.	70.	16.	14.	-	-	1.34.
23.	6.700.	68.5.	83.	16.	1.	-	-	1.18.
24.	3.400.	57.	86.	14.	-	-	-	1.14.
25.	5.500.	53.	82.	14.	2.	-	-	1.22.
26.	7.200.	39.	82.	18.	-	-	-	1.18.
27.	6.400.	38.5.	73.	25.	2.	-	-	1.29.
28.	4.800.	55.	84.	16.	-	-	-	1.16.
29.	5.200.	47.5.	94.	6.	-	-	-	1.06.
30.	4.700.	40.	73.	25.	2.	-	-	1.29.
31.	6.600.	43.	85.	15.	-	-	-	1.15.
32.	4.000.	57.	70.	26.	4.	-	-	1.34.
33.	6.200.	59.5.	82.	17.	1.	-	-	1.19.
34.	3.600.	48.5.	83.	15.	2.	-	-	1.19.
35.	4.600.	59.5.	83.		-	-	-	1.07.
36.	4.200.	47.5.	77.	12.	1.	-	-	1.14.
37.	6.200.	50.	93.	6.	1.	-	-	1.08.
38.	4.200.	29.5.	92.	8.	-	-	-	1.08.
39.	6.500.	44.5.	78.	19.	3.	-	-	1.25.
40.	3.500.	46.	72.	24.	4.	-	-	1.32.
41.	6.600.	54.	88.	11.	1.	-	-	1.13.
42.	6.200.	53.	73.	23.	4.	-	-	1.31.
43.	5.000.	48.	79.	19.	2.	-	-	1.23.
44.	2.400.	42.	90.	10.	-	-	-	1.10.
45.	4.500.	49.5.	73.	24.	3.	-	-	1.30.

/3. Phlebotomus Fever. (cont.).

No.	T.W.C.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
46.	7.400.	53.5.	84.	15.	1.	-	-	1.17.
47.	4.500.	44.	89.	10.	1.	-	-	1.12.
48.	5.000.	44.5.	88.	12.	-	-	-	1.12.
49.	4.000.	50.5.	79.	18.	3.	-	-	1.24.
50.	4.500.	44.	93.	7	-	-	-	1.07.
51.	4.400.	42.5	87.	13.	-	-	-	1.13.
52.	4.200.	46.5.	77.	20.	3.	-	-	1.26.
53.	7.000.	49.	74.	22.	4.	-	-	1.30.
54.	4.000.	43.5.	83.	17.	-	-	-	1.17.
55.	7.100.	47.5.	87.	13.	-	-	-	1.13.
56.	6.300.	45.5.	79.	19.	2.	-	-	1.23.
57.	5.900.	47.5.	81.	16.	3.	-	-	1.22.
58.	6.200.	51.5.	75.	24.	1.	-	-	1.26.
59.	7.100.	47.	81.	18.	1.	-	-	1.20.
60.	6.200.	58.	78.	18.	4.	-	-	1.26.
61.	6.400.	47.	82.	17.	1.	-	-	1.19.
62.	4.700.	50.5.	81.	19.	-	-	-	1.19.
63.	8.100.	51.	76.	22.	2.	-	-	1.26.
64.	6.500.	56.5.	72.	27.	1.	-	-	1.29.
65.	4.200.	46.5.	92.	4.	-	-	-	1.04.
66.	7.400.	55.5.	82.	18.	-	-	-	1.18.
67.	6.400.	58.	82.	17.	1.	-	-	1.19.
68.	4.300.	43.	91.	8;	1.	-	-	1.10.
69.	5.100.	46.	91.	9.	-	-	-	1.09.
70.	6.300.	42.	93.	7	-	-	-	1.07.
71.	4.100.	44.	76.	23.	1.	-	-	1.25.
72.	5.200.	46.5.	74.	23.	3.	-	-	1.32.
73.	3.300.	29.	93.	7.	-	-	-	1.07.
74.	4.200.	27.5.	67.	32.	1.	-	-	1.37.

4. Malaria - Malignant Tertian.

No.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
1.	66.5	76.	20.	4.	-	-	1.28.
2.	78.	79.	21.	-	-	-	1.21.
3.	57.	66.	27.	7.	-	-	1.41.
4.	77.5.	63.	30.	6.	-	-	1.45.
5.	71.	88.	11.	6.	1.	-	1.23.
6.	43.5.	74.	21.	4.	1.	-	1.32.
7.	61.5.	79.	21.	-	-	-	1.21.
8.	63.	94.	6.	-	-	-	1.06.
9.	65.	83.	16.	1.	-	-	1.18.
10.	74.	57.	29.	13.	1.	-	1.58.
11.	49.	88.	12.	-	-	-	1.12.
12.	59.5.	88.	11.	1.	-	-	1.13.
13.	71.5.	82.	18.	-	-	-	1.18.
14.	53.	81.	18.	1.	-	-	1.20.
15.	75.	84.	14.	1.	1.	-	1.19.
16.	59.	77.	21.	2.	-	-	1.25.
17.	68.	84.	14.	2.	-	-	1.18.
18.	54.5.	70.	26.	3.	1.	-	1.35.
19.	79.5.	83.	13.	4.	-	-	1.21.
20.	83.5.	77.	18.	4.	1.	-	1.29.
21.	55.	83.	16.	1.	-	-	1.18.
22.	63.	70.	24.	5.	1.	-	1.37.
23.	76.5.	85.	13.	2.	-	-	1.17.
24.	59.5.	88.	11.	1.	-	-	1.13.
25.	73.	81.	18.	1.	-	-	1.21.
26.	50.	92.	8.	-	-	-	1.08.
27.	63.	87.	10.	2.	1.	-	1.17.
28.	60.5.	70.	20.	7.	2.	1.	1.44.
29.	78.5.	55.	32.	12.	1.	-	1.54.
30.	74.5.	78.	17.	5.	-	-	1.27.
31.	56.5.	64.	32.	4.	-	-	1.40.
32.	72.	80.	19.	4.	-	-	1.21.
33.	61.	84.	14.	2.	-	-	1.18.
34.	75.5.	79.	20.	1.	-	-	1.22.
35.	57.	61.	31.	7.	1.	-	1.48.
36.	53.5.	71.	26.	3.	-	-	1.32.
37.	47.5.	79.	19.	2.	-	-	1.23.
38.	72.	78.	10.	3.	-	-	1.25.
39.	59.5.	50.	36.	12.	2.	-	1.66.
40.	73.5.	71.	24.	4.	1.	-	1.35.
41.	69.	86.	13.	1.	-	-	1.15.
42.	47.5.	72.	24.	3.	1.	-	1.33.
43.	59.	92.	8.				1.08.
44.	85.	79.	19.	2.	-	-	1.23.
45.	67.	81.	18.	1.	-	-	1.20.

4. Malaria - Malignant Tertian (cont.).

No.	% Polymorphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
46.	71.	63.	25.	11.	1.	-	1.50.
47.	48.	86.	14.	-	-	-	1.14.
48.	57.5.	87.	13.	-	-	-	1.13.
49.	72.	81.	19.	-	-	-	1.19.
50.	52.5.	78.	19.	3.	-	-	1.22.
51.	73.	82.	13.	4.	1.	-	1.24.
52.	55.	71.	25.	3.	1.	-	1.34.
53.	81.	78.	20.	2.	-	-	1.24.
54.	57.	82.	16.	2.	-	-	1.20.
55.	62.	87.	12.	1.	-	-	1.14.
56.	74.	74.	22.	3.	1.	-	1.31.
57.	52.	83.	17.	-	-	-	1.17.
58.	59.5.	62.	33.	4.	1.	-	1.44.
59.	73.	77.	19.	9.	-	-	1.27.
60.	44.	86.	13.	1.	-	-	1.15.
61.	65.5.	84.	16.	-	-	-	1.16.
62.	62.	80.	19.	1.	-	-	1.21.
63.	79.5.	65.	29.	5.	1.	-	1.42.
64.	70.	74.	19.	7	1.	-	1.33.
65.	76.5.	86.	13.	1.	-	-	1.15.
66.	67.	87.	11.	1.	-	-	1.15.
67.	63.	85.	15.	-	-	-	1.15.
68.	85.5.	92.	5.	3.	-	-	1.11.
69.	86.5.	77.	21.	1.	1.	-	1.26.
70.	58.	90.	10.	-	-	-	1.10.
71.	81.	95.	5.	-	-	-	1.05.
72.	71.	92.	5.	3.	-	-	1.11.
73.	46.	95.	4.	1.	-	-	1.06.
74.	68.	96.	4.	-	-	-	1.04.
75.	78.5.	90.	7.	3.	-	-	1.13.
76.	63.	76.	20.	4.	-	-	1.28.
77.	30.	76.	22.	2.	-	-	1.26.
78.	66.5.	84.	15.	1.	-	-	1.17.
79.	60.	80.	20.	-	-	-	1.20.
80.	76.	82.	13.	5.	-	-	1.23.
81.	78.5.	83.	14.	3.	-	-	1.20.
82.	74.	84.	13.	3.	-	-	1.19.
83.	77.	82.	13.	5.	-	-	1.23.
84.	75.5.	93.	6.	1.	-	-	1.08.
85.	70.5.	66.	27.	6.	1.	-	1.42.
86.	64.	76.	21.	2.	1.	-	1.28.
87.	37.	94.	6.	-	-	-	1.06.
88.	70.	81.	18.	1.	-	-	1.20.
89.	61.	86.	13.	1.	-	-	1.15.
90.	71.5.	82.	17.	1.	-	-	1.19.

4. Malaria - Benign Tertian.

No.	T.W.C.	% Poly-morphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
1.		74.5	49.	37.	12.	2.	-	1.67.
2.		74.	62.	31.	6.	1.	-	1.46.
3.		74.	72.	27.	1.	-	-	1.29.
4.		65.5.	62.	32	6.	-	-	1.44.
5.		56.	79.	19.	2.	-	-	1.23.
6.		81.	76.	22.	2.	-	-	1.26.
7.		81.	90.	8.	2.	-	-	1.16.
8.		59.5.	88.	9.	3.	-	-	1.15.
9.		62.5.	87.	13.	-	-	-	1.13.
10.		64.	87.	13.	-	-	-	1.13.
11.		82.	89.	9.	2.	-	-	1.13.
12.		49.	67.	27.	6.	-	-	1.39.
13.		57.5.	87.	11.	2.	-	-	1.15.
14.		57.5.	92.	8.	-	-	-	1.08.
15.		49.5.	87.	11.	2.	-	-	1.15.
16.		45.	87.	11.	1.	1.	-	1.16.
17.		75.5.	95.	5.	-	-	-	1.05.
18.		76.	87.	11.	2.	-	-	1.15.
19.		34.	89.	11.	-	-	-	1.11.
20.		67.	85.	13.		-	-	1.15.
21.		80.5.	87.	12.	1.	-	-	1.14.
22.		75.5.	65.	32.	2.	-	1.	1.45.
23.		61.	82.	18.	-	-	-	1.18.
24.		63.	83.	17.	-	-	-	1.17.
25.		71.	89.	10.	1.	-	-	1.12.
26.		63.	89.	11.	-	-	-	1.11.
27.		80.	88.	11.	1.	-	-	1.13.
28.		66.	93.	7.	-	-	-	1.07.
29.		53.5.	84.	14.	2.	-	-	1.18.
30.		72.	74.	23.	3.	-	-	1.29.
31.		74.	79.	16.	5.	-	-	1.26.
32.		73.5.	76.	21.	2.	1.	-	1.28.
33.		68.	84.	15.	1.	-	-	1.17.
34.		32.5.	83.	13.	3.	1.	-	1.22.
35.		68.5.	78.	21.	1.	-	-	1.23.
36.		36.5.	85.	15.	-	-	-	1.15.

5. Leprosy.

No.	T.W.C.	% Poly-morphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
1.		19.5.	71.	19.	10.	-	-	1.39.
2.		48.5.	55.	35.	8.	2.	-	1.57.
3.		64.5.	41.	40.	17.	2.	-	1.80.
4.		47.5.	47.	39.	13.	1.	-	1.68.
5.		34.	57.	32.	11.	-	-	1.54.
6.		37.	72.	23.	4.	1.	-	1.34.
7.		65.5.	69.	25.	6.	-	-	1.37.
8.		23.	71.	21.	7.	1.	-	1.38.
9.		43.	57.	36.	6.	1.	-	1.51.
10.		37.5.	57.	29.	12.	2.	-	1.59.
11.		32.5.	43.	44.	12.	1.	-	1.71.
12.		21.	62.	28.	10.	-	-	1.48.
13.		31.5.	54.	37.	8.	1.	-	1.56.
14.		42.	45.	47.	7.	1.	-	1.64.
15.		35.5.	59.	31.	9.	1.	-	1.52.
16.		34.	53.	33.	13.	1.	-	1.62.
17.		30.5.	75.	24.	1.	-	-	1.26.
18.		31.	53.	39.	7.	1.	-	1.56.
19.		39.5.	67.	25.	6.	2.	-	1.43.
20.		39.5.	63.	28.	9.	-	-	1.46.
21.		24.5.	66.	31.	3.	-	-	1.37.
22.		39.	16.	39.	32.	11.	2.	2.44.
23.		34.	72.	18.	7.	2.	1.	1.43.
24.		57.5.	26.	38.	19.	6.	1.	2.18.
25.		40.5.	57.	36.	5.	2.	-	1.52.
26.		37.5.	65.	27.	8.	-	-	1.43.
27.		50.	68.	30.	2.	-	-	1.34.
28.		49.	57.	34.	8.	1.	-	1.53.
29.		40.5.	48.	37.	14.	1.	-	1.76.
30.		45.	43.	48.	7.	2.	-	1.68.
31.		47.	47.	41.	12.	-	-	1.65.
32.		32.	40.	36.	17.	6.	1.	1.92.
33.		36.	46.	42.	11.	1.	-	1.67.
34.		49.5.	70.	30.	-	-	-	1.30.
35.		41.	30.	44.	21.	5.	-	2.01.
36.		41.	51.	35.	13.	1.	-	1.64.
37.		40.5.	60.	30.	10.	-	-	1.50.
38.		37.	76.	20.	4.	-	-	1.28.
39.		27.	51.	33.	14.	2.	-	1.67.
40.		42.	51.	37.	12.	-	-	1.61.
41.		58.5.	67.	23.	8.	2.	-	1.45.
42.		63.	69.	25.	6.	-	-	1.37.
43.		61.	55.	33.	12.	-	-	1.57.
44.		58.5.	66.	28.	6.	-	-	1.40.
45.		38.	48.	38.	12.	2.	-	1.68.

5. Leprosy (cont.)

No.	% Poly-morphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
46.	58.5.	41.	45.	13.	1.	-	1.74.
47.	65.5.	59.	32.	9.	-	-	1.50.
48.	60.5.	34.	46.	14.	6.	-	1.92.
49.	35.5.	75.	22.	5.	-	-	1.32.
50.	51.5.	59.	29.	10.	2.	-	1.55.
51.	53.5.	55.	39.	5.	1.	-	1.52.
52.	51.5.	65.	30.	5.	-	-	1.40.
53.	46.	45.	39.	14.	2.	-	1.73.
54.	50.5.	58.	36.	5.	1.	-	1.49.
55.	67.	66.	27.	7.	1.	-	1.48.
56.	53.5.	87.	12.	1.	-	-	1.14.
57.	58.	51.	40.	9.	-	-	1.58.
58.	47.	58.	36.	6.	-	-	1.48.
59.	43.5.	51.	38.	10.	1.	-	1.56.
60.	63.5.	56.	34.	8.	2.	-	1.56.
61.	59.5.	66.	25.	7.	2.	-	1.45.
62.	13.5.	77.	18.	5.	-	-	1.28.
63.	22.	54.	34.	12.	-	-	1.58.
64.	37.	33.	40.	23.	4.	-	1.98.
65.	40.5.	60.	32.	6.	2.	-	1.50.
66.	12.5.	35.	40.	23.	2.	-	1.92.
67.	61.	63.	25.	1.	1.	-	1.30.
68.	44.	64.	33.	3.	-	-	1.89.
69.	60.	83.	13.	4.	-	-	1.21.
70.	54.5.	61.	33.	5.	1.	-	1.46.
71.	51.5.	32.	56.	10.	2.	-	1.82.
72.	58.	69.	26.	5.	-	-	1.36.
73.	50.	70.	27.	3.	-	-	1.33.
74.	46.	41.	50.	8.	1.	-	1.69.
75.	50.5.	61.	29.	9.	1.	-	1.50.
76.	54.	66.	32.	2.	-	-	1.36.
77.	59.5.	48.	38.	12.	2.	-	1.68.
78.	46.	55.	33.	10.	2.	-	1.59.
79.	52.	46.	35.	15.	3.	1.	1.78.
80.	45.5.	69.	27.	4.	-	-	1.35.
81.	41.5.	57.	34.	9.	-	-	1.52.
82.	69.	56.	31.	11.	1.	1.	1.60.
83.	64.	59.	33.	6.	2.	-	1.51.
84.	45.5.	83.	16.	1.	-	-	1.18.
85.	42.	61.	31.	8.	-	-	1.47.
86.	48.	78.	21.	3.	-	-	1.27.
87.	58.	70.	20.	10.	-	-	1.40.
88.	53.	55.	38.	7.	-	-	1.52.
89.	61.5.	63.	32.	5.	-	-	1.42.
90.	41.5.	75.	23.	2.	-	-	1.27.

5. Leprosy (contd.).

No.	% Poly-morphs.	Polynuclear Count. 1.	2.	3.	4.	5.	W.M.
91.	63.5.	71.	25.	3.	1.	-	1.34.
92.	51.5.	70.	27.	3.	-	-	1.33.
93.	57.5.	77.	21.	2.	-	-	1.25.
94.	62.5.	74.	22.	4.	-	-	1.20.
95.	60.5.	84.	15.	1.	-	-	1.17.
96.	64.5.	87.	13.	-	-	-	1.13.