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DISEASE THREAT AT HIGH TERRESTRIAL ALTITUDES

VOLUME 1

August 1979

Final Departmental Study

Prepared by

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and Information Agency
Fort Detrick
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DISEASE THREAT AT HIGH TERRESTRIAL ALTITUDES

VOLUME 1

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PREFACE

This study investigates the risk of diseases to unacclimatized personnel rapidly translocated to, or stationed in, terrestrial areas at altitudes above 3,000 meters. Both short and long term impacts (if any) such diseases would have on military operations at these elevations are addressed.

Volume 1 of this study covers the incidence of various diseases at high altitudes, discusses related environmental factors, examines foreign research and development and assesses disease impact. Volume 2 provides maps delineating high altitude areas of the world and a survey of climatological factors.

This product is intended to be used to provide direction to both basic and applied research efforts within the US Army Research Institute of Environmental Medicine and for the Department of the Army contractual program in high altitude research. It may also prove useful to military operations planners and unit commanders who may have to prepare for deployment of troops to a region above 3,000 meters.

A

TABLE OF CONTENTS

LIST OF TABLES

MIIA-1-79
August 1979

SUMMARY

Due to a paucity of available research data, only a limited intelligence assessment of disease risks to the health of unacclimatized personnel at altitudes above 3,000 meters can be made.

Disease problems will, as a rule, be progressively less frequently encountered with increasing altitude and distance from the equator. However, the complex interaction of environmental and biological factors produces exceptions to this generality in some geographic areas. Although acute mountain sickness may increase susceptibility to disease, a direct correlation between the two has not been firmly established.

Insect-borne diseases will probably be the most prevalent ones encountered at elevations above 3,000 meters. Of this group, the tickborne diseases are the most common. In the tick, the life cycles of some infectious microorganisms can be completed without the need for an intermediate host, such as man; thus ticks represent a disease hazard, even in uninhabited areas. Relapsing fever, spotted fevers, Q fever, encephalitis, and tularemia are all potential dangers. The mite-borne disease, scrub typhus, may be encountered in high altitude areas and, like the tickborne diseases, requires no intermediate host for survival of the causative organism.

Louseborne diseases, including epidemic typhus, trench fever, and relapsing fever are fairly common in inhabited areas, especially in colder regions where people may be crowded together in dwellings under conditions of poor personal hygiene.

Mosquito-borne diseases should present no problem, except in some of the warmest mountain areas, where there is some risk of malaria.

Studies have shown that some diseases caused by intestinal parasites occur in Peru and Tibet, but present no major public health problems.

Some problems could be expected with diseases associated with crowded living conditions (e.g., colds, influenza, tuberculosis, diarrheas, and dysenteries). No outbreaks of meningitis have been reported from areas at altitudes of 3,000 meters or higher.

Animal-to-man transmitted diseases, primarily anthrax and rabies, should not present problems in areas above 3,000 meters elevation, as long as personnel avoid contacts with domestic and wild animals.

SECTION I

INTRODUCTION

1. General

The vast diversity of environmental conditions which exist in those areas of the world above 3,000 meters altitude makes a simple assessment of disease risk impossible. There is no "typical situation," i.e., there are no clearly identifiable sets of environmental and/or biological circumstances existing with sufficient frequency to allow an assessment of the disease threat on the sole basis of elevation. This is further complicated by the worldwide lack of ongoing research on the subject, due primarily to the fact that few people live at elevations above 3,000 meters in most parts of the world. As a result, there has been little need for medical research in such areas. Nevertheless, some observations have been made which could be of assistance to the military commander who must deploy troops at extreme elevations.

2. Areas of the World Above 3,000 Meters

An area of approximately 2,700,000 square miles (nearly five percent of the earth's land mass) is 3,000 meters or more above sea level. Almost one-half of this area is in Antarctica, where an ice sheet over 1,500 meters thick covers a land surface predominately below 2,000 meters. Much of the remaining 2.5% of the high altitude land area is covered with permanent ice and snow, or with only a thin layer of lichen-type vegetation. Only in relatively few areas of the earth above 3,000 meters are environmental conditions such, that significant disease problems are likely to be encountered. Some of these areas, however, have geopolitical boundaries separating traditional enemies. Some could possibly be used as guerrilla bases and many are strategically located, thus all must be considered as potential battlegrounds of the future.

The Tibetan Plateau in Asia, the Andes in South America, the Alps in Europe, and the Rockies in North America are the best known areas of the earth above 3,000 meters. In addition, there are about 131 mountains above this altitude in areas such as the Atlas Mountains in Morocco, the Abyssinian Highlands in Ethiopia, the Caucasus Mountains in the USSR, and some isolated peaks, such as Chiriqui in Panama, Carstensz in New Guinea, and Kerintji in Indonesia. The attached world map (Figure 1) shows the location of high altitude areas.

3. High Altitude Syndrome: Impact on Personnel Effectiveness

The abrupt translocation of an individual from a low lying geographical area to a region of relatively high altitude can result in a profoundly debilitating syndrome known as Acute Mountain Sickness (AMS). The syndrome is characterized by severe headache, nausea, increased respiratory rate, fatigue, abnormally rapid heartbeat, loss of memory and the inability to concentrate. AMS is caused by the reduced atmospheric oxygen tension found at high altitude; this, in turn, lowers the partial pressure of oxygen in the alveoli of the lung and results in inadequate oxygenation of the blood and tissues (hypoxia). The first symptoms of AMS occur between four and twelve hours after arrival at the higher altitude and persist for four to seven days thereafter. Susceptibility to AMS varies with differences in individual physiology. The symptoms of AMS generally begin to occur at about 2,400 meters and become progressively more severe with increasing altitude. The physiological limit of human tolerance to reduced atmospheric oxygen appears to be reached at about 9,545 meters. The Indian experience during the 1969 war with China and the limited US experience in high altitude military operations during WW II indicate that if a military unit is abruptly transferred to an area above 4,000 meters, 50-80% of the force is likely to experience some degree of disability and reduced effectiveness due to AMS. The severity of AMS symptoms is reduced upon moving to lower altitudes. If troops remain at the 4,000 meter level it will take seven to twelve days for most personnel to adapt to the conditions. Although most symptoms disappear eventually, the individual does not recover his full capabilities while remaining at the high altitude. Studies have shown that even after several months at 4,000-4,300 meters, the maximum rate of work remains only 70-80% of that at sea level, and may never reach sea level values even after years of adaptation.

Although a direct correlation has not been established, it is possible that the weakened condition brought about by AMS and/or a prolonged stay at altitudes above 3,000 meters, could leave the individual more vulnerable to infectious and organic diseases. The first four to seven days after arrival in areas above 3,000 meters could be critical in regard to disease susceptibility and special precautions might be in order. There is evidence, however, that morbidity rates for many common diseases may actually be reduced at high altitudes in comparison to those at sea level over a prolonged period. In studies on Indian Army personnel 18-54 years of age stationed at altitudes ranging from 3,690 to 5,540 meters for two to three years, it was shown that morbidity rates for chicken pox, infectious hepatitis, malaria, tuberculosis, diabetes, asthma, and psychiatric disorders were significantly lower than at lower altitudes. The same was true with dysentery, diarrheas, some respiratory infections, mumps, ischaemic heart disease, anaemias, and skin diseases. There was no significant difference in the morbidity rates of hypertension, meningitis, and peptic ulcer. The only disease showing a higher morbidity rate was pneumonia. The differences in these morbidity patterns were believed to be related to environmental factors such as the quality of solar radiation and the low moisture content of the air.

Acclimatization of troops destined for assignment to a high altitude area is necessary to prevent reduction of their physical and mental capabilities. At least three methods have been identified. The staged movement of troops from one elevation to another, with a few days stay at each level, is one regimen. Two days each at 2,000, 3,000, and 4,000 meters has been suggested. If a staged movement plan is impossible, symptoms of mountain sickness can be reduced by the administration of 1,000 mg of acetazolamide daily, beginning 48 hours prior to ascent and for 48 hours after arrival. This regimen has been shown to be effective for ascent to altitudes up to 5,300 meters. A third approach is staging at 1,600 meters for four days, in combination with acetazolamide administration 48 hours before and after ascent. This last regimen has been shown to eliminate AMS symptoms at altitudes up to 4,300 meters. However, neither acetazolamide alone, or in combination with staging, has been found to be effective in normalizing the reduced capacity for heavy physical work, visual defects, or mental incapacitation resulting from high altitude hypoxia.

4. Low Temperatures

The intense cold at higher altitudes in many parts of the world is a significant factor in reducing the prevalence of microorganisms; nevertheless, precautions against infectious diseases, especially those of the respiratory system, should be taken. Provision of clothing appropriate for prevention of hypothermia and emphasis on proper personal hygiene are essential.

SECTION II

ENVIRONMENTAL AND ECOLOGICAL FACTORS RELATED TO DISEASE AT ALTITUDE

1. Environmental Factors

Because of the diversity of macro-and micro-environments which may be found at altitudes of 3,000 meters and above, an assessment of disease risks, even on a regional basis, becomes extremely complex, if not impossible. Generally, it can be assumed that the disease risk profile at 3,000 or more meters altitude will be substantially different than that at sea level, because of the radically different and often extreme nature of the environments.

An attempt to categorize insect fauna on the basis of altitude criteria alone is a difficult task. Numerous experiments have shown that atmospheric pressure, in and of itself, has little effect on the vertical distribution of insects and other related arthropods. Many are capable of surviving at altitudes well above the highest mountain peak.

The vertical distribution of insect fauna is, however, dependent on a number of other ecological factors, many of which are directly or indirectly related to atmospheric pressure. The most outstanding of these factors is the forest line, or tree line, which delineates the upper limit of the forest ecosystem and the lower threshold of the high altitude insect biota.

Vegetation, as a primary determinant of the fauna, is largely a product of environmental conditions. Climatic factors such as temperature, rainfall, wind, etc., have a marked effect in determining the various types and distribution of plants within an area. Thus, vegetation patterns characteristic of different mountain ranges and, in fact, between peaks within a range, are the result of variations in environmental factors. Unfortunately, information on vegetation patterns for many of the high altitudes areas of the world is limited, or nonexistent, at this time. Available information indicates generalized vegetation types, with little information on the species present or their abundance. It should be emphasized that microenvironmental conditions within any given high altitude area may result in small areas of vegetation types markedly different from the generalized vegetation patterns described. Extreme floral diversity also occurs as a result of man's activities. Activities such as cutting, cultivating, grazing, etc., result in greater variability in species and drastic variations from the generalized indigenous flora characteristics of the high altitude areas of the world.

The upper altitudinal limit of the forest varies greatly and is influenced by a number of factors such as location of the mountain range in the northern or southern hemisphere, the nature of the general climate of the region, direction of the slope, presence and arrangement of ridges and valleys, annual rainfall, and numerous other complex ecological factors. The forest line on a given slope may even shift dramatically over time as the composition of the above-mentioned factors fluctuates. However, the forest line generally coincides with a 10° to 12° C isotherm of the mean midday temperature from May to September. This may occur as high as 4,600 meters on the Tibetan Himalaya, to as low as 400 meters on the north Fennoscandian Mountains. Since most authors define high altitude insects as those insects which occur above the forest line, attempts to categorize this group of organisms on the basis of altitude alone do not give a clear picture of their ecological affinities. In many mountainous regions of the world, 3,000 meters would fall within the upper alpine zone, but in the tropical regions closest to the equator, it would still be well within the forest canopy.

The biome (an extensive community of plants and animals with similar environmental requirements for existence) which lies between the forest line and the permanent snowline is generally referred to as the alpine zone. The alpine zone is further divided into four subzones: (1) the nival zone - from the highest peaks down to the level of abundant growth of vegetation mats; (2) the subnival zone - from the area of abundant vegetation mats down to the closed meadows; (3) the upper alpine zone - between the closed meadows and the shrub zones; and (4) the lower alpine (or subalpine) zone - between the shrub zone and the forest line. The boundaries of these subzones are not sharply defined and show considerable variation on different mountains, depending on the complexity of local factors. Although there may be considerable overlap, much of the insect fauna, along with the flora on which it is partially dependent, is restricted to one or two of these subzones.

Although reduced atmospheric pressure has little effect on insects, it does result in a number of ecologically important factors which do have a profound effect on the ability of insects to survive at high altitudes. These factors are as follows: reduced water vapor tension, resulting in high altitude atmospheric aridity and lowered precipitation; high transparency of the air, resulting in a lowering of atmospheric temperatures which retards evaporation from exposed surfaces (partly counteracting the harmful effects of high altitude aridity) and increased intensity of ultraviolet radiation; low atmospheric temperature, leading to precipitation of atmospheric moisture as snow and ice; low atmospheric density and aridity, allowing a high rate of insolation and radiation, producing widely fluctuating atmospheric and ground temperatures; and rarified and arid conditions, which accelerate evaporation from exposed surfaces, creating a problem of desiccation for soft-bodied organisms. On mountain ranges like the Himalaya, Caucasus, Alps, and Pyrenees, which are oriented in an east-west direction, the environmental conditions and the insect biota are usually markedly different on the northern and southern slopes at the same altitude. The influence of altitude on the mean environment is profoundly modified by the differences of the north-south slope exposure. These modifications result from differences in the angle of the incidence of the sun's rays, which alters the degree of insolation. Differences in the gradient of opposing slopes also greatly affect the degree of insolation.

Due to the milder and more uniform nature of the climate and the interrelationship and interdependency with its adjacent montane-forest zone, the lower alpine zone tends to have richest insect fauna. This is true in terms of both number of species and individuals. The upper reaches of the subnival zone around areas of snow melt tend to have the second highest density of insects due to the buffering effects of snow cover and increased availability of soil and atmospheric moisture. The upper-alpine zone is generally regarded as a "biological desert", with the flora and fauna existing under climax conditions (extreme environmental conditions). Here, the number of insect species is greatly reduced. However, those species which do reside in this zone frequently occur in tremendous numbers, as is the case in most other climax situations.

2. Vegetation Profiles of Major Regions

A. Western Hemisphere

(1) The Andes Mountain System

The Andes mountain system is not a single line of formidable peaks, but a succession of parallel and transverse plateaus and depressions. Its extensive north-south orientation as well as the west to east bulges in the system result in a wide variety of climatic conditions and vegetation types. Vegetation patterns change as latitude and longitude, temperature, and levels of precipitation vary.

(a) Vegetation Types at Various Elevations

Vegetation is generally absent in areas above 5,000 meters where snow, icefields and glaciers predominate. The permanent snowline exists at approximately 4,600 meters in the more southern latitudes. Even in the tropical latitudes, climatic conditions are sufficiently severe that vegetation cannot survive.

A vegetation form called the "paramo" exists between 4,000 and 5,000 meters. The paramo consists of rosettes, cushion plants, and bunch grass. It has little woody vegetation because of the severity of the wind, the cold temperatures, and the low rainfall. Rosette and cushion plants are often thick and can vary in height from 0.5 to 5 meters.

Generally below the paramo, a vegetation type known as the subparamo exists. The subparamo often contains one of the denser types of vegetation, the elfin forest, where the trees are gnarled, dwarfed (usually only 2 to 8 meters tall), and densely festooned with mosses.

A variety of vegetation types occur between 3,000 and 4,000 meters, depending upon climatic conditions. Vegetation types change with both latitude and longitude as can be seen in Table 1. A description of the vegetation types listed in the table is as follows:

TABLE 1. VEGETATION TYPES, 3,000 TO 4,000 METERS

ALTITUDE	3,000 to 4,000 meters		
	Western Slopes	Intermontaine	Eastern Slopes
7°N to 1°N	open mountain bushland high cold mountain forest wet mountain cloud forest	high cold mountain forest	alpine meadow open woodland
1°N to 5°S	alpine meadow open woodland open mountain bushland	alpine meadow	alpine meadow open woodland open mountain bushland wet mountain cloud forest
5°S to 10°S	open mountain woodland	alpine meadow	alpine meadow open mountain bushland open woodland wet mountain cloud forest
10°S to 20°S	alpine meadow open mountain bushland	alpine meadow	alpine meadow open mountain bushland open woodland wet mountain cloud forest
20°S to 28°S	open moutain bushland desert cactus and thorn-bush	open mountain bushland desert cactus and thorn-bush	open mountain bushland desert cactus and thorn-bush
28°S to 39°S	open mountain bushland	open mountain bushland	open mountain bushland dry forest and scrub
39°S to 43°S	barren	barren	barren

(b) Forest Types and Meadows

The wet mountain cloud forest occurs in areas of high and continuous rainfall, usually where there is a strong concentration of orographic rainfall and belts of clouds. The canopy is dense and there are usually two layers of tree crowns, one at 25 to 35 meters and a lower one at 3 to 15 meters. There is usually a minimum of undergrowth, but there may be areas of local thicket growth of palms and other lower plants. This vegetation type is characteristic of areas between 3,000 and 3,300 meters.

The high cold mountain forest is sometimes a continuation of the mountain cloud forest, but may be a direct upward continuation of a tropical rain forest. It occurs in areas where there is heavy rainfall throughout the year. The canopy tends to be two-storied, with layers at 10 to 15 meters and 20 to 25 meters. Dense palm-shrub layers may be present in the undergrowth. With increasing altitude, shrubs and dwarf trees decrease in height and become more widely spaced.

Open woodlands occur where lower temperatures and less rainfall reduce the favorable environmental conditions needed for heavy forest growth. These woodlands are generally found between the open mountain bushlands and the alpine meadows and are physiognomically analagous to lowland savannas. The wide spacing of the trees and shrubs allows for the development of high savanna grasses and bunch grass. Trees usually do not exceed 10 meters in height and may be gnarled and twisted at higher altitudes. Bunch grasses are often 2 meters or more in height. The open mountain bushland occurs on slopes above the open woodlands in areas with diminishing rainfall and temperature. Shrubs and dwarf trees in this vegetation type range from 1 to 5 meters and are usually widely spaced.

The alpine meadow usually occurs in the northern and western Andes above 3,500 meters. The climate is too dry in the southern Andes for good development of this vegetation. Short grasses are characteristic of this vegetation type.

This type of vegetation occurs in the drier areas of the mountain system, with desert vegetation such as cactus, thorn bush, and other xerophytes being an adjustment to areas of extreme drought. Usually, the tallest spiny trees do not exceed 10 meters in height. Areas of cactus shrub may range from 1 to 5 meters in height. Thorn thickets can be quite dense because of the close spacing of the small, armed trunks.

(2) The Mexican Highlands

The snowline in the Mexican highlands exists at approximately 4,700 meters, but snow may cover the entire alpine area during the winter months. Open grass meadows dominate between 3,700 and 4,300 meters and few woody plants, and no actual trees, are present above 4,100 meters. A coniferous forest of Pinus hartwegii exists between 3,800 and 3,900 meters.

B. Asia

(1) The Himalayan System

The vegetation pattern of the Himalayan Mountains is quite varied, reflecting the wide variation in the climate of this area. In the western Himalayas, the treeline extends to 4,200 meters, while in the warmer Eastern Himalayas, the treeline extends to 4,400 meters. Above the treeline, wet and moist alpine-type vegetation occurs throughout the system. Juniper is widely distributed and is found on sunny, steep, rocky slopes and in drier areas; Mt. Nanga Parbat, it is found at an altitude of 3,870 meters. Rhododendron occurs everywhere, but is more abundant in the wetter parts of the eastern Himalayas, where it grows in all sizes, from trees to low shrubs. Mosses and lichens grow in shaded areas where the humidity is high. Flowering plants grow at higher altitudes, especially on Mt. Nanga Parbat and Mt. Everest.

The windswept arid Byang-thang plateau of northern Tibet has an average elevation of 4,600 meters and is devoid of trees and larger forms of vegetation. In the river valleys and in the lower wetter regions of the south and southeast, plant life is quite varied, including many types of trees and flowering plants.

In the Kunlun Mountains, cold, desert-like conditions prevail. Completely barren spaces predominate, alternating with small areas that support a thin plant cover.

Vegetation in the Pamir area is poorly developed, especially in the Eastern Pamirs, where woody vegetation is completely absent and only low growing plants, which have adapted to severe climatic conditions, exist. Alpine cobresia meadows occur between 3,700 and 4,300 meters. Above 4,400 meters, vegetation is scarce.

In the Altai Mountains of Mongolia, subalpine shrubs are replaced by meadows. With increasing elevation, mosses are replaced by bared rock and ice.

In the Sayan Mountains of Siberia, snow exists above 3,000 meters and there is a lack of any dense vegetation. The treeline occurs well below 3,000 meters.

(2) New Guinea

In the mountainous areas of New Guinea, there is a gradual reduction of vegetation height with increasing altitude and a tendency for the forest to be replaced by grassland, scrub, scattered trees, and groves. Tall trees and shrubs cease to exist at approximately 4,000 meters. At this altitude, the canopy is still generally at 3 to 6 meters, but occasionally trees are much taller; on Mt. Carstensz, the forest is composed largely of tree ferns. Above the treeline, grasslands and rocky herb fields predominate, with considerable shrub. Tussock grasses predominate, but there are many smaller herbs and scattered shrubs. On steep, rocky sites the grasslands grade into grass heaths and where ground-water is prevalent, into bogs of mosses and minor herbs. With increasing elevation, the grasslands become simpler in floristic composition and more open in structure.

The snowline occurs at approximately 4,600 meters.

(3) Indonesia

Treeline exists between 3,000 and 3,600 meters. Most of the limited vegetation in this area is apparently associated with recent volcanic activity or with burning.

(4) Sabah

On Mt. Kinabalu, the treeline exists at approximately 3,600 meters. Dwarf shrubs and herbs growing as scattered plants and clumps in cracks have been recorded. Conditions do not favor a rich or varied flora.

(5) New Zealand

Areas above 3,000 meters in New Zealand are mostly snow covered.

(6) Formosa

Above 3,000 meters, dense scrub cover of Juniperus, Rhododendron, and Berberis, which continues on to the mountain peaks, is present.

C. Europe

(1) The Alps

Vegetation varies with climatic conditions in the Alps. The treeline is well below 3,000 meters. In Switzerland, Alpine pastures reach an altitude of 3,300 meters. Grasses, shrubs, and flowers become less frequent with increasing altitude. In the Italian Alps, twisted shrubs, including rhododendron, green alder, and dwarf juniper, are replaced (with increasing altitude) by pastures having grasses, sedges and wild flowers. On the snowline, there are innumerable mosses, lichens, and flags.

(2) The Pyrenees

The composition of the sparsely covered alpine pastures varies with climatic conditions. The western Pyrenees receive a greater rainfall and the vegetation of the high Alpine pastures is much more resistant to conditions of dampness and permanent snow than is the vegetation of the eastern Pyrenees.

(3) The Caucasus Mountains

In the Caucasus range, glaciers and perpetual snow begin at approximately 3,000 meters.

C. Africa

(1) East Africa

The mountains of equatorial East Africa have a cool climate and a vegetation pattern quite distinct from that of the warmer surrounding lowlands. Betwen 3,000 and 4,000 meters, upland forest gives way to woodlands of giant heath and heath-like plants. The density of the vegetation is dependent upon the amount of rainfall and in the wetter mountain areas, ericaceous woodlands are most extensive and can be quite dense. The canopy of this woodland varies from 1.5 to 13 meters. The undergrowth varies with altitude and in some places is mainly mosses, but at higher altitudes, the undergrowth is sometimes dominated by the silvery-leaved Alchemilla which can form quite tall shrubs. Drought, fire, and sometimes grazing have thinned the woodland in some areas and have eliminated it in others. Much of the vegetation in such areas consists of low-stature tussock grasslands with scattered scrubs. In the driest mountains, woodland areas may be limited to moist places such as stream sides and ravines. Tussock grasslands are most characteristic of these areas.

Above 4,000 meters, the giant heath diminishes in size and at about 4,200 meters is replaced by scrub cover of straw-colored Helichrysum stuhlmanii. This type of vegetation is most prevalent on steep, rocky slopes between 3,600 and 4,300 meters and in some places is so thick it is hard to walk through.

The lower edge of the glacier line is found between 3,960 and 4,570 meters. Here, the vegetation is very open. The upper limit of plant growth exists at approximately 5,000 meters.

(2) Abyssinian Highlands

The vegetation pattern of the western portion of the Abyssinian Highlands consists mostly of grasslands and farmlands, with occasional clumps of trees. The treeline exists at about 3,000 meters and above this altitude only coarse grasses, giant lobelias, and other high altitude vegetation is present. On Mt. Ras Dashan, however, a fairly extensive growth of tall Erica aborea trees, rather than shrubs, exists at 4,250 meters.

(3) The Atlas Mountains

In the Atlas Mountains, cedar trees predominate at the higher altitudes. However, on the dry summits, the vegetation is reduced to scattered stands of green oak and juniper trees.

3. Sources of Disease in the High Altitude Ecosystem

A. General

Since there are relatively few people inhabiting areas at elevations over 3,000 meters, the most probable source of disease transmission is through bites of animals and insects. There is far less danger of disease transmission by food, water, or fomites. All modes of disease transmission do, however, exist in high altitude regions and some precautions will be necessary to protect troops against infection. There are insufficient data available to make a region-by-region intelligence assessment of disease risks to unacclimatized personnel. However, there is some information on health problems in a few key areas. This information provides some insight into potential disease risks in these and adjacent geographic areas. In addition, a study of various ecosystems can help to determine what diseases may be endemic. Since disease occurrence is strongly influenced by the type of flora, vegetation profiles were helpful in determining areas where vectors and associated disease organisms may exist.

B. Diseases Transmitted by Insects

The diseases most likely to be encountered in high altitude regions are those transmitted by insects. Generally, insect populations in such areas tend to decrease in number and variety of species as the elevation increases. However, this is not necessarily true within alpine regions. The lower alpine zone tends to have the richest insect fauna due to its milder, more uniform climate and its interrelationship with the adjacent montane-forest zone. The upper reaches of the subnival zone around areas of snow melt usually have the second highest density of insects, due to the buffering effects of snow cover and increased availability of soil and atmospheric moisture. The numbers of insect species in the upper alpine zone are greatly reduced, but species that are present frequently occur in tremendous numbers typical of a biological climax situation. There is little or no insect population in the nival zone.

Most of the insect groups associated with mammalian diseases are dependent on mammals or other related vertebrates for survival. Most utilize their hosts as a food source, feeding on the blood or waste products. The mammal's place of abode is also frequently utilized as a place of refuge from the harsh environment encountered at high altitudes. Therefore, the relative abundance of these insect groups is greatly affected by the relative abundance of available hosts. Since the vertical distribution of potential mammalian hosts tends to decrease in both kinds and numbers with an increase in altitude, the associated insect fauna also decreases accordingly. This is partially offset, however, by the ability of many of these insects to reproduce in extremely large numbers. This is particularly true of those groups which require a blood meal for egg development. Over-reproduction increases the probability that at least some portion of the population will find suitable hosts and insure the propagation of the species.

Studies have shown that the percentage of a potential vector population actually infected by causal organisms of disease decreases geometrically with the decrease in available host organisms. This is due primarily to the decreased chances of these organisms being transmitted from one host to another. At high elevations there are additional environmental factors which may also come into play. Although the potential remains, the probability of encountering many of the insect-borne diseases of man decreases as altitude increases.

(1) Tickborne Diseases

Tickborne diseases would be the most likely group of insect-borne diseases encountered in areas above 3,000 meters. Ticks can survive in a wide variety of environmental conditions and, during periods of cold temperatures, are capable of hibernating, emerging only when the temperature becomes suitable to feed and complete the life cycle. The mammals, birds, and reptiles on which the ticks feed have a wide geographic range and when the tick attaches itself to the host to feed, it can be carried by the host to varying locations, including areas above 3,000 meters. Upon feeding to repletion, the tick drops to the ground where it molts, and deposits its eggs, then crawls onto bushes or other vegetation to wait for a suitable host to happen by on which to feed and continue its life cycle. Adult ticks can withstand starvation for several years while waiting for a host to pass by. Protected areas such as summer cottages, caves, valleys, or areas where animals may seek shelter from the harsh environment above 3,000 meters, may harbor large numbers of ticks and become, therefore, foci of disease.

Another important factor regarding tickborne diseases is transovarian transfer (from the ovary of the gravid female tick to the next generation of offspring) of the disease agent. Intermediate hosts such as man, therefore, are totally incidental to the disease cycle. Thus, tickborne diseases could be a potential risk to man even in areas where human habitation is totally absent. In addition, since the disease agent completes its life cycle within the tick and is therefore not affected by environmental factors, harsh conditions will not affect its geographic distribution or its presence in areas of the world above 3,000 meters.

There are two family groups of ticks, the Argasidae, or soft-bodied ticks, and the Ixodidae, or hard-bodied ticks. Soft-bodied ticks of the genus Ornithodorus can transmit spirochetes which cause relapsing fever, or rickettsiae which cause spotted fevers. The hard-bodied ticks, including the frequently encountered genera Dermacentor, Amblyomma, and Rhipicephalus, can transmit the rickettsiae which cause spotted fevers or Q fever, the virus which causes one type of encephalitis, and the bacteria which cause tularemia.

Three strains of spotted fever rickettsiae and the recently described Hazara virus were isolated from rodents at 3,000 to 3,600 meters in the Kaghan Valley, Hazara District, Pakistan. A focus of tickborne encephalitis was identified in the Transiliysk Mountains, Alma-Ata Oblast, USSR, at 2,700 meters; the principal tick vector, Ixodes persulcatus, was present at 2,970 meters. In the village of Pusi, Pusi District, Province of Huancane, Department of Puno, Peru, (altitude 3,500 meters), 11.7% of the study population was found to have antibodies to Coxiella burneti (the causative agent of Q fever) and 1.9% to Rickettsia rickettsi (the causative agent of Rocky Mountain spotted fever).

(2) Mite-borne Diseases

The mite- or chigger-borne disease, scrub typhus, may be encountered in areas above 3,000 meters. Its known geographic distribution, however, is limited to Asia.

As with the tickborne diseases, the infectious agent of scrub typhus, Rickettsia tsutsugamushi is maintained in the mite population by transovarian passage. There may also be a mite-wild rodent-mite cycle in which transfer of the rickettsia occurs when the larval mite feeds upon the blood of an infected rodent. Man, therefore, is not essential to the maintenance of the infectious cycle and acquires the disease when bitten by an infected mite while in an endemic area.

Endemic areas of scrub typhus are characterized by the relatively recent changing of environmental conditions, such as areas of deforestation or the presence of hedge-rows (naturally occurring or planted by man), which border virgin forests. Scrub typhus is normally considered a tropical disease, with warmth and humidity necessary for the development of the mite vectors. However, the mite Leptotrombidium deliensis has been recorded at 2,200 meters in the Kashmir Himalayas and both L. deliensis and L. akamushi have been found at 2,200 meters on Mt. Kinabalu, Sabah. Scrub typhus strains from mite vectors collected at 2,400 meters in the Kaghan Valley, Peshawar, Pakistan have been identified and scrub typhus rickettsiae have been isolated from rodents in the same area at 3,200 meters.

(3) Louseborne Diseases

Louseborne diseases could be quite prevalent in areas above 3,000 meters. Unlike tick- or mite-borne diseases, however, louseborne diseases occur only in areas of human habitation. There is no known animal reservoir for the louseborne diseases and the rickettsiae of epidemic typhus (Rickettsia prowazeki) and trench fever (R. quintana), and the spirochete of relapsing fever, Borrelia recurrentis, cannot be transferred transovarially. Consequently, the louse must be infected by ingesting the blood of an infected human.

Throughout the world, louseborne diseases are more common in colder areas where people are crowded together indoors, with little or no opportunity for frequent changes of clothing or for bathing. The body louse (Pediculus humanus humanus) is dependent on its human host for food and warmth, attaching its eggs to the fibers of clothing where they hatch at body temperature. Lice are very active travelers and with the slightest body contact, readily transfer from one host to another of the same species. In addition to the disease they transmit, the bite of a louse may produce an irritating dermatitis, pediculosis.

Louseborne typhus is reported to be prevalent in the higher altitudes of the tropics and cases have occurred in the mountainous regions of Bolivia at well over 3,600 meters. In the village of Pusi, Peru, at an altitude of 3,500 meters, 26.1% of the study population was found to have antibodies to R. prowazecki and body lice were an almost universal occurrence among the residents of the village. Pediculosis was present in 49.6% of the study population. A high incidence of body lice was also reported in Badrinth, India, altitude 3,200 meters and the prevalence of pediculosis was high.

(4) Mosquito-borne Diseases

Mosquitoes constitute the single most important family of insects from the standpoint of human health and can be found anywhere on the continents except in areas of permanent ice and snow. Some species of mosquitoes have adapted to cooler climates and have the ability to overwinter, usually in the egg stage. The eggs freeze during the winter and when warmer conditions return, some hatch and continue the life cycle. Mosquito-borne diseases are unquestionably more prevalent in tropical areas. One reason is that many of the disease agents require warm temperatures in which to complete their life cycles. However, in some of the more protected valleys of areas above 3,000 meters, the climate may be sufficiently warm at certain times of the year for both the disease vector and the disease agent to complete their life cycles. Both Plasmodium falciparum and P. vivax malaria have been found to be endemic in villages in the Gilgit Agency of Pakistan, at altitudes between 2,900 and 3,700 meters. The rate of positive blood films declined with increasing altitude. At two villages in Pakistan, Chhassee (2,900 meters), and Phander (2,950 meters), the prevalence rates were in the moderate range, 38 and 25% respectively. At three other villages in the same area above 3,000 meters (Teruat at 3,200 meters, Barsat at 3,350 meters, and Malain Shah at 3,770 meters), the prevalence rates were low, ranging from 7 to 12%. Plasmodium falciparum was present in all the villages, with P. vivax present only in Chhassee and Teruat. Malaria parasites were found in the blood of young children as well as in the blood of older individuals, indicating that malaria transmission was most probably occurring and that the infection had been acquired in the area, not at some lower altitude.

The malaria vector, Anopheles superpictus, has been found at altitudes of 3,300 meters in the Gilgit Agency of Pakistan and at 2,600 meters in the Vanch District of Afghanistan. Anopheles pseudopunctipennis, the malaria vector in Colombia and Ecuador, has been found at altitudes up to 3,200 meters.

Malaria is not usually considered to be a disease problem at high altitudes and transmission is generally restricted to areas below 1,800 meters. Malaria is reportedly not present above 1,500 meters in India, 1,900 meters in Ethiopia, 2,000 meters in Nepal, and 2,400 meters in New Guinea.

Other diseases transmitted by mosquitoes do not appear to be a problem in areas above 3,000 meters. Japanese B encephalitis was found to be present in Java, Indonesia, only in areas below 2,500 meters. Serological tests in an arbovirus survey at Pusi, Peru (3,500 meters) were negative at titers of 1:40 for Mayaro, Western Equine Encephalitis, Eastern Equine Encephalitis, Dengue II, Ilheus, St. Louis Encephalitis, and Yellow Fever. In general, it would appear that mosquito-borne diseases would not be a problem in areas above 3,000 meters.

(5) Skin Diseases Caused by Insects

In those areas above 3,000 meters where the harsh climate discourages frequent bathing, skin diseases could become a problem. Lice, mites, and fleas can all cause irritating bites which may become infected when scratched.

C. Parasitic Diseases

Although many intestinal parasites never cause overt human disease under normal circumstances, some, under crowded and unsanitary conditions, could cause diarrhea, dysentery, or other intestinal problems in previously unexposed personnel. In a survey conducted at Pusi, Peru (altitude 3,500 meters), single-stool examinations indicated the following prevalence rates for intestinal parasites: Entamoeba coli, 76.1%; E. histolytica, 28.0%; Iodamoeba butschlii, 12.77%; Endolimax nana, 12.8%; Chilomastix mesnili, 8.4%; Giardia lamblia, 3.6%; Balantidium coli, 1.9%; Trichuris trichiura, 65.8%; Ascaris lumbricoides, 32.5%; Hymenolepis nana, 3.8%; Taenia spp., 1.6%; Strongyloides stercoralis, 1.2%; and hookworm (genus/genera not specified) 0.4%. Diseases caused by some of these same organisms (ascariasis, strongyloidiasis, taeniasis, and trichuriasis) have also been reported in Tibet.

Another parasitic disease which has been reported to be a public health problem in high altitude areas of Peru is echinococcosis, or hydatid disease. The disease, caused by the tapeworm Echinococcus granulosus, is not limited to the intestine of man and other mammalian hosts. The disease in man is characterized by the formation of fluid-filled cysts which may cause pressure damage as they grow and hypersensitivity reactions to components of the fluid which may be serious, or even fatal, in the event of accidental rupture of a cyst.

D. Man-to-Man Diseases

The most prevalent man-to-man transmitted diseases in areas above 3,000 meters would include those most commonly associated with crowded living conditions and poor hygiene, e.g., influenza, tuberculosis, meningitis, venereal diseases, diarrheas, and dysenteries.

In Pusi, Peru, (altitude 3,500 meters), 43.4% of the study population had positive skin reactions to tuberculin PPD-S, 19.3% had positive reactions to PPD-G, and 2.1% had tubercular lesions on chest X-rays. In tests for venereal disease, 2.1% had positive Fluorescent Treponemal Antibody Absorption tests, 2.1% had positive VDRL slide flocculation tests, and 5.4% had positive cardiolipin tests. Other reports from high altitude areas of Peru also indicate that tuberculosis, syphilis, and acute respiratory infections are common occurrences. At Badrinth, India (altitude 3,200 meters), a report indicated that even in populations native to high altitude regions, respiratory diseases have more serious consequences than they would elsewhere, accounting for the majority of the deaths in the region.

There are no reports of meningitis outbreaks in high altitude areas. However, any man-to-man transmitted diseases associated with crowded conditions, such as meningitis, should be considered as possible disease problems in areas above 3,000 meters.

E. Animal-to-Man Diseases

Although there have been no reported human cases of either anthrax or rabies in areas of the world above 3,000 meters, the presence of both diseases should be considered as a possibility. Anthrax spores are noted for their capability to survive and retain their infectivity, even in the harshest of environmental conditions; in Tibet, anthrax in animals is reportedly very prevalent. Sylvatic rabies, or rabies of wild carnivores and bats, has been found in arctic regions and climate appears to have no influence on its occurrence. The presence of rabid carnivores in areas above 3,000 meters should be considered a possibility. The disease could be a problem in the Southern Andes and the Caucasus, where several species of carnivores are found. Few species inhabit the Northern Andes or Alps, thus the rabies potential is low. Anthrax and rabies should pose little threat to troops if carnivores and bats are avoided.

Table 2 presents diseases which have been identified as present in the various mountain groups.

TABLE 2. DISEASE INFORMATION ON SPECIFIC GEOGRAPHIC AREAS

a. Alps

Disease	Reservoir	Vector	Comments
Plague, Sylvatic (Yersinia pestis)	Wild rodents	Fleas (various genera)	Present in rodent populations; distribution not known.

b. Andes, Southern

Disease	Reservoir	Vector	Comment
Plague, Sylvatic (Yersinia pestis)	Wild rodents	Fleas (various genera)	Present in rodent populations; distribution not known.

c. Andes, Northern

Disease	Reservoir	Vector	Comment
Q Fever (Coxiella burneti)	Ticks, wild animals, cattle sheep, goats		11.7% of study population in Pusi, Peru had antibodies.
Rocky Mountain Spotted Fever (Rickettsia rickettsi)	Ticks	Ticks (various genera)	1.9% of study population in Pusi, Peru had antibodies.

c. Andes, Northern (Continued)

Disease	Reservoir	Vector	Comments
Typhus, Louse-borne (Rickettsia prowazeki)	Man	Louse (Pediculus humanus humanus)	2.6% of study population in Pusi, Peru had antibodies; also reported to occur in Bolivia.
Pediculosis (Result of infestation with lice)	Man		46.9% of study population in Pusi, Peru infested.
Malaria (Plasmodium spp.)	Man	Mosquito (Anopheles pseudopunctipennis, Colombia and Ecuador)	
Bacillary Dysentery (Salmonella spp, Shigella spp.)	Man		Shigella spp. most common cause in young children in Peru.
Intestinal Parasites			
Entamoeba coli	Man		76.1% of study population in Pusi, Peru infected
Entamoeba histolytica	Man		28.0% of study population in Pusi, Peru infected.
Iodamoeba butschlii	Man		13.7% of study population in Pusi, Peru infected.
Endolimax nana	Man		12.8% of study population in Pusi, Peru infected.

c. Andes, Northern (Continued)

Disease	Reservoir	Vector	Comments
Intestinal Parasites (Cont'd)			
Chilomastix mesnili	Man		8.4% of study population in Pusi, Peru infected.
Balantidiasis (Balantidium coli)	Man		1.9% of study population in Pusi, Peru infected.
Trichuriasis (Trichuris trichiura)	Man		65.8% of study population in Pusi, Peru infected.
Ascariasis (Ascaris lumbricoides)	Man		32.5% of study population in Pusi, Peru infected.
Hymenolepis nana	Man		3.8% of study population in Pusi, Peru infected.
Taeniasis (Taenia spp.)	Man		1.6% of study population in Pusi, Peru infected.
Strongyloidiasis (Strongyloides stercoralis)	Man		1.2% of study population in Pusi, Peru infected.
Ancylostomiasis (Ancylostoma spp.)	Man		0.4% of study population in Pusi, Peru infected.

c. Andes, Northern (Continued)

Disease	Reservoir	Vector	Comments
Echinococcosis (Echinococcus granulosus)	Dogs, wolves, other canidae		Reported to be a public health problem in Peru.
Tuberculosis (Mycobacterium spp.)	Man		43.4% of study population in Pusi, Peru had positive skin reactions to PPD-S; 19.3% to PPD-G; 2.1% had tubercular lesions on chest x-rays.
Respiratory infections	Man		Reportedly common in Peru.
Syphilis (Treponema pallidum)	Man		2.1% of study population in Pusi, Peru had positive Fluorescent Treponemal Antibody Absorption tests; 2.1% positive VDRL slide flocculation tests; 5.4% positive cardiolipin tests.
Scabies (Mite infestation)	Man	Mite (Sarcoptes scabiei)	14.2% of study population in Pusi, Peru infected.
Plague, sylvatic (Yersinia pestis)	Wild rodents	Fleas (various genera)	Present in rodent population; distribution not known.

d. Atlas

Disease	Reservoir	Vector	Comments
No information available.			

e. Caucasus

Disease	Reservoir	Vector	Comments
Plague, sylvatic (*Yersinia pestis*)	Wild rodents	Fleas (various genera)	Present in rodent populations; distribution not known

f. Himalayas

Disease	Reservoir	Vector	Comments
Spotted fever (*Rickettsia* spp.)	Ticks, possibly other animals	Ticks (various genera)	3 strains isolated from rodents in Kaghan Valley, Pakistan.
Hazara virus	Ticks, possibly other animals	Ticks (various genera)	Isolated from rodents in Kaghan Valley, Pakistan
Typhus, scrub (*Rickettsia tsutsugamushi*)	*Rattus rattus tistae*	Mite (*Leptotrombidium deliensis*, Eastern Himalayas)	Isolated from rodents.
Pediculosis (Result of infestation with lice.)	Man		High incidence reported in Badrinth, India

f. *Himalayas* (Continued)

Disease	Reservoir	Vector	Comments
Parasitic Infections			
Malaria (*Plasmodium* spp.)	Man	Mosquito (*Anopheles superpictus*)	7 to 12% in three villages in Gilgit Agency, Pakistan. Parasite found in young children, confirming transmission.
Ascariasis (*Ascaris* spp.)	Man		Reported to occur in Tibet.
Strongyloidiasis (*Strongyloides* spp.)	Man		Reported to occur in Tibet.
Taeniasis (*Taenia* spp.)	Man		Reported to occur in Tibet.
Trichuriasis (*Trichuris trichiura*)	Man		Reported to occur in Tibet.
Respiratory infections	Man		Reportedly a serious health problem in Badrinth, India. Cause of the majority of deaths.
Anthrax (*Bacillus anthracis*)	None		Reportedly prevalent in animals in Tibet.
Scabies (mite infestation)	Man	Mite (*Sarcoptes scabiei*)	3% of population in Badrinth, India infected.
Plague, sylvatic (*Yersinia pestis*)	Siberian marmot	Flea (*Oropsilla* spp.)	Present in rodent population; distribution not known.

g. Pyrenees

Disease	Reservoir	Vector	Comment
Plague, sylvatic (*Yersinia pestis*)	Wild rodents	Fleas (various genera)	Present in rodent population; distribution not known

h. Sayans

No information available.

SECTION III

FOREIGN RESEARCH AND DEVELOPMENT

1. General

No current foreign research projects concerned specifically with diseases at altitudes above 3,000 meters have been identified. In addition, very few reports are available on altitude-related disease problems experienced during foreign military operations, or on how such problems might have affected these operations. Relatively few people inhabit most high altitude areas, therefore, there has been little need for disease research. Some studies on the distribution of flora and fauna (and for a very few areas, diseases) have been done, but most have not been extensive.

2. Research Efforts

a. The People's Republic of China (PRC) has established a special agency in Tibet to study high altitude disease, but the emphasis appears to be on the physiological effects of high altitude, rather than on disease patterns. The PRC has also sent medical personnel to Tibet to provide medical care and to train "barefoot" doctors. Whether disease statistics are collected, or whether the capability of these personnel is sophisticated enough to accurately diagnose many of the diseases, is not known.

b. Researchers at India's Defense Institute of Physiology and Allied Sciences have conducted studies on disease morbidity patterns at high altitudes. The studies compared the incidence of various diseases occurring in Indian troops stationed at high altitudes between 1965 and 1972, with those of troops stationed on the plains. The troops ranged from 18 to 54 years of age and were stationed at altitudes of 3,690 to 5,540 meters for two to three years; those stationed on the plains were in the same age range. The study showed that morbidity rates for chickenpox, infectious hepatitis, malaria, pulmonary tuberculosis, diabetes, asthma, and psychiatric disorders were significantly higher among the plains troops than among those at high altitudes. This was also the case with dysentery, diarrheas, respiratory infections other than tuberculosis, mumps, ischaemic heart disease, anemias, and skin diseases. There were no significant differences in the morbidity rates for hypertension, meningitis, and peptic ulcer. The only disease that showed a higher morbidity rate at high altitude was pneumonia. The generally favorable effect on morbidity patterns was found to be related to environmental conditions detrimental to the survival of disease organisms, coupled with a combination of beneficial hormonal, biochemical, immunological, fibrinolytic, and hemodynamic changes. Although this research strongly suggested a substantially reduced disease risk at high altitudes, the results are not necessarily representative of a worldwide pattern. Much more research of this kind, conducted in diverse geographic areas, is needed. Although the Indian research showed lowered rates of incidence, a disease hazard still remained.

c. Between 1964 and 1974, multidisciplinary projects were conducted in high altitude areas of Chile, Bolivia, Peru, Ethiopia, Nepal, and the Soviet Union, under the auspices of the International Biological Programme (IBP). Unfortunately, only the Soviet Union had sufficient interest to adequately fund a substantial research program in its high mountain areas. As a result, little information on disease in the other regions was gained. In addition, much of the information derived from the Soviet studies in the Tien Shan and Pamir mountains has yet to be made widely available.

3. Assessment

To date, the amount of basic research effort is insufficient to support a global assessment of disease risks at high altitudes. Research projects specifically designed to provide data on all aspects of the epidemiology of diseases at high altitudes are still needed. Relatively long-term studies, such as those conducted in India, would be extremely valuable to planners assessing the impact of disease on high altitude operations.

SECTION IV

IMPACT OF DISEASE ON MILITARY OPERATIONS AT HIGH TERRESTRIAL ALTITUDES

1. Occurrence of Diseases and Insect-Related Problems

Arthropod-borne diseases will probably have the greatest impact on troop operations at high altitudes. Most insects will exist in greatest concentration in forested areas, therefore, elevation, per se, may be less of a factor in insect-related disease occurrence than the level of the forest line. Next to the montane-forest zone, troops are most likely to encounter arthropods within the lower alpine zone, whether this zone occurs above or below the 3,000 meter level. With the possible exceptions of the ticks, the black flies, and the ever present swarming flies, medically important arthropods and their accompanying pathogens become less abundant as one passes through the upper alpine zone and into the nival zones. (Once again, this is independent of altitude.) Insects are not of any significant medical importance in areas of permanent snow cover. The general nuisance associated with insects and allergic reactions to their bites would most likely present the greatest insect-related problems encountered by troops at high elevations. This would be particularly true for troops that had recently moved into an area. The persistent biting by large numbers of black flies or biting midges, for example, could greatly hinder troop activity and efficiency.

The arthropods most likely to have an annoying effect on troops in high mountain terrain are the ticks and chiggers, which may be encountered in areas of flowing water and moist soil, and swarming flies and mosquitoes.

Problems with flea bites, and to some extent tick, mite, and louse bites, may increase in areas of prolonged encampment as the local rodent populations begin utilizing places of human habitation as sources of food and shelter. Diseases endemic to these rodent populations, such as plague, typhus, spotted fever, and encephalitis, could occur among troops as contacts with these animal reservoirs increase. Action should be taken to minimize rodent populations in areas of prolonged encampment.

Food contamination by Muscoid flies must be guarded against. Myiasis, resulting from invasion of the tissues by bot or warble fly larvae, may also present some problems, especially in the Southern Hemisphere. Curing these infestations is generally easier than their prevention.

Although malaria is known to occur above 3,000 meters in isolated areas of Asia and South America, it should only be considered a potential problem in areas where the forest-line exceeds the 3,000 meter level.

2. Impact on Military Operations

The impact of disease per se on military operations at elevations exceeding 3,000 meters would not necessarily be more serious than in lower lying areas. While certain dormant diseases like amebic dysentary and infectious hepatitis have been observed to flare up at high altitudes and silent gastric ulcer tends to bleed, there is evidence to indicate that morbidity rates for many common diseases are actually less in such areas. Morbidity rates for some other diseases have been shown to remain essentially the same whether at high altitudes or at sea level. The one disease which could cause serious problems is pneumonia; it has been found to be more common in high terrestrial areas.

The reduced incidence of many common diseases at high elevations does not, however, necessarily mean a reduced hazard to military operations. If a soldier is experiencing symptoms of mountain sickness, as is likely in the first few days stay at a high elevation, even a mild infectious disease could cause greater incapacity than at sea level. An appropriate period of acclimatization prior to deployment to the high altitude region could help considerably to alleviate this problem. Even then, there is reason to believe that disease can be a more serious matter for troops stationed in such regions over prolonged periods. Although mountain sickness symptoms normally disappear within a few days, the individual's work capacity may never return to that at sea level. Therefore, contractions of any disease is likely to reduce the individuals ability to fuction to a lower level than if he were at sea level.

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This study investigates the risk of diseases to unacclimatized personnel rapidly translocated to, or stationed in, terrestrial areas at altitudes above 3,000 meters. Both short and long term impacts (if any) such diseases would have on military operations at these elevations are addressed.

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