Tropical Fatigue and Warfare

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History abounds in examples of the costliness, in human lives and suffering, of military expeditions undertaken in tropical climates, of armies rapidly dwindling in numbers and losing their effective fighting power quite apart from the infliction of battle casualties by the enemy. Such was the experience of Sennacherib, the Assyrian before Lachish, Alexander the Great in his conquest of Asia, the Spaniards in their conquest of the New World, the Dutch in the East Indies and the British in India. It is no wonder then that the tropics came to be feared as evil in themselves.

With advances in medical knowledge, it became clear that much of this morbidity could be attributed to specific diseases, more especially those loosely referred to as ‘tropical diseases’—malaria, yellow fever, typhus fever, and the bowel disorders, typhoid, cholera and the dysenteries—but there still remained the firmly rooted conviction that there was a residuum of morbidity directly attributable to exposure to extremes of heat and humidity. Today this belief finds its expression in the practice of sending children ‘home’ from the tropics to be brought up, in the granting of generous leave in temperate climates to officials serving in the tropics, and in the short tours of duty assigned to troops in tropical areas. To this residuum of morbidity, i.e., that due to the influence of climate per se, the term ‘tropical fatigue’ has come to be applied.

The modern developments in the effective control of tropical disease, especially the outstanding work of Brigadier N. H. Fairley on malarial prophylaxis and treatment, has caused this so-called tropical fatigue to assume greater relative importance as a disability-producing factor in tropical warfare. The entry of Japan into the recent war and the engagement of Australian and Allied troops in the Southwest Pacific Area provided both the opportunity and the necessity for investigating the noninfective aspects of tropical disabilities.

About the middle of 1944, it was decided that an investigation into the nature and incidence of tropical fatigue among military personnel serving in the Southwest Pacific Area should be conducted under joint arrangements

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between the Australian Military Forces and the Royal Australian Air Force, and that facilities and personnel should be made available by both these organizations.

Such an investigation would have to establish two points; first, the existence of tropical fatigue; and second, its nature. With respect to this second point, it is obvious that if tropical fatigue exists, it may be either a physical or a mental phenomenon or a combination of both. Enquiry revealed that, in general, the methods available for the investigation of psychological phenomena are not suitable for a field survey. It was decided, therefore, to concentrate on the physiological aspects and to treat the mental aspects largely by a method of elimination.

The following approach to the problem was therefore adopted: a) to record the opinions of commanding and medical officers as to the efficiency of personnel in relation to length of tropical service; b) to measure by suitable tests the physical condition of personnel and to relate these measurements to the length of tropical service; c) to determine the extent to which tropical fatigue may be considered a psychological phenomenon by comparing the physical deterioration found with the loss of efficiency reported.

It was intended that this should be a preliminary survey and that any positive findings should be followed up by the continuous study of a unit actively engaged in warfare. The cessation of hostilities made this impossible.

METHODS

The method of investigation falls naturally into two divisions: a) the collection of data in the field and b) the analysis of such data. The question of what data to collect had to be answered on a priori grounds. It is obvious that any added strain of tropical living would have to be borne chiefly by the cardio-vascular, nervous and heat regulatory mechanisms, and this, to a large extent, determined what physical examinations would be made. During the course of the survey other factors—sickness rate, the nature and extent of weight changes, the prevalence of skin affections, the effect of glare—came to assume importance and subsidiary investigations dealing with them were conducted.

The collection of data in the field fell into three divisions: a) the taking of adequate histories; b) the conduct of the physical examination; and c) general observation and interrogation.

In the taking of the case history, each subject was first assigned a serial number and assured of anonymity. The date and place of examination were then entered, together with routine particulars such as rank, age, marital state, civilian occupation, date of enlistment and embarkation. A
careful location history involving the two years prior to the date of examination was then taken in order that the subject's climatic experience might be adequately assessed. His present and any previous mustering (i.e., service occupational grouping) were recorded, and enquiry was made as to whether he liked or disliked the duties assigned to him and why. Under the heading 'Incentives' was recorded an assessment, on a numerical basis, of

<table>
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<tr>
<th>TABLE I. CORRELATION BETWEEN HARVARD PACK TEST INDEX AND OTHER ITEMS IN TROPICAL PERSONNEL</th>
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<tbody>
<tr>
<td><strong>ITEM</strong></td>
</tr>
<tr>
<td>a) Significant at 0.1% level</td>
</tr>
<tr>
<td>Subjective estimate of efficiency</td>
</tr>
<tr>
<td>Length of tropical service</td>
</tr>
<tr>
<td>Intensity of mental work</td>
</tr>
<tr>
<td>Previous tropical exposure</td>
</tr>
<tr>
<td>b) Significant at 5% level</td>
</tr>
<tr>
<td>Objective estimate of efficiency</td>
</tr>
<tr>
<td>Promotion incentive</td>
</tr>
<tr>
<td>Medical history during tour</td>
</tr>
<tr>
<td>c) Not significant</td>
</tr>
<tr>
<td>Unit incentive</td>
</tr>
<tr>
<td>Medical history prior to tour</td>
</tr>
<tr>
<td>Intensity of physical work</td>
</tr>
<tr>
<td>Duration of mental work</td>
</tr>
<tr>
<td>Duration of physical work</td>
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* Item estimated on a basis of 4 units from lowest to highest.
† Depending upon factors excluded in calculating partial correlation and regression.
‡ Per week of tropical as opposed to temperate exposure.

the factors, such as unit esprit de corps, expected promotion and relation to operational activities, considered conducive to maintenance of a high standard of efficiency. The man's habits with regard to alcohol and tobacco were recorded. The subject was then asked whether he considered that his efficiency as an airman and tradesman, and, in appropriate cases, as an NCO, had improved, deteriorated or remained stationary since his arrival in tropical areas. He was then further asked to assess his efficiency in terms of 'excellent', 'superior', 'satisfactory', 'moderate', 'inferior'. Later the subject's officer, or senior NCO, was asked the same question concerning each man. These two assessments are referred to as 'subjective estimate of efficiency' and 'objective estimate of efficiency', respectively. The type, intensity and duration of the work performed by the subject was then recorded and any special circumstances connected with his duties noted. Next a comprehensive medical history was taken and divided into two parts, the first dealing with the period prior to commencement of the current tour.
and the second with that tour. Finally, any information concerning the
man, volunteered by him or supplied by his medical or commanding officer,
and considered to be of interest or importance was added.

For convenience in statistical analysis of the data provided, the results,
where possible, were recorded according to a predetermined numerical scale.

The physical examination commenced with the assessment, according to
the predetermined scale, of the subject’s stance, gait, dress and complexion.
The stability of the cardiovascular system was then examined by observing
the reactions of the pulse rate and blood pressure to sudden elevation to 70°
after twenty minutes’ rest on a tilt table. The subject’s sensations on tilting
were also recorded. The height and weight (clothed and nude) having been
determined and the time noted, the subject then underwent the Harvard
Pack Test for the assessment of his cardiovascular reactions to acute
maximal exercise.

In this test, as originally described by Johnson, Brouha and Darling
(1), the subject wears a pack weighing one-third of his body weight and
steps up onto and down from a platform sixteen inches high, once every two
seconds, until he cannot maintain the pace or until five minutes have
elapsed. The Index is given by the formula

$$I = \frac{100 \times \text{Duration in seconds}}{\text{Twice the sum of the pulse beat counted}}$$
$$\quad \text{at } 1\frac{1}{2}, 2-2\frac{1}{2}, 4-4\frac{1}{2} \text{ minutes after cessation.}$$

At this stage, the wet and dry bulb and globe thermometer readings
were recorded. After a rest period of 30 minutes, the subject was submitted
to a subacute exercise test which consisted of marching in a standard dress,
carrying a standard pack of 18 kilos, for 30 minutes at standard marching
pace. At the conclusion of this test, his pulse rate was observed over a
period of 30 minutes and his heart auscultated to ensure that no abnormality
of heart sounds or rhythm had been uncovered by the exercise. The ex-
amination was concluded by weighing the subject again, both clothed
and nude, and recording the time of the weighing.

The completed case sheets, which were recorded in duplicate, were
checked and despatched with ancillary data for statistical analysis at the
University.

RESULTS

A. Harvard Pack Test Index

From table 1 it will be seen that the subject’s own estimate of his
efficiency was fairly closely associated with his score. It will be seen also
that, although the regression with length of tropical service is small, it
would attain an important magnitude after one year. Previous tropical
exposure, on the other hand, has less than one third of the effect of tropical service.

Again, while the correlation between intensity of mental work and the index obtained is relatively low, the difference (10.36 units) between those engaged in the extremes of mental work may be quite important. The low rating of the driver-despatch rider group (table 2), as compared with other musterings, is noteworthy.

Table 2. Distribution of Harvard Pack Test Index with Mustering in Tropical Personnel

1. Driver despatch rider group
   a) Significantly lower than in Heavy skilled labor group.
   at 0.1% level
   b) Significantly lower than in Heavy unskilled labor group.
   at 1% level
   c) Significantly lower than in Light unskilled labor;
      at 5% level Light skilled labor;
      Instructor and supervisor groups.

2. Other groups
   No significant differences

From table 3 it will be seen that, in general, those factors which were found to be correlated in a highly significant manner with the Harvard Pack Test Index in the tropical group are not significantly associated with it in the control group. This emphasizes the peculiar importance of these items in the tropics. The score obtained with this test by infantrymen was not affected by 4 to 9-day jungle patrols.

B. Other objective estimates

Table 4 compares the results obtained for certain other objective estimates in the tropical and the control groups. It will be seen that, while there are differences between the groups which are highly significant statistically, the absolute value is small and not correlated with length of tropical service.

No progressive loss of weight was found in a group of 236 men of an AIF infantry battalion, except in those who had a high first weight. There were no important weight changes in infantrymen engaged on 4 to 9-day jungle patrols.

Beyond a slight and possibly significant fall in systolic blood pressure, and a slight increase in dizziness on tilting, there were no observable differences in cardiovascular function between the tropical and the control groups of RAAF ground crew; but a suggestion of slight residual increase in cardiovascular instability was found in the men returning from jungle patrols.
C. Clinical findings

The comparative incidence of clinical disturbances in the tropical and the control groups of RAAF ground crew was \(1.218 \pm .039\) and \(0.992 \pm .063\), respectively, as measured by a numerical assessment of the medical history given by the men. This difference is significant at the 0.25 per cent level.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>LEVEL OF SIGNIF. IN TROPICAL GROUP</th>
<th>LEVEL OF SIGNIF. IN CONTROL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subjective estimate of efficiency</td>
<td>0.1%</td>
<td>N.S.</td>
</tr>
<tr>
<td>Intensity of mental work</td>
<td>0.1%</td>
<td>N.S.</td>
</tr>
<tr>
<td>Previous tropical exposure</td>
<td>0.1%</td>
<td>N.S.</td>
</tr>
<tr>
<td>Objective estimate of efficiency</td>
<td>3%</td>
<td>N.S.</td>
</tr>
<tr>
<td>Promotion incentive</td>
<td>5%</td>
<td>N.S.</td>
</tr>
<tr>
<td>Medical history during tour</td>
<td>5%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Unit incentive</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>Intensity of physical work</td>
<td>N.S.</td>
<td>5%</td>
</tr>
<tr>
<td>Duration of mental work</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
<tr>
<td>Duration of physical work</td>
<td>N.S.</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

As regards the type of clinical disturbance in the tropical personnel examined, the following observations are pertinent: a) respiratory diseases were uncommon; b) the incidence of malaria was low and no man examined had had typhus; c) mild diarrhea was common, but dysentery rare; d) burns, usually minor, were quite frequent; e) functional disorders were common, in spite of the fact that no man examined had been a battle casualty; and f) skin affections were very common.

In those men considered to be showing a functional disorder, the following symptoms were usually complained of: sleeplessness, headache, vague abdominal pain, loss of appetite, pains in the back, supposed loss of weight and dizziness on standing up. Examination suggested that the symptoms resulted rather from an elevation of the significance of minor disturbances than from an increased frequency or intensity of the events themselves.

It early became evident that skin affections were prevalent in the tropical personnel and constituted both a source of annoyance to the men concerned and a threat to the effectiveness of the force. The extent of the affliction can be gauged from the fact that, in a random sample of 450 ground crew from our records, whose average length of tropical service was 31.7 weeks, 256 (57%) had developed one or more skin lesions. It was estimated that out of 100,000 man-days of service represented by this group of 450 men, a minimum of 800 man-days were completely noneffective and a
minimum of 9000 partially noneffective from this cause alone. The percentage incidence naturally rises with continued exposure, and it was estimated that, after twelve months' service in the areas concerned, the incidence of skin affection in the force would have attained a steady figure of about 80 per cent.

**D. Commanders' reports**

**RAAF.** All officers questioned stated quite definitely that deterioration occurred in the ground crew after a time, but they differed in their estimate of the length of time and the degree of failure involved. It was generally agreed that men were relatively inefficient for two or three weeks after arrival, but that after that they maintained a steady state of approximately normal efficiency for six months. Deterioration was thought to commence at varying periods thereafter and to be well marked by 12 months. There was a common belief that the length of the tropical tour of duty had been officially set at 15 months for ground crew. Most officers agreed that this belief had a lot to do with the time factor in the onset of deterioration.

The evidence for deterioration appeared to be threefold: *a*) increase in the time taken to perform a task; *b*) reduction in the quality and reliability of performance as revealed by inspection; and *c*) increased complaints in respect of minor disabilities and minor annoyances.

Factors which officers felt were conducive to more rapid and marked deterioration included setting a time limit to tropical service; too much heavy work; too little and boring work; separation from the family; reports of misbehavior by the family; sexual deprivation; a feeling that reliefs were unduly delayed en route; a feeling that the particular work being done was unimportant or even futile; prior service in areas with hot climates which did not, however, count towards the period of tropical service; absence of rest areas in contact with civilized communities; and association with other groups (fighter pilots) who had very much shorter periods of tropical service.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>TROPICAL GROUP</th>
<th>CONTROL GROUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stance (arb. units) ..........</td>
<td>3.38 ± 0.027</td>
<td>3.06 ± 0.054</td>
</tr>
<tr>
<td>Gait (arb. units)</td>
<td>3.37 ± 0.028</td>
<td>3.81 ± 0.050</td>
</tr>
<tr>
<td>Dress (arb. units)</td>
<td>3.37 ± 0.028</td>
<td>3.86 ± 0.051</td>
</tr>
<tr>
<td>Nude weight (kilos)</td>
<td>65.30 ± 2.31</td>
<td>67.58 ± 4.88</td>
</tr>
<tr>
<td>Height-weight ratio (cm/kilo)</td>
<td>2.67 ± 0.007</td>
<td>2.37 ± 0.014</td>
</tr>
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</table>
Army medical officers gave the general impression that they considered complaints of tropical fatigue largely exaggerated. They emphasized the important effect of constant activity (within reasonable limits) and the possession of objectives clearly apparent to the individual soldier.

Some commanding officers felt that the Australian public was responsible for a part of any reduction in general efficiency which might exist: first, because they did not give the impression of being actively concerned in a total war effort (in contrast to the people of England) and second, because too much emphasis was placed by some members of the public upon the comfort and entitlements of the soldier engaged in active operations. War, it was pointed out, is a grim business, and a man who is being constantly reminded of what he is missing and what he is entitled to is less likely to become inured to its inevitable hardships. Leave, in particular, it was considered, would best come as a reward for work done, and in accordance with operational requirements, not as an automatic entitlement with the effluxion of time.

E. Subjective estimates

Almost every one of the tropical RAAF ground crew examined asserted in general conversation that he was not personally as efficient as when he entered the tropics. When later interrogated more exactly, however, as to whether he considered his standard of efficiency as an airman and a tradesman had improved, remained stationary or deteriorated, he gave a somewhat brighter picture. The results given by this later interrogation still show a distinct contrast, however, with the replies obtained in a similar way from the control group, as indicated by the following table:

<table>
<thead>
<tr>
<th>Percentage of Replies</th>
<th>Tropical</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved................</td>
<td>11</td>
<td>65</td>
</tr>
<tr>
<td>Stationary..............</td>
<td>55</td>
<td>29</td>
</tr>
<tr>
<td>Deteriorated............</td>
<td>33</td>
<td>5</td>
</tr>
</tbody>
</table>

When further questioned as to what changes they had noticed, and from what disabilities they had suffered, the tropical personnel complained of one or more of the following: loss of weight, loss of energy and a feeling of constant tiredness, inability to produce their customary amount of work in the tropics, increase in ill-health, a feeling of general malaise, a loss of appetite, unreliable memory, loss of initiative, slowing of the mental processes, and increased irritability. The relationship between these subjective experiences and the complaints of those who had developed frank psychological insufficiency (3c) will be evident.
No comparable systematic interrogation was conducted upon members of the AMF, but we can state quite definitely that the individual soldier was not nearly so conscious of deterioration and loss of efficiency.

**F. Qualitative observations**

In common with other scientists, we prefer to deal with carefully collected quantitative measurements, but the qualitative impressions of a trained observer sometimes make available evidence which could not have been obtained in any other way under the circumstances prevailing. We believe that certain observations we made and opinions we formed are of this nature.

There appeared to have been little, if any, indoctrination of the men as to the effect they might expect the tropical climate to have *per se* upon their physical and mental well-being. It is doubtful if this was properly understood, even by senior officers. In this respect, the AMF had gained some advantage through its experience in the Middle East, but the effects of a humid tropical climate are often quite different from those of a hot arid climate.

In many instances no forethought appeared to have been given to the protection of men and their working places from the worst climatic effects. Bush shelters, awnings and tarpaulins are easily rigged but were frequently neglected on the score that it was 'not the unit's job'. In the absence of unit instructions, the men seldom took appropriate action on their own account. White coral in the working areas is easily covered with darker soil mixed with a little oil, but this was often neglected and the discomfort from glare was allowed to persist.

Evidence of loss of efficiency seemed to occur particularly where one or more of the following conditions existed: human material of less than average quality; poor unit spirit and lack of esprit de corps; lack of tasks of obvious operational significance; insufficient man-mastership and discipline; inadequate organization of leisure time; monotonous diet, bad cooking and poor eating conditions; the siesta habit; and indiscriminate medication privately or from the medical supplies.

Where the following practices operated, they appeared to favor the onset of deterioration or to make more evident the psychological consequences thereof: establishment of a set period as the tour of tropical duty; differentiations in the rate of pay for a given rank, so that a markedly junior rank might be better paid than a senior rank charged with discipline; promotion within the service instead of within the command; absence of rest areas within the combat zone in which relatively normal civilization might be encountered; and inadequate selection of personnel in relation to the duties to be performed.
Existence of deterioration

There is no doubt that in the light of the evidence given there was a lowering of general efficiency in the RAAF ground crew surveyed in the tropical areas, as compared with those examined near Brisbane. A comparable systematic survey was not made of members of the AMF, but close contact with that service led us to believe that deterioration was much less marked in them, except perhaps in the case of skin affection.

Nature of the deterioration

Beyond a slight initial loss of weight and a doubtful increase in vaso-motor instability, the only evidence of any deterioration in what might generally be termed 'physical fitness' that we were able to obtain by objective examination was that given by the Harvard Pack Test Index, which showed a net fall of 0.19 units per week of tropical service. While small, this regression may represent an important deterioration after 12 months or more of tropical service. It is noteworthy, too, that this index was significantly affected in tropical personnel by the subject's own estimate of efficiency and by previous tropical exposure but unaffected by these factors in the control personnel.

On the other hand, the extensive incidence of skin affections must be taken as evidence of deterioration of a physical order, if only because of the actual or potential handicap it presents to the efficient conduct of the man's duties. It should, however, be considered in a different category from that of a general reduction in physical fitness.

Even when due allowance is made for the extensive incidence of skin affections, it is evident that the degree of physical deterioration found is totally inadequate to account for the marked loss of general efficiency apparent in the ground crew. The fact that AMF personnel, exposed to a physical environment which is no better, show less marked loss of efficiency also suggests that the physical aspect plays a lesser rôle in the production of this deterioration.

We are left, therefore, with the conclusion that a major part of such deterioration as does occur is of a psychological order. We realize, of course, that physical and psychological factors, whether as causes or effects, cannot be entirely dissociated, but we do feel that the evidence undoubtedly calls for the emphasis to be placed upon the psychological.

This conclusion, first formulated by comparing the physical deterioration found with the total inefficiency complained of, is amply supported by the other evidence collected concerning RAAF ground crew. To recapitulate, the high incidence of functional disorders, the reduced subjective appreciation of efficiency, the frequent complaints of vague subjective
disturbances, the acute consciousness of the number of days served in the tropics, and the general lowering of the morale of living—all stress the importance of the psychological aspect.

Factors responsible

The basic physiology of man's reactions to hot environment has been reviewed by one of us (Lee, 2) and further discussion will not be undertaken here. Suffice to say that it appears evident that the direct effect of a hot environment, such as prevails in the areas studied, is felt mainly by the cardiovascular system, in which the ratio of the blood volume to the capacity of the circulation often falls below the normal level. The cerebral cortex is particularly susceptible to any such reduction, both by its sensitivity and by its location at the point of highest elevation. Alimentary tone is also susceptible and, therefore, a reduction of appetite is to be expected. The somatic musculature may also arrive at the fatigue point more readily when the blood supply is deficient.

For these reasons the climatic conditions may be held directly responsible for any reduction in physical fitness encountered and also for a primary reduction of initiative and a feeling of lassitude. On the other hand, there is a growing body of evidence from both experimental enquiry and field observation which suggests that nonclimatic factors play an important part in limiting or extending the degree of these changes.

The close association noticed in our investigations between a more marked incidence of lowered efficiency and several nonclimatic factors reinforces this view. It must, of course, be remembered that our observations were made upon service personnel on active service, which entails a highly artificial set of conditions. The more important may be classified as follows: a) those which tend to improve adjustment to the environment—discipline, leadership, possession of objectives; b) those which tend to make adjustment difficult, but are unavoidable—separation from families, sexual deprivation, absence of normal civilian amenities, periods of monotony; c) those which tend to make adjustment difficult, and which could be circumvented or minimized with care—monotonous diet, bad eating arrangements, poor organization of leisure time, uncertainty of post-war occupation, non-appreciation of operational rôle, personality clashes, over-sympathetic treatment by medical staff, unduly unsympathetic treatment by superiors, intrusion of domestic or financial cares, appearances of unfair allocation of work and privileges or rewards.

Relationship to civilian settlement

By contrast, civilian settlement of tropical areas, at least with reason-
able care, can maintain many of the helpful features of military life while dispensing with or minimizing the deleterious factors. If certain important principles are observed in developing these settlements, psychological deterioration should be minimized and with that the physical deterioration, small to start with, might very well disappear.

These principles may be briefly summarized as follows: a) proper selection of community sites and careful planning of their development, in the light of available scientific knowledge; b) development of local educational, cultural and social institutions; c) a rational attitude towards the problem of native labor; d) home and office design according to available scientific knowledge; e) provision for adequate local short rest periods and for longer holidays (not leave to) in nontropical areas, in such a way as to maintain the concept of the settlement as ‘home’; f) maintenance of clear personal objectives, both short-term and long-term; and g) establishment of a reasonable daily physical and mental regime to include both employment and recreation, exercise and rest.

Further studies needed

It goes without saying that many and extensive further studies are required of the nature, extent and determinant conditions of any reduction in physical and psychological efficiency accompanying residence in tropical areas. We feel that four types of investigations, closely integrated, are necessary for any satisfactory understanding of this problem. These are, in brief: a) surveys of the physical and psychological status of the civilian inhabitants of the tropics, preferably at repeated intervals; b) observational studies of the actual behaviour and productivity of civilian inhabitants without any interruption of or interference with their natural activities; c) systematic investigation of methods whereby living conditions may be improved, with particular reference to housing, clothing and social amenities; and d) comparative racial studies in the physiology of heat regulation. It is to be hoped that a properly co-ordinated plan of investigation in human climatology will be undertaken in Australia and that these studies will be incorporated therein.

SUMMARY

In a field survey under joint arrangements by the Australian Military Forces and the Royal Australian Air Force, a systematic study was made of 1507 ground crew serving in the combat zone and of 250 ground crew stationed in southern Queensland. Records were made in each case of relevant factors such as pre-embarkation service; length of tropical service; mustering; incentives; subjective and objective estimates of efficiency; nature, intensity and duration of work; medical history. Measurements
were made and recorded of objective indices such as stance, gait and dress, height and weight, circulatory reactions to tilting, rate of sweat loss and evaporation, Harvard pack test, subacute exercise test. Correlation of objective indices with length of tropical service and other items was sought statistically and, where they were significant, regressions determined.

Subsidiary investigations were made of weight loss, skin disease, surface brightness and the effect of jungle patrols.

The main facts emerging from a statistical analysis of the data obtained were: a) the Harvard Pack Test Index in tropical personnel showed the following associations: a reduction of 0.06 units per week of previous tropical exposure; a reduction of 0.18 units per week of tropical service; a rise with the intensity of the mental work customarily performed; a close association with the subject's own estimate of his efficiency; and a significant reduction in the driver-despatch rider group. b) Only a slight increase in vasomotor instability was discernible in tropical personnel. Pulse rates and blood pressures were relatively unaffected. c) While tropical personnel showed slight losses of weight as compared with controls, there was no evidence that this was progressive. d) Fifty-seven per cent of personnel (average tropical service 31.7 weeks) had contracted some skin disease, although usually of mild or moderate degree. e) As against the relatively slight objective findings, there was no doubt that reduced efficiency was wide-spread in RAAF ground crew. This was revealed by officers' replies to questions, lowered subjective estimates of efficiency, undue complaint by the men of minor affections and increased attendance for medical attention.

While climatic effects per se can be cited as the major cause of skin affections and a contributory cause of general inefficiency, the observers were led to the conclusion that personal and psychological factors were of paramount importance, and that much of the inefficiency is preventible by realistic handling of these factors.

The authors wish to acknowledge the encouragement and very ready help they received from the Directorate of Research, Allied Land Headquarters; the Director General of Medical Services, RAAF, and the Flying Personnel Research Committee; and from all officers of the field forces investigated. Invaluable guidance was given in the statistical work by Squadron Leader McGovern. Without the willing assistance of the RAAF members of the Tropical Research Party and the AWAS attached to the Physiology Department, the extensive and often monotonous work could not have been carried through.

Expenditure in respect of nonservice items involved in this investigation was met by the National Health and Medical Research Council.

REFERENCES