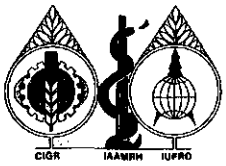

The Symposium was organized by the Ergonomic Commissions of the International Association of Agricultural Medicine and Rural Health, *Commission Internationale du Génie Rural*, and International Union of Forestry Research Organizations

Ergonomics in tropical agriculture and forestry

Proceedings of the
Fifth Joint Ergonomic Symposium
organized by the Ergonomic Commissions of
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CONTENTS

Ergonomics studies men at work and aims at "fitting the job to the worker", or better at "optimizing man-task-systems" in order to promote the worker's health, well-being and efficiency.

Ergonomics is a rather new field of study. In industrialized countries Ergonomics is gradually developing to a coherent science. Research, education and practical application are steadily in progress. In order to promote Ergonomics in tropical countries a Symposium was organised to discuss relevant problems in tropical agriculture and forestry.

The conference was the 5th in the series Joint Ergonomic Symposia, organized by the Ergonomic Commissions of three international organizations. The International Association of Agricultural Medicine and Rural Health (IAAMRH) brings together the medical workers in rural areas. The Commission Internationale du Génie Rural (CIGR) covers the field of agricultural engineering and technique. The International Union of Forestry Research Organizations (IUFRO) deals with research in forestry.

The basic program of the symposium consisted of a series of Invited Papers prepared by experts in the relevant topics. In addition several participants delivered a Voluntary Paper.

In these Proceedings all Invited Papers are presented at full length. As to the Voluntary Papers restrictions were necessary. Consequently, papers not fully related to tropical problems have not been included. Other papers are printed in an abriged or summarized version.

It was the aim of the symposium to bring together experts and interested workers in the field of Tropical Ergonomics for an exchange of relevant information and know-how. Moreover, the Symposium was meant to stimulate the further development of Tropical Ergonomics. Therefore, "Recommendations" were formulated and approved by all participants in the final meeting (see Part A. Chapter 4). Suggestions on the promotion of Ergonomics and the development of relevant research, education and training in tropical countries are given. It is our hope that in addition the Proceedings of this Symposium will be another contribution to the development of Ergonomics in tropical agriculture and forestry.

Part A - Invited papers

ERGONOMICS IN TROPICAL AGRICULTURE AND FORESTRY

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Summary

Ergonomics is engaged with the work situation, with the objective to achieve an optimum man-task system, in which a proper balance can be maintained between the worker and the working conditions.

The model is described - including the processes and their feedbacks -, which are determining the health and load of the worker, as well as the performance and safety of the system.

Working in agriculture and forestry plays an important role in tropical countries; ergonomics can play a role to improve the living and working conditions in these fields. The differences between work and working conditions in agriculture and forestry in tropical and of temperate zones are discussed.

Based upon the ignorance of the majority of the conditions in tropical regions from an ergonomic point of view, possibilities for future developments of ergonomics in tropical agriculture and forestry will be mentioned.

Introduction

Ever since the days when man first ventured out of those limited regions of the world where he could be comfortable all the year round without clothing and other artificial aids to environmental adjustment, or even earlier days when the first tools were invented, there have been individuals sensitive to their own and other people's problems of adaptibility.
These individuals have approached the resulting design questions with intelligence and, eventually, with accumulated experience. As long as tools and machines used by man were simple, it was possible to produce satisfactory designs by purely emperical methods.
The introduction of mechanization causes considerable changes in working methods and working conditions. Sometimes it makes the work easier and more congenial, in many cases, however, the work load changes rapidly; a decrease of the physical work load is coupled with an increase of the perceptual and mental work load. Now that machinery is increasing in complexity, however, the emperical approach is no longer sufficient.

Seeing that working in agriculture and forestry plays an important role in tropical countries, ergonomics can contribute to improve the living and working conditions in these fields.
Ergonomics ("Fitting the job to the worker") is engaged with the work situation, with the objective to achieve an optimum man-task system, in which a proper balance can be maintained between the worker and the working conditions.

The results of an ergonomic approach will contribute to:

a. The design of an optimum man-task system; (Preventive ergonomics)

b. The testing of a man-task system; (Curative ergonomics)

c. The prediction of the load of the worker, as well as the performance and safety of the system.

Ergonomics

1. General

Ergonomics is a multi-disciplinary activity, it crosses the boundaries between many scientific and professional disciplines and draws upon the data, findings and principles of all of them.
In analysing a man-task system there is primarily the contribution of many sciences like anatomy, physiology, psychology, sociology, engineering and management.

The multi-disciplinary character of a man-task system is shown in figure 1.

A continual stream of information - from the tool or the machine - is received by the working man using his senses: Perception and leading to perceptual load. The perception is followed by testing on the memory, and then to make decisions between the alternatives to guide a specific operation: Selection and leading to mental load. The output of man is muscle activity: Action and leading to physical load. Through the action changes take place: Performance.

During this process the man will continuously observe the effects of his actions. This process is called feedback (---).

Viewing the nature of ergonomics it is necessary to state from the various components and processes in a man-task system which parameters can be determined, as well as the criteria belonging to them.

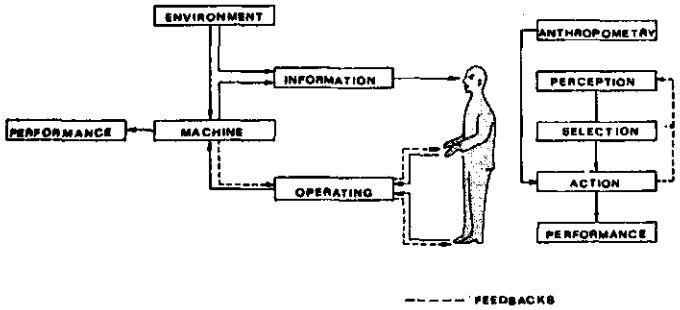

Figure 1. Man-task system

2. Anthropometry

The data about the work-place lay-out, including the controls, are determined by the characteristics of the human body. Anthropometry refers to human body measurements and biomechanical aspects of movements of the body and body members, as well as the working posture and the forces to be exerted upon the objects - handtools and controls - surrounding him.

In designing an optimum work-place, various considerations need to be taken into account, in particular:

Body measurements

By statistical research carried out in several countries, the knowledge of body dimensions of large population groups has been considerable extended for several years. Various publications mention the dimensions of the human body, specified by sex, age and race. When using these data we must not only look at the mythical average, but at the large and small brothers; for deviating circumstances (Large, small, thick or thin people) there has to be sufficient space for an adaptation, which can be made in a simple and safe way.

Discussion of body measurements includes the following:

- A definition of the body dimension and how it was measured;
- The data, in tabular form, for the 5th, 50th and 95th percentiles and the standard deviation;
- Correction factors for clothing and personal equipment and other relevant reliables.

When some dimensions of a population group are available, some data for workplace lay-out may be calculated.

Body motions

In order to realize a good performance it is necessary, that the movements of the body members are such that a favourable load originates; fatiguing body motions have to be avoided.

According to the principles of motion economy, the motions should be confined to the lowest classification with which it is possible to perform the task satisfactorily. By moving body members - shading off into one another - in synchrony, simple and logical motions can be obtained. Attention shall be paid to the following:

- A good balance shall be established among body movements;
- Amplitude, strength, speed and pace of movements shall be mutually adjustable;
- Movements with great accuracy requirements shall not entail exertion of considerable muscular strength.

Posture

The working posture of a man is largely determined by the lay-out and shaping of the tools, as well as by the location and displacement of the controls. Probable site of pain or other symptoms, as consequence of bad posture, have been described in literature.

There are three general types of design for posture: Standing, seated at all times and a design in which the worker may shift , between seated and standing positions. The standing position is generally considered to be a "standing and walking position"; the worker is free at all times to move in various directions. If this freedom is not available or required, the work-place should be designed so that the worker either sits all the time or can move between a seated and standing position; static muscular fatigue must be avoided.

Forces

The forces, which can be exerted, depend on the group of muscles, the body posture, the direction and strength of the forces, as well as the duration. In general a human being is capable to maintaining 10 - 15% of the

maximum force of a muscle during a longer period of time without muscle fatigue; exercise can increase the strength and the endurance within the limits imposed by a worker's innate physical potential. Attention shall be paid to the following:

- Strength demands shall be compatible with the physical capacity of the worker;
- Muscle groups involved must be strong enough to meet the strength demands;
- If strength demands are exessive, auxiliary sources of energy shall be introduced;
- Maintainance of uninterrupted tension in the same muscle for a long period of time shall be avoided.

Many hand tools and machines in agriculture and forestry in tropical countries are imported from other countries. This can lead to inadequate work-place layouts, if no attention is paid to the anthropometric and biomechanical aspects of the users. Therefore anthropometric surveys have to be carried out in these countries.

3. Perception

The perception of information, that a worker receives from work-place and environment, takes place via the senses, which are sensitive to specific impulses. The reaction to the information depends upon the sense organ that is stimulated, the strength of the stimulus and the place where the stimulus arrives.
For each of these senses the human body commands perceptive sensations, in particular:

Sight

Sight plays an important role in man-task systems, since most information enters the central nervous system via the eyes; moreover, most actions are performed under optical control. With our eyes we cannot only observe colours, light and darkness, but it is also possible to estimate in a reasonable way the direction and speed of moving objects.
The characteristics of the visual field are determining the visibility of the work. The visual field can be enlarged by body motions, which, however, lead to loss in quality of the body posture, as well as increased work load and a decreased performance.

Hearing

Communication between man and task, as well as between men mutually, takes place through hearing, in which variations of pressure act as a medium. Depending on frequency, sound pressure level and duration of the exposure, sound has an annoying to damaging effect.

The sound pressure level of machines in agriculture and forestry has received a great deal of attention recently. It appears that for many machines the average sound pressure is too high and this will lead to impairment of hearing, which is mostly of a permanent nature and they are irreversible.
It has been generally accepted at the moment that a permanent exposure to sound pressure levels of 85 dB_A and more necessitates protection of the ears to avoid damage. Protection is by technical means (Machines making less sound, isolation of the sound force and reduction of sound transmission) or personal means (Larger distance between source and man, ear protection by wearing plugs in the ear or cups usually known as ear muffs).

Scent and taste

From an ergonomic point of view, scent and taste are less important, because only a small number of actions appeal specifically to these senses. However, workers in agriculture and forestry are being subjected to increasing amounts of air pollutants as dust, gases and smokes.

Working under dusty, dirty and smoky conditions reduces visibility, produces eye, nose and throat irritation and can induce sickness. There are generally the short term effects; of greater concern are the long term chronic effects, which induce illness or cause debility; they affect the worker's vitality and make him more susceptible to many forms of disease.

Feeling

Though rather little operational information is entering the central nervous system through feeling, in detecting mechanical vibrations it has much impact on the worker's health and performance. Vibrations will be transmitted to a worker through those parts of his body in contact with the source of vibration, usually the hands, arms, feet and buttocks. Sometimes the hands or arms only are under vibration, in other cases the whole body.
During recent years special attention has been paid to various body deficiencies adn informities, related to exposure to mechanical vibrations. The effect and impact of vibrations varies with the frequency, as the human body is most sensitive to mechanical vibrations within the range from 2 Hz to 6 Hz; the impact of vibrations can differ from some annoyance to damage to the worker's health and performance degradation. It appears that the fingers, the spine and the stomach are especially sensitive to mechanical vibrations.
Protection against mechanical vibrations is by technical means (Reduction and isolation of the vibration source, as well as

reduction of vibration transmission) or personal means (Cushions and seats).

4. Selection
The transport of data from the stimulated organs to the effectors is not simply and solely transport; the data are processed, from the various possibilities the right answer is chosen and transformed into action. The capacity of information processing is primarily determined by the capacity of the central decision mechanism; the more complex the circuits to be followed, the less the capacity.
In the great variety of structure and operation the sense organs, as well as the complex character of the decision mechanism, it is hardly thinkable that one universal parameter could be found for the assessment of mental load. The following categories may be distinguished:

- Performance measurements,
- Psychological measurements,
- Physiological measurements.

The assessment of mental laod presents a great challenge to experimental psychologists and psychophysiologists and, despite a plethora of techniques, few are of general applicability and those that are, have still question marks regarding their validity. Based upon the results of investigations available, the best results for the assessment of mental load can be expected from:

- The method with dual tasks, whereby the spare mental capacity is occupied by supplying an additional task;
- The heart rate, in particular the relative suppression of the sinus arrhythmia, measured in comparison with the situation during rest.

Next to the process of information processing and the assessment of mental load, it is necessary to deal with some aspects of mental processes, in particular:

Learning
When periodic or otherwise predictable inputs are recognized and learned, the worker begins to respond with well practiced movements and is effectively working. The learning effect consists of an easier, quicker an better reaction on the information presented. Moreover, the worker is more and faster familiar with his machine than with another, which causes a slighter chance of making mistakes. This will lead, indirectly, to a better output of the whole man-task system.

Simulation
For studying the loading components in a man-task system under controlled conditions and to obtain information regarding the ergonomic qualities of the work-place lay-out of a certain machine or the effect of training, simulators have been developed for various tasks. This makes it possible, with improvements in research costs, to obtain valuable data in a relatively short period.

The ergonomist must try to reduce the mental load in various mental processes in agriculture and forestry. This is possible by repelling redundant and non-relevant information, as well as an adequate presentation of the relevant information. By paying attention to these aspects, ergonomics can contribute to adequate processing of the increasing information speed - as a result of an increasing capacity - and a favourable worker's load.

5. Action
In order that a man can work or move about or even just stay alive in a relaxed position, there must be energy available for his body to use. The energy that is required in order that the muscles can exert forces, must have previously entered the body in the form of food. In its simplest terms, the body is an engine that provides power from the locomotor system using oxygen that enters through the respiratory system to burn up the fuel entering through the digestive system.
When a man increases his rate of energy expenditure by working harder, the following effects inevitably occur. He will breathe more rapidly and more deeply in order to increase his intake of oxygen. The heart rate will increase and it proves necessary to use the blood to transport more oxygen from the lungs to the muscels and move excess heat away form the working muscles to be dispersed around the body; this excess heat will also cause the body temperature to rise. The working capacity of an individual is limited and primarily determined by the capability of supplying sufficient oxygen and taking sufficient food. Some factors, influencing the work capacity, are: Health, fitness and nutrition. The mechanical efficiency of human labour can vary from 0 - 20%; the maximum efficiency is seldom realized, some muscels are permantly unfavourable loaded. The highest possible output is being obtained with rhythmic movements, when a muscle or a group of muscles is being strained and relaxed in turn. Little is known about the physiological and pathalogical effects of the cumulative fatigue that arises after many successive days of hard work; nor it is possible to define the limits of the physical activity to which a worker is capable of rising to in an emergency.

For the assessment of physical load well-functioning parameters are available; the assessment is based on measuring one of the following, physiological parameters:

- Energy consumption;
- Ventilation rate;
- Heart rate;
- Body temperature.

Based upon the various physiological parameters, scaling of the physical load is possible.
The results of physiological research can be applied to:

- The design of the work-places;
- The comparison of tools or machines;
- The comparison of working methods;
- The improvement of working methods;
- The calculation of rest allowances.

Various surveys have been carried out all over the world to determine the rates of work activities in agriculture and forestry; little is known about the rates of work activities in tropical countries. Therefore physiological surveys have to be carried out in these countries.

Although mechanization can lighten many of the traditional tasks, working in agriculture and forestry is still an occupation where much energy may be expended during a working day.

6. Climate

If a man works under unfavourable climate, we cannot expect the same kind of performance we can when the environment is optimal. The comfort of man depends upon the relative humidity, temperature and velocity of the air; the subjective judgement of the climate is determined by the heat balance of the human body.
Physiological reactions on heat stress are mostly an increase of the heart rate, body temperature and recovery time, as well as an increased sweat secretion. The general trend of all studies of the working environment is clear: Atmospheric conditions interfering with normal or constant body temperature reduce mental and physical working capacity. In essence the core temperature of the body must not increase above 38 °C in prolonged daily exposure to heat and intense physical work; moreover, the diet - in particular the intake of fluids and salt - must be adequate to replace losses. The thrist mechanism is not very sensitive, so that people exposed to heat must be encouraged to drink more. Weight losses due to dehydration should not exceed 2-3% of the body-weight.
On tools and machines the provision of an optimum temperature in not easy, but something can be achieved with a shield or a cab.

Next to the components, as well as their processes and feedbacks, of a man-task system, it is necessary to deal with some special aspects, in particular safety and social environment.

Safety

Human beings at work are very liable to make mistakes, leading to accidents or injuries to themselves or to others, damage to the equipment (Tools, machines, implements, etc.), or just annoying hold-up. The incidence of errors can be reduced by applying the principles of ergonomics. In general, the safety of the equipment's users is the joint responsibility of the designer and manufacturer, the owners or users and all officials who are employed to ensure safety.

All have a part to play and in each case the application of "common sense" is one of the most effective factors in ensuring freedom from hazards.
The reduction of accident hazards in tropical agriculture and forestry may be divided by:

- A study of the statistics of accidents, injuries or fatalities in relation to the usage of the equipment.
- The primary causes of such accidents, including considerations of the hazards most likely to cause injury or death.

In addition to these approaches, safe design can be achieved by following certain priciples - in particular: Laws, regulations and safety assessment methods -, as well as by education of the users.
It is undeniable that work in agriculture and forestry is more hazardous than it used to be. There is a number of circumstances peculiar to agriculture and forestry, which contribute to what is recognized to be high accident rate; these are:

- Varying terrain, ground and weather conditions;
- Seasonal peaks demanding sustained effort and extra hours;
- Most workers on their own and when in difficulty, have no help within call;
- Inadequate training in the use of equipment.

It is possible to state a number of positive principles, which will generally lead to safe use of equipment; per example:

- Provide adequate training in using equipment;

- Provide the worker with equipment, which is free from fatigue and stress-inducing features;
- Provide clear identification of controls and instruments so that misuse is eliminated;
- Provide easily reached and operated "emergencystop" facilities;
- Ensure that the equipment cannot be set in motion by accident.

Design measures need to be backed up by adequate safety education and supervision, but correct design for safety does have one large advantage over safety education and periodic supervision; it makes the equipment inherently safe without being dependent on the mental attitude of the user.

Social environment

Features of the social environment as communications, responsibilities and working in groups also present problems. These can be dealt with partly under the heading of job design by providing clear job definitions and instructions, but the adaptability of the worker and the everchanging requirements of his job lead to considerable dependence on day-to-day contact with other people.

Conclusions

It is not likely and not necessary that a human being must be able to adapt himself to his task indefinitely. For this reason ergonomics would be considered as a fundamental subject and an essential part to improve the working conditions in agriculture and forestry in tropical countries. The cooperation of man and equipment has been described by a man-task system, in which all processes - in particular anthropometry, perception, selection and action - and their feedbacks are determining the health and work load of human beings, as well as the safety and performance of the system.

It has not been the intent of this paper to compile and organize an amount of available pertinent information related to human attributes and behavior. Rather, the intent has focused around certain, more modest objectives. These include the presentation of at least more information about certain human characteristics, that might contribute to greater understanding of human behavior and performance. In addition, efforts have been made to illustrate the ways in which human abilities and other characteristics are related to their performance in various aspects of human work and to the performance of the systems of which they are a part. It has also been the intent to present discussions of at least some techniques, methods and results, as well as to discuss some aspects of the application of ergonomic data and principles.

The human factors - especially the application of ergonomics in agriculture and forestry - not only deserve full attention, but are determining for workers in tropical countries, whether or not they will have reasonable working conditions in the future, which can bear the comparison with other professions. The awareness of the many human aspects of the living and working conditions in tropical countries, is at least the first prerequisite to create those conditions in which human talents can be most effectively utilized in the furtherance of human well-being.

Resumen

La ergonomía se ocupa con la situacíon de trabajo, con el fin de realizar una relacíon sumamente favorable entre el hombre y su tarea, en la que séra posible mantener el equilibrio acertado entre el trabajador y las condiciones de trabajo. Se describre el modelo - inclusive los procedimientos y realimentaciones que determinan tanto la salud y capacidad del trabajador como el funcionamiento y la seguridad del sistema.

El trabajo en la agricultura y silvicultura es de gran importancia en los paises trópicos; la ergonomía puede contribuir al mejoramiento de las condiciones de vida y trabajo en este respecto. Se trata de las diferencias entre condiciones de vida y trabajo en la agricultura y silvicultura de zonas trópicas y templadas.

El desconocimiento de la mayoría de las condiciones en regiones trópicas desde un punto de vistá ergonómica es la base para el desarrollo futuro de la ergonomía en la agricultura y silvicultura trópicas, y con este motiva se estudian varias posibilidades.

Résumé

La science du travail a pour domaine la situation du travail, et son objectif est de mettre au point un système optimal dans lequel il soit possible de maintenir un équilibre adéquat entre le travailleur et les conditions de travail.

Le modèle est décrit - avec les processus et les réactions qui déterminent la santé du travailleur et sa capacité de travail - ainsi que les réalisations et la sécurité du système

Les traveaux agricoles et sylvicoles jouent un rôle important dans les pays tropicaux; la science du travail peut contribuer à l'amélioration des conditions de vie et de travail dans ces domaines. Les différences dans le travail et les conditions de travail en agriculture et en sylviculture entre les zones tropicales et les zones tempérées sont

étudiées.
Les possibilités de futurs développements de la science du travail dans l'agriculture et la sylviculture tropicales seront mentionées, en tenant compte de l'ignorance de la plupart des conditions prévalant en matière de science du travail dans l'agriculture et la sylviculture tropicales.

NUTRITION AND PHYSICAL WORKING CAPACITY

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Summary

Agricultural workers in tropical countries are, in general, shorter and lighter than their European counterparts. Since physical work capacity, estimated in terms of oxygen consumption ($VO_{2\ max}$) is related to body weight, the tropical worker, even if healthy and adequately nourished, may find many agricultural tasks involve exhausting labour. Disease, particularly malaria and parasitic diseases such as hookworm, are common and impair physical work capacity.

Levels of nutrition vary in different tropical regions: in some areas there is adequate food production, in others there may be sufficient food available in terms of calories but protein intake is very limited. In New Guinea, sodium intake is exceptionally low and is replaced by potassium. In large areas, such as India, the overall level of calorie intake is low and this affects growth and hence physical work capacity.

Introduction

The accurate measurements of physical work and of food intake are not easy to achieve; the difficulties are increased when the measurements have to be made in field conditions. Until recently, information about tropical agricultural workers was scanty, but the Human Adaptability Section of the International Biological Programme was responsible for worldwide studies which included physical work capacity and nutrition. Although there remain large areas of ignorance, it is now possible to make some general statements, supported by a considerable volume of results. A number of volumes have appeared in which the results obtained have been summarised, including "Human Physiological Work Capacity" by R.J. Shephard, "Worldwide variation in Human Growth" by P.B. Eveleth and J.M. Tanner, and "Population Structure and Human Variation" edited by G.A. Harrison. These volumes include detailed references to the many hundreds of relevant papers. Before presenting any of this material, some general points should be made.

Working capacity

This term, it is now widely agreed, refers to the individual's maximum oxygen consumption, $VO_{2\ max}$. The measurement of $VO_{2\ max}$ is a relatively demanding procedure, usually carried out with the subject riding a bicycle ergometer at 4-5 levels of work, beginning at a relatively low level and ending at the limit of the subject's capacity. Expired air is collected and the O_2 content measured, hence oxygen consumption can be determined. The results are conventionally expressed in terms of ml O_2/min/kg body weight or, in a more sophisticated way, ml O_2/min/kg lean body mass.

In many field situations it is not easy to carry out such a procedure. Apart from the logistic problems of getting the necessary equipment into remote areas, there are the difficulties of persuading a sufficient number of subjects to exert themselves to their maximum capacity. In some cases, a bicycle itself may be a novelty, although there is good evidence that valid results can be obtained from naive subjects. For these reasons, simplified techniques have been used, such as the measurement of heart rate at different levels, together with oxygen consumption, but stopping before the state of maximum effort. Plotting heart rate against oxygen consumption should give a straight line; this can be extrapolated to the predicted maximum heart rate (Åstrand & Rhyming, 1954). Instead of oxygen consumption the energy expenditure or work rate in watts can be used. Other methods include the measurement of the work output at a fixed level of oxygen consumption or fixed level of heart rate.

Since $VO_{2\ max}$ is usually expressed in terms of ml O_2/min/kg body weight, it follows that the subject's body weight is related to his working capacity. This is too simple a generalisation, but body weight does provide a rough index of working capacity. A better one is lean body mass, i.e., body weight minus total body fat. The measurement of total body fat can be done by determining body specific gravity, which implies weighing under water; a fairly simple procedure but requiring equipment which is not easily portable. The most widely used field method is the measurement of skinfold thickness using standard calipers (Harpenden) and tables prepared by Durnin & Rahaman (1967). These and other methods are described in the IBP Handbook edited by Weiner & Lourie (1969). (A new edition is in preparation which will include a number of more recent techniques). Apart from muscle mass, which is the most important determination of $VO_{2\ max}$, lack of training and disease can alter working

capacity. In some cases, such as malaria, this impairment is due to a diminished haemoglobin level, which may be made worse by a diminished blood volume. However, the effect of disease, although frequently presumed or assumed, has not been studied with accuracy. An important exception is the study by Collins et al. (1976) on the effects of schistosomiasis on work capacity. Mild to moderate infection did not affect performance in sugar cane cutting; it was only with high levels of ova in the stools that VO_2 max was reduced.

Nutrition

The effect of nutrition on working capacity is complex, but the most important relationship is concerned with the energy content or calorie intake. The law of the conservation of energy holds good for man, in spite of apparent contradictions. For short periods energy expenditure can exceed energy intake, and an accumulated deficiency of some 42 MJ does not appear to affect working capacity (Edholm, 1977). When the deficiency exceeds 63-85 MJ then there is a significant impairment, as found in the famous Minnesota experiment on human starvation. It is likely, but not yet demonstrated, that the size of the deficiency needed to produce an effect will be related to muscle mass; the smaller the mass the smaller the deficiency which can be tolerated.

Protein caloric deficiency (PCD) is the second most important nutritional defect. In practice, this affects children more than adults and results in kwashiorkor, common in Africa and the West Indies. PCD is one of the factors responsible for stunted growth, and small adult size.

In any mal- or inadequately nourished group there may be specific deficiencies of vitamins, of salts and of minerals. Particular circumstances may affect requirements; the requirement for iron will be increased by diseases such as malaria which cause anaemia.

Although the most useful concept in considering nutrition and work capacity is that of calorie balance, the 'extraction ratio' is a more informative index of the efficiency of food production. The ratio, introduced into human biology by J.S. Weiner (1964) concerns the proportion of total energy expended, which is devoted to food production. A detailed job analysis is needed, and the calorie value of all food produced as well as the calorie value of all food consumed. Such information needs to be collected over a period of a year, to cover seasonal changes not only in climate but also, more relevant, the variations in physical activity on the land. In this way an overall budget can be constructed showing the net annual balance as well as the true extractive ratio. Needless to say, very few investigations have so far been carried out which provide sufficient data to enable the extractive ratio to be calculated, except in a tentative way.

The available information will be presented in the form of summaries on a regional basis. A few comprehensive investigations will be described in more detail.

New Guinea

An Anglo-Australian research team, organised under the HA Section of the IBP, carried out a study of the islanders of Karkar, off the northern coast of New Guinea and of a highland group living near Goroka, about 100 miles from Karkar. Food intake was measured over a year, and energy expenditure at intervals during a year. In addition, there was an anthropometric survey and all subjects had a clinical examination. The climatic conditions to which the subjects were exposed were recorded. Hornabrook (1977) has given a general account of the results, details of which have been published in Phil. Trans. Roy. Soc. B, 268, 1974. (see list of refs., New Guinea).

There were some unusual features as regards nutrition. The highlanders have an exceptionally low intake of sodium and a correspondingly high potassium intake. The main food is cassava, with other vegetables, so the amount of animal protein consumed is small. In spite of an apparently unsatisfactory diet, the adult men are well developed, with good musculature, little subcutaneous fat, and a VO_2 max of over 50 ml/min/kg body weight, equivalent to amateur athletes in the U.K.

The highlanders live at an altitude of 1500-2000 m where the climate is not demanding, although it is so close to the equator. On the island of Karkar, there is little seasonal variation in weather, which is hot and humid. The islanders consume more protein than the highlanders, principally in the form of fish. They work in their 'gardens' growing fruit and vegetables in clearings in the forest. The results of the various measurements are shown in Table 1.

It will be seen that in spite of an highly expert team there are discrepancies between intake and expenditure. Such findings illustrate the great difficulty of obtaining absolutely reliable findings under field conditions. Apart from these problems, the results show that the levels of energy expenditure are not particularly high, except if allowance is made for body weight and height. These people are quite well-nourished, with a satisfactory level of VO_2 max.

Table 1. Results of measurements of New Guinea subjects.

	Karkar		Goroka	
	Male	Female	Male	Female
Intake (MJ)	8.2	5.9	10.5	8.8
Expenditure (MJ)	9.8	7.5	10.9	9.4
VO_2 max (ml/min/kg)	40		50	
Height (cm)	165	156	162	152
Weight (kg)	58.3	52.4	59.7	52.4

The Gambia

One of the most effective studies in this field was carried out by Fox in 1950-51 and the results were published in the form of a Ph.D. thesis in 1953. Fox studied the inhabitants of a village in the Gambia for over a year. The villagers lived in a forest area, close to the river, and their cultivated land consisted of clearings in the forest. In the period following harvest, body weight rose with plentiful food and little work to do on the land. Body weight stabilised and then fell as on the one hand land had to be prepared and, on the other, food stocks diminished. In the final stages leading up to the harvest, the work load was heavy but food by then was becoming exhausted. The physiological cost of performing some of these tasks is shown in Table 2.

Table 2. Energy expenditure in the Gambia.

Task	Energy cost above basal (MJ)	O_2 cons. (l/min)
	MEN	
Clearing	1.5	1.45
Ridging	2.2	1.93
Planting	0.65	0.76
Weeding	1.0	1.00
Hoeing	1.25	1.15
	WOMEN	
Pounding rice	1.0	1.00

The results show that some of the tasks required the expenditure of effort which probably exceeded 50% of the physical work capacity of the villagers. They can only work for limited periods if oxygen consumption exceeds 1 litre O_2/min, and such work has to be done in the relatively cool conditions early or late in the day. Hot, humid conditions limit physical working capacity, a fact which has often been confirmed in experiments in climatic chambers; this limitation is mainly due to the rise of body temperature. Fox's results showed that in any one short period the villagers were either in calorie deficit or excess, hardly ever in balance, but over the course of a year intake balanced expenditure. It is probable that such a pattern will be found wherever food production is marginal, with little or no surplus. In the case of the Gambia villagers, they did have a surplus (of groundnuts) which they sold for cash. But the money earned was spent on trinkets not on food.

Israel

An IBP study was carried out in Israel on two groups of Jewish settlers, one from Kurdistan (the region straddling the border between Iraq and Iran) and the other from the Yemen (Edholm & Samueloff, 1973; Edholm et al., 1973). The members of these groups lived in adjacent villages in the Negev, the semi-arid region in the south of Israel. They carried out similar agriculture, using irrigation, and in the hot summers and mild winters cultivation was continuous. There was no period specially devoted to harvest or to soil preparation. At any season some crops were being harvested and others were planted. From the measurements and observations made it appeared that energy expenditure was at about the same level, averaging 12.5 MJ/day throughout the year for the men. Details of $VO_{2\ max}$, food intake, etc., are given in Tables 3 and 4. The extractive ratio has not been calculated as the energy value of the food produced was not estimated. In terms of income and food intake, it was clear that a considerable profit was made on the sale of produce. The pattern of energy

Table 3. Maximum aerobic power - predicted at heart rate 195/min of Yemenite and Kurdish Jews

	Male		Female	
	Mean	S.D.	Mean	S.D.
	Yemenite Jews			
l/min	2.98	0.50	1.77	0.43
ml/kg body mass	46.91	5.27	35.40	7.73
ml/cm height	18.23	2.81	11.65	2.60
ml/kg lean body mass	66.48	7.07	62.40	15.63
	Kurdish Jews			
l/min	2.89	0.46	1.63	0.33
ml/kg body mass	44.45	7.05	28.96	8.28
ml/cm height	16.72	2.67	10.51	1.98
ml/kg lean body mass	60.13	10.20	54.38	10.70

expenditure varied considerably amongst individuals and there were large daily variations in individuals. Nevertheless, it could be estimated that of the total 12.5 MJ expended per day approximately one-third to two-fifths was involved in farming activity.

Table 4. Daily energy expenditure and intake (MJ) of Yemenite and Kurdish Jews

	Yemenite Jews		Kurdish Jews	
	Male	Female	Male	Female
Summer				
Expenditure	12.7	9.5	12.7	9.4
Intake	13.4	9.5	15.0	11.4
Winter				
Expenditure	12.6	10.0	13.0	10.0
Intake	11.8	9.5	16.1	11.9

The standard of farming was relatively sophisticated, and was rapidly becoming more so. Both the Yemenites and the Kurds who were studied were in the age group 20-30 and had been born outside Israel. Their parents had been poor, living in primitive conditions, and when they arrived in Israel were in many cases malnourished and frequently had serious diseases (tuberculosis, malaria, schistosomiasis). After their entry into Israel (1950-52) they were settled in their own (new) villages where their standard of living gradually improved. The age group studied (20-30 yr) were by 1968-69 taller and heavier than their parents.

It was estimated that some 80% of those in the age group in the villages studied were examined clinically and anthropometrically. The remaining 20% included a number absent on military service, some who were sick, and others (about 5%) who refused to take part. Only a proportion of the 80% were available for the laboratory measurements of VO_2 max as it was often difficult for farmers to be absent for a day, and of the potential 200 subjects some 65 were tested.

Africa

A number of the IBP studies in Africa have been presented in papers published under the title "Human Biology of Environmental Change" (1972). One of the papers describes a study in Nigeria by Ojikutu et al. (1972). They examined villagers, students and industrial workers. The VO_2 max was predicted from measurements made during submaximal exercise. The villagers had a maximum oxygen intake of 48.4±4.1 ml/min/kg body weight, or 61.2±3.3 ml/min/kg lean body mass. They weighed 61.63±4.55 kg, were 169.2±4.58 cm tall and were 25±3 years old. Compared with the industrial workers, the villagers were, in terms of VO_2 max, intermediate between the heavy and the light industrial workers. The main purpose of this study was to examine the heat tolerance of the subjects and no nutritional investigations were undertaken.

In Zaire, two tribes have been studied by Ghesquiere (1972) and Austin (1974). These are the Hutu and the Twa; in Table 5 are given the results of the measurements made.

Table 5. Characteristics of two African tribes.

	Hutu	Twa
n	27	23
Height (cm)	169.0±0.5	160.0±0.98
Weight (kg)	56.0±0.7	51.2±0.8
Vital capacity (l)	3.82±0.02	3.17±0.08
VO_2 (ml/kg/min)	42.7±0.54	47.5±0.80

The Twa are significantly shorter and lighter than the Hutu but their VO_2 max expressed in terms of kg body weight is significantly higher than that of the Hutu. Austin examined the habitual activities of these two groups. They are swidden (slash and burn) agriculturalists who also hunt. The men clear and burn areas for new fields, hunt and fish, and also build and maintain the village houses. The women are responsible for the crops, planting, hoeing and harvesting. In addition, the women collect firewood and carry it back to the villages where they prepare the plants which they have harvested for cooking. Such preparation takes many hours of work.

The day begins between 0500 and 0600 hrs, with a light meal followed by 10-30 min walk to the fields. The women work for about 4 hours and then return to the village to prepare food; after working and eating the women rest for about 2 hours and then prepare the evening meal which is eaten about 1900 hrs. The men work for about 3-4 hours in the morning, on the average 3 days a week, preparing new fields by clearing and burning brush and undergrowth. They hunt using bows and arrows, stalking game, but there is considerable variation between individuals in the frequency of hunting.

The Bantu have been studied extensively by Wyndham and his colleagues (1972); they have also examined some Bushmen. In the Bantu the maximum O_2 consumption ranged from 41.0 to 46.4 ml/min/kg body weight; the Bushmen attained 47.1 ml/min/kg body weight.

Pramprero and Ceretelli (1969) measured VO_2 max in the Turkana, Dorobo and the Masai in East Africa. The results were similar in the three tribes, being between 45 and 50 ml/min/kg body weight.

South America

In South America, P. Baker (1966) has

studied the Shipibo Indians who live in a hot and humid climate. The men were, on average, 159 cm high and weighed 59 kg. Similar results were obtained by Newman (1962) on other Amazonian tribes in whom the men weighed 55-58 kg and were 154-159 cm high. Baker measured the body temperature and heart rate in the Shipibo Indians during walking at different speeds, and concluded that they were physically fit.

Gardner (1973) measured VO_2 max in the Warao Indians who live in the forests of Venezuela. His results were relatively high with a mean figure of 51.2 ml/kg body wt/min. The nutrition of these Amazonian tribes is based on starchy plants like the sweet potato supplemented by some protein from hunting game. It is evident that there is considerable variation between tribes and within each tribe there is some seasonal change.

The nutrition of people living in tropical areas varies considerably from one region to another. Many have a low protein intake, and even more have a low calorie intake. Much of the available information is based on assessments of the total amount of food available over a period of a year, individual intake being calculated from the total number living in the area, with adjustments for children and for women. Such food balance sheets are only reliable if an accurate measurement can be made of all available food. Ultersdorf (1972), writing about nutrient intake in East Africa, points out 'most people live as subsistence farmers and there is little exact information about yields, storage losses, consumption of wild leaves and berries'. Such a statement applies to many other tropical areas; exact knowledge depends upon results of dietary surveys. Relatively few such surveys have been carried out; however, the figures arrived at by such surveys show that calorie intakes can be lower than expected.

In India, average intake as calculated from food balance sheets is low, of the order of 6.3 MJ/day. There is considerable reliance on these food balance calculations, as there is a continuous assessment of food production throughout the country. Nevertheless, there are great variations in such a large country, so detailed information is really needed but, as Devadas & Easwaran (1972) point out: "Quantitative data on the food and nutrient intake of these vulnerable sections (i.e., poor socio-economic groups) are scarce'. The authors' own findings showed that calorie intake of expectant mothers averaged 5.8 MJ/day. Similar findings have been reported by others. Although direct measurements of villagers engaged in agricultural work do not appear to have been done, it seems probable that food intake is, on average, low throughout India. In some regions, such as the Punjab, the people are taller and heavier than those living in the south of India, and their level of nutrition is presumably higher also. There is no doubt that much more detailed information is required.

Conclusions

The inhabitants of tropical regions who live by farming the land are, in general, small people, and with a level of oxygen consumption which is low in terms of the physical work they may have to do, but is comparable to that found in western countries when expressed in relation to body weight. In many cases, physical work capacity is impaired by disease, of which malaria is the commonest.

Nutrition is extremely variable, but there is reliance on foods such as cassava, millet, sweet potato, and other starchy roots. Protein intake is frequently low. The seasonal variation of farming activity implies that there is also a seasonal variation in energy requirement. It has been shown that this can result in periods of plenty and periods of inadequate food intake. Whether such variation is widespread is not yet known.

There has been a considerable increase in knowledge thanks to the International Biological Programme. The studies conducted under the auspices of the Human Adaptability Section of the programme have, however, served to underline our ignorance of the majority of those living and working in tropical regions.

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Resumen

Obreros agrícolas en paises trópicos generalmente son más cortos y ligeros que sus equivalentes europeos. Ya que la capacidad física de trabajo, estimada por lo que se refiere al consumo de oxígeno ($\dot{V}O_{2\ max}$) está relacionada con el peso del cuerpo, el obrero trópico, aunque sea sano y bien nutrido, puede descúbrir que muchas tareas agrícolas ocasionan trabajo agotador. Enfermedades particularmente malaria y enfermedades paráditos como anquilostoma, son comunes y debilitan la capacidad física de trabajo.

Niveles de nutrición varían en diferentes regiones trópicas: en ciertas zonas hay producción adecuada de alimento, en otras se dispone de alimento suficiente en cuanto a calorías, pero la toma de proteína está limitada.
En Nueva Guinea la toma de sodio está excepcionalmente baja y es substituida por potasio. En enormes zonas, como India, el nivel total de toma de calorías está bajo y eso afecta el desarrollo y, por consiquiente, la capacidad física de trabajo.

Résumé

Les travailleurs agricoles dans les pays tropiques sont en général plus petits et plus légers que leurs collègues européens. Comme la capacité de travail physique, estimée en termes de consommation d'oxygène (VO_{2max}) dépend du poids de l'homme, même le travailleur tropical adéquatement nourri et jouissant d'une bonne santé, peut trouver que beaucoup de travaux agricoles demandent une labeur épuisante.
Les maladies, surtout la malaria et les maladies parasitaires telles que l'ankylostomiase sont fréquentes et font diminuer la capacité de travail physique. Les niveaux de nutrition diffèrent d'une région tropicale à l'autre: dans certaines régions la production alimentaire est

adéquate, dans d'autres les aliments disponibles, tout en fournissant assez de calories, contiennent très peu de protéines. En Nouvelle Guinée, la consommation de sodium est extrêmement faible et cet élément est remplacé par la potasse. Dans de vastes régions comme l'Inde, la consommation générale de calories est faible, ce qui réduit la croissance et par là aussi la capacité de travail physique.

PHYSICAL WORK CAPACITY OF THE TROPICAL WORKER IN RELATION TO PRODUCTIVITY AND IRON DEFICIENCY ANAEMIA

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Summary

Data collected by the author during a 2-year stay in the tropics suggest that physical working capacity (PWC), measured as the maximal aerobic power output ($\dot{V}O_{2\ max}$) of African agricultural workers engaged in sugar cane cutting, gives a relatively poor guide to measured work output in the cane fields. The $\dot{V}O_{2\ max}$ was found to be independent of the workers' absolute productivity in tems of kilotons of cane cut per season and showed only a weak correlation ($r = + 0.46$) with daily output. In statistical terms $\dot{V}O_{2\ max}$ accounted for < 25% of the total variance of productivity, thus when making recommendations regarding Ergonomics in tropical agriculture, this physiological observation should be bourne in mind and some consideration given to such social and psychological factors (motivation, skill, experience and standard of leadership) which may influence the general working environment. It was found that the marked diminution in $\dot{V}O_{2\ max}$ ($\sim$ 40%) resulting from severe (Hb < 5g/100ml) iron deficiency anaemia could be reversed over a period of 3 months oral iron therapy provided the treatment was supervised and the subjects remained active.

Introduction

Professor Edholm in his paper on nutrition and physical working capacity (PWC) of the tropical worker identifies PWC with maximal aerobic power output ($\dot{V}O_{2\ max}$). This procedure has now gained international acceptance on the basis that the $\dot{V}O_{2\ max}$ essentially measures the ability of the cardiorespiratory system and working muscles respectively to transport and utilize oxygen, and thus must ultimately reflect the body's capacity for sustained work. It has also been shown that the $\dot{V}O_{2\ max}$ can be influenced by age, race, sex, physique and training and although none of these factors is in dispute, a vital question, in my view, for this symposium to consider is whether the $\dot{V}O_{2\ max}$ is actually related to work output under tropical agricultural and forestry conditions? To my knowledge, apart from the study I shall describe, no one has attempted to answer this question in the developed or developing tropical countries of the world.

Productivity

In 1972 I was presented with an opportunity to study the productivity and PWC of East African sugar cane workers on the Kilombero Sugar Estate, Kidato, Tanzania. The investigation has been published in full (Davies 1973, and for the interested delegate, also see Davies et al 1976, which covers some later work in the Sudan), but briefly, for present purposes, the 585 sugar cane workers employed on the estate were screened at the beginning (May) of the season for age, weight, height and blood haemoglobin concentration during a routine medical examination. From the detailed records of the actual work performed in the cane fields in terms of tonnage of cut cane by each worker which were meticulously kept by the management (the cutters were individually and daily paid on this basis and absenteeism was noted) and the preliminary medical data (men with parasitic infection or anaemia were exclused - see below). 80 men were selected and divided evenly (in the event 2 became sick and had to be excluded) into 4 groups: young (18-35yr), low, medium and high output workers and older (> 35 yr) men. These subjects were measured towards the end (December) of the cane cutting season in a field laboratory set up to measure PWC in terms of $\dot{V}O_{2\ max}$.

The results showed that the total work output (in terms of kilotons of cane cut per season) was independent of their $\dot{V}O_{2\ max}$. The correlation coefficient (r) between the two variables was + 0.21 ($P > 0.05$), the slope of the regression line did not differ significantly from zero. However, further analysis of the data revealed that this observation was to some extent misleading as the high procedures appeared to spend less time (i.e. they worked at a higher rate) to produce a given output and voluntarily absented themselves less from the cane fields.
The low producer on the other hand worked more days to achieve the same output and took more unpaid "rest" days away from the fields. Thus, if the data were reanalysed in terms of daily productivity (kilotons of cane cut per day) a significant ($P < 0.001$) and positive association ($r = + 0.46$) with $\dot{V}O_{2\ max}$ was obtained. The absenteeism rate showed a weak

but significant ($P < 0.001$) inverse relationship ($r = -0.32$) to $\dot{V}O_{2\ max}$.

These observations suggest that the $\dot{V}O_{2\ max}$ is related to productivity in an occupation which demands a high level of energy expenditure but the intersubject variability is large and as a single factor only accounts for approximately 21% of the total variance of daily cane cutting output, clearly the individual predictive value of $\dot{V}O_{2\ max}$ and as an indicator of work output under the observed conditions is useless, but on a group basis it has some merits. The high producers (group 1) possessed ∿ 20% advantage in $\dot{V}O_{2\ max}$ over the low producers (group 3) which was exactly parallelled by the difference in their work outputs and the decline of $\dot{V}O_{2\ max}$ observed with age (group 4) was reflected in a concomitant fall in productivity (Table 1). Nevertheless measurement of the PWC in the form of $\dot{V}O_{2\ max}$ leaves at least 79% of the variability of actual work output unexplained and I think this rather unpalatable "fact" must be bourne in mind by the delegates attending this symposium. Work physiology is a challending but difficult field in which to work, for as in all aspects of human endeavour, there is always a strong interplay between psychological and physiological factors which only serve to confound the often hapless investigator. We must accept that such factors as skill, motivation, experience, standard of leadership, attitudes, moods, etc., may play a more important role than PWC in determining the contribution of ergonomics to human agricultural problems in the tropics.

This is an important conclusion, but having stated it, one must be careful not to imply that the limitations of $\dot{V}O_{2\ max}$ as an index of working capacity affects, in any way, its validity as a physiological tool for studying the O_2 transporting system and the assessment of the aerobic work potential of an indicidual per se. It merely serves to place a constraint on the ergonomist working in an applied (and in the context of this symposium, tropical) situation. It is against this background I would like to make some final observations on a second topic raised (but not discussed) in Professor Edholm's opening address, that of the potential debilitating effects of iron deficiency anaemia.

Iron deficiency anaemia

Anaemia still remains endemic within most tropical countries particularly those of the developing third world (Figure 1). It will be noted that 15% of the population have Hb levels < 10g/100ml and 50% < 12g/100ml, the recommended lower limit for normal healthy subjects by the World Health Organization. The aetiology of the disease is well known, but there are few studies of the effect of iron (mainly due to nutritional) deficiency anaemia and from these, the data are conflicting and the evidence confused (Davies et al 1973). The data I shall present are again based on published work (Davies et al 1973

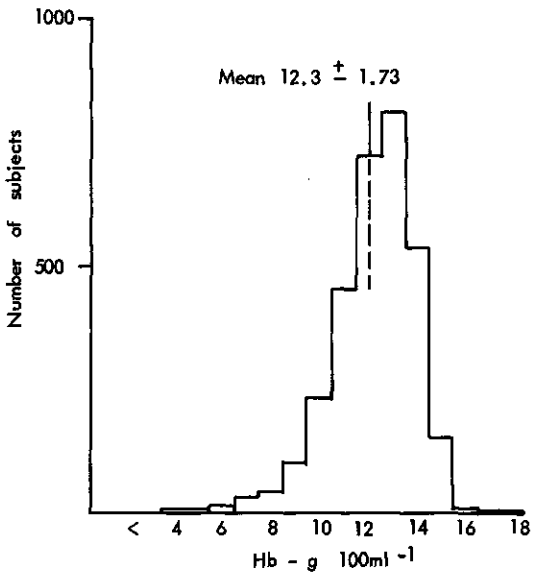

Figure 1. Histogram showing the distribution of blood haemoglobin concentration of 3400 urban East African workers.

Table 1. Maximal aerobic power output ($\dot{V}O_{2\ max}$), absolute productivity, daily productivity and absenteeism from the cane fields.

Group	n	(l/min)	$\dot{V}O_{2\ max}$ (ml/kg.min)	Absolute output (kilotons)	Relative output (kilotons/day)	Absenteeism (days)
1 High producers	20	3.20***3,4	51.0***3,4	361***2,3,4	3.51***2,3,4	8.7***2,3,4
2 Medium producers	19	2.95	48.0	295	3.04***3	15.2***3
3 Low producers	19	2.80	47.3	252	2.60***4	21.1***4
4 Older men	20	2.76	43.0	287	2.95	14.7

Comparison of groups - significance *** $P < 0.001$

and Davies and Van Haaren 1973) resulting from my 2 yr stay in East Africa. During this period two investigations were carried out. The results of the first in which 33 subjects were studied: 16 controls (Hb = 14.5 ± 1.5 g/100ml); 7 moderately anaemic (Hb = 9.2 ± 8g/100ml) and 10 severely anaemic (Hb = 6.7 ± 1.1g/100ml), are summarised in Table 2. The data show unequivocally that iron deficiency anaemia markedly reduces $\dot{V}O_{2\ max}$. The effect becomes apparent at or below a Hb level of approximately 11g/100ml (Figure 2). At Hb < 5g/100ml the decrease in $\dot{V}O_{2\ max}$ is of the order of - 40%. These low levels of Hb were associated with "compensatory" changes in the cardiorespiratory system (e.g. plasma [but not blood] volume increased, cardiac frequency and output for a given oxygen intake were raised and the heart volume at rest was enlarged (for details see Davies et al 1973) but these were insufficient to offset the diminished $\dot{V}O_{2\ max}$ of the severely anaemic subjects when compared to their healthy controls.

The second study (Davies and Van Haaren 1973) showed that the changes in $\dot{V}O_{2\ max}$ could be reversed by appropriate daily, oral iron therapy over a 3 month period (Figure 3).

The practical implications of these studies for this symposium are clear. In those tropical countries where social and economic development largely depend on subsistence agriculture, forestry and physical labour, iron deficiency anaemia it left untreated will have a serious debilitating affect on potential human aerobic work performance but (to end on a positive note!) provided the problems of supervision are overcome (see Davies and Van Haaren 1973) it would seem (Figure 3) that this problem is soluble and (using oral iron tablets), at minimal cost to the community.

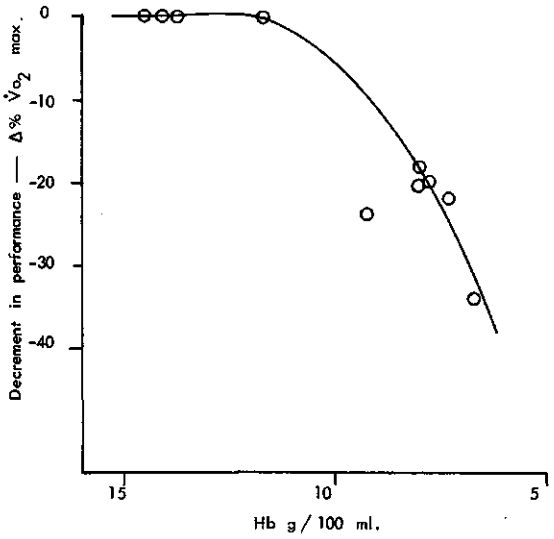

Figure 2. The relationship between the decrement in maximal aerobic power output (% $\Delta\ \dot{V}O_{2\ max}$) as a function of plasma haemoglobin (Hb) concentration. Mean data.

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Table 2. The age, height (ht), weight (wt), blood haemoglobin concentration (Hb), and maximal areobic power output ($\dot{V}O_{2\ max}$) of healthy controls (1) and moderately (2) and severely aneamic (3) subjects. Mean ± SD data

Group	n	Age (yr)	Wt (kg)	Ht (cm)	Hb (g/100ml)	$\dot{V}O_{2\ max}$ (l/min)
1	16	27.1	54.7	165.6	14.5***2,3	2.88***3
		±7.1	±5.4	± 4.3	±1.5	±0.46**2
2	7	23.7	50.9	164.0	9.2***3	2.20
		±9.7	±8.4	± 7.2	±0.8	±0.42
3	10	22.0	54.4	163.7	6.7	1.90
		±6.2	±5.4	± 2.8	±1.1	±0.37

Group comparison as in Table 1 *** P < 0.001 ; ** P < 0.01

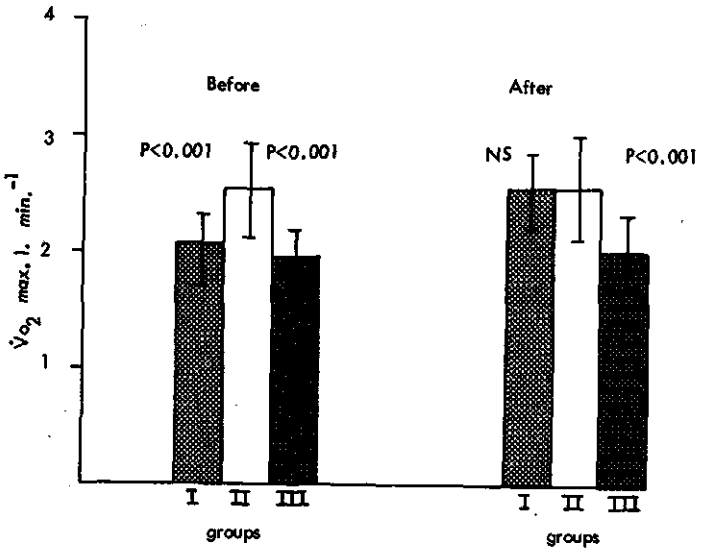

Figure 3. The effects of daily oral iron therapy on maximal aerobic power ($\dot{V}O_{2\ max}$).
(a) before and (b) after treatment.
Group 1 (n = 8) anaemia
Subjects

Resumen

Datos acumulados por el autor durante una estancia de 2 anos en los trópicos indican que la capacidad física laborable (PWC), medida como la producción máxima aeróbica de energía ($\dot{V}O_{2\ max}$) de obreros africanos agrícolas ocupados en cortar la cana de azúcar, es una indicación poco segura de la producción de trabajo medida en los campos de cana de azúcar. La $\dot{V}O_{2\ max}$ resultó ser independiente de la productividad absoluta de los obreros por lo que se refiere a kilotoneladas de cana cortada a la temporada e indicó no más que una correlación floja (r=+0.46) con la producción diaria. En términos estatísticos $\dot{V}O_{2\ max}$ responde de < 25% del desacuerdo total de productividad, así que, dando recomendaciones en cuanto a la ergonómica en agricultura trópica, hay que tener presente esta observación fisiológica; además hay que dar atención a tales factores sociales y psicológica (motivación, habilidadm experiencia y nivel de mando) como puedan influir el ambiente general de trabajo. Resultó que la diminición notable en $\dot{V}O_{2\ max}$ ($\sim$ 40%) debida a una deficiencia grave (Hb < 5g/100 ml) de hierro (anemia) podría cambiarse durante un período de 3 meses de terapia oral de hierro, con tal que se supervisara el tratamiento y los individuos quedaran activos.

Résumé

L'information receuillie par l'auteur pendant un séjour de 2 ans dans les tropiques mène à penser que la capacité de travail physique (PWC), mesurée en termes de consommation d'oxygène ($\dot{V}O_{2max}$) de travailleurs agricoles africains coupant la canne à sucre, est une indication relativement pauvre de la performance du travailleur sur les champs de canne. On a constaté que le $\dot{V}O_{2max}$ n'a pas de relation avec la productivité absolue de l'ouvrier, calculée en milliers de tonnes de canne coupée par saison et n'a qu'une faible relation avec la performance journalière (r = + 0.46).
Dans le cadre des statistiques, le $\dot{V}O_{2max}$ a causé < 25 % de la variation totale de la productivité. Aussi, en faisant des recommandations sur l'ergonomie dans l'agriculture tropicale, cette constatation physiologique doit être présente à l'esprit et des facteurs sociaux et psychologiques (motivation, habileté, expérience et le niveau de direction) qui peuvent exercer une influence sur tout le milieu de travail, doivent aussi être considérés.
Il a été constaté qu'on peut remédier à la baisse sensible du $\dot{V}O_{2max}$ ($\sim$ 40 %) résultant d'une grave anémie (Hb <5 g/100 ml) par une thérapie orale de fer de 3 mois, à condition que le traitement soit contrôlé et que les malades restent actifs.

DETERMINANTS OF HEALTH AND DISEASE

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Summary

In tropical areas several factors contribute to unfavourable health conditions, such as the quality of nutrition and drinking water, housing and living habits.

The spread of infectious diseases (malaria, filariasis, yellow fever etc.) may be furthered by the abundant availability of suitable vector hosts (mosquitoes, snails, flies etc.) and the lack of adequate sanitary facilities (doctors, nurses, drugs, vaccines etc.). A description of schistosomiasis is given from which disease more than 200 million people in tropical countries are suffering.

Disease may influence the physical fitness and working capacity negatively which should be taken into account when setting standards for the ergonomic work load evaluation in tropical areas.

Introduction

When we look at the more than 3.5 billion people who inhabit the world, there is little reason to be satisfied about their health. Although there have been no severe pandemics since the pandemic of influenza in 1918, many people are less healthy than they could be. If all our available knowledge were applied to their health problems, this situation would be greatly improved.

It is estimated that only one quarter of the present world population reaps the benefit of reasonable sanitary facilities and reasonable nutrition. Most of the people live in the tropics, where transmission of communicable disease due to climatic factors occurs very easily.

The health of the people living in the temperate climate is in general better than the health of the people in the tropics. Many diseases which were common in the past, now have almost disappeared from the countries in temperate climates. This is true for tuberculosis, for the late stages of syphilis, for malaria, for hookworm disease, for typhoid and cholera, for diphteria, for ricketts and scurvy, and for a number of other diseases.

If we ask what caused these diseases to disappear, we have to admit that there is no simple answer. The health of people improved before there was much knowledge about the causation of disease.

However, one of the contributory newer factors is undoubtedly modern preventive medicine. With polio vaccines for instance, it has been possible to stop the further appearance of clinical cases of paralytic poliomyelitis. Smallpox also can be stopped by vaccination; although this has been known for almost two centuries, implementation has been successful only in this century. Research for good vaccines is still needed to provide us with more tools to eliminate a number of communicable diseases as causes of preventable sickness.

A second important factor has been the use of new drugs to suppress the multiplication of microorganisms in human tissues. This means that the number of microorganisms that reach the environment is now less than was the case in the past. And this means that the infection risk is less now than in earlier days for a number of communicable diseases, such as typhoid, tuberculosis, the dysenteries, scabies etc.

A third important factor is the rising level of education in health matters. The people in these countries generally have acquired an understanding of the principles of communicable disease control, desirable nutrition and dangers of certain occupations.

If we look at a community in the tropics it will on the average be much smaller and depend much more on its local resources to solve medical problems than in what may be called the 'Western World'. Knowledge about the causation of diseases is poor and there is an abundance of insects. Customs often have a bad effect on nutritional intake of pregnant women and toddlers. Accidents result in wounds which could be easily healed; but due to absence of medical facilities they are neglected. There is pollution of the soil with faeces and urine of man and animals. There may be pollution of the water with faecal material. There are repeated pregnancies with unskilled assistance for the deliveries. And there are many children who walk on bare feet, eat irregularly and play with dirty objects.

Infectious diseases

Discussing health and disease in tropical countries a chapter of major importance is: the infectious diseases. Most of these diseases are caused by microorganisms which are transferred by contact with a host who harbours and excretes the microorganism.

Microorganisms are lower forms of life which by their multitude or toxic products can harm man's health. Worms and a few insects (mainly mites) are for didactic reasons included in the group, though most of them are large enough to be seen without a microscope.

At the end of the past century the unclassified fevers from which man had been suffering since the dark past, were shown to depend largely on the presence of microorganisms. The malaria parasites for example, were first seen by Laveran in 1878. After that several bacilli were discovered, such as the tuberculosis and the cholera bacillus.

There is an important difference between the worms and the less differentiated microorganisms, for the number of worms in the host depends on the number of eggs or larvae that reach the host. Bacteria, protozoa and virus on the other hand, multiply in the host at a formidable rate under favourable circumstances and depend on their numbers and toxic products to make up for their small size.

In the Netherlands bacteriologists like to talk about three types of microorganisms. The first group contains the absolute pathogens. They practically always cause disease. Examples are: the smallpox virus, the plague bacillus and the tetanus bacillus. At the other side of the scale we have the commensals. They are usually harmless and rarely cause disease. Large numbers of staphylococci and streptococci for example are normally present on the human skin and in the human nose. When the resistance of the host is lowered they may cause diseases, such as boils, sore throat, pneumonia. In between stand the passants which never stay long with the host. They often pass the host without clear evidence of disease. Poliomyelitis, salmonellosis and influenza are diseases caused by microorganisms that belong to this group.

The pathogenic microorganisms can be classified as follows:

a) fungi and yeast which belong to the plant world;
b) bacteria which have characteristics of plant and animal life;
c) protozoa which certainly belong to the animal life;
d) helminths which belong to the higher forms of animal life;
e) insects which are still higher forms of animal life;
f) virus and rickettsiae which are so small that they stand at the borderline between life and death.

Some of the microorganisms are easily transmitted directly from man to man, for example influenza virus, cholera bacilli, TB-bacilli, pinworms. Others, such as most worms and protozoa, can only infect a new host after passage through a suitable medium in which further development takes place. A number of microorganisms, such as tetanus bacilli and rabies virus, practically always give dead end infections when they use man as a host.

Environmental factors such as temperature and humidity play an important role in the transmission of some of the microorganisms. Hookworm eggs for example will hatch only if there is high temperature and high humidity of the soil. Malaria parasites can only go through their development stages in mosquitoes when the temperature is sufficiently high. Survival of virus and bacteria also depends on such factors.

What we have learned so far shows that much popular thinking about infectious diseases is oversimplified. Though the microorganisms are essential in the disease process, many utterly unrelated factors can lead to an epidemic. First of all, there has to be a sufficient number of new hosts with little or no specific resistance. Secondly, there has to be a means of transmission, starting with a portal of exit and ending with a portal of entry into the new host. Thirdly, there has to be a sufficient dose, for otherwise the microorganism may be unable to overcome the general resistance that most people have against small numbers of invading organisms.

Ways of control

From a viewpoint of environmental health, the transmission routes are of primary interest. It is here that engineering methods can be applied to prevent epidemics. The attack can be of a general nature. Clean dry surfaces of metal, stone or wood offer little chance of survival for most microorganisms. Light is important, if only to prevent invisible accumulation of dirt. The attack also can be of a specific nature. Pasteurization of milk can stop the transmission of bovine tuberculosis and brucellosis. Chlorination of drinking water will kill most pathogenic microorganisms that might be present in the faeces. Species elimination using specific molluscicides may eventually rid populations of schistosomiasis. Rat flea control can prevent an outbreak of plague. Residual spraying of walls can stop the transmission of malaria.

From a general viewpoint of public health, other aspects of cummunicable diseases offer possibilities to assist with the control of these diseases. Through study of microorganisms, it was discovered that their pathogenicity can be different, due to either spontaneous changes or prolonged cultivation under unfavorable circumstances. Pasteur was the first scientist who showed that it is possible to protect man and animal against communicable disease by bringing him into contact with artificially weakened strains of the organism before being exposed to the wild strain. Many rabies victims have been saved by this method. Vaccines are now available against smallpox, diphteria, whooping cough, tetanus, typhoid, cholera, yellow fever, measles etc.

The presence of natural or acquired immunity against communicable diseases also explains why man in endemic areas does not suffer more from these diseases. Fortunately

man in the course of his evolution was provided with defense mechanisms against the ever present threat of microbes. Through better understanding of these mechanisms it already has been possible to shift the balance in his favour and it is doubtful that we have reached the end of the possibilities.

There are some infectious diseases which, in the past, have caused serious epidemics, such as plague, cholera, typhus and relapsing fever, smallpox. Other infectious diseases may have a more or less endemic character, such as malaria and yellow fever. Wide spread diseases are minor bowel infections due to the food.

Schistosomiasis

After malaria, schistosomiasis is probably the most important parasitic disease in the tropical countries. It is estimated that there are at the moment at least 200 million victims of schistosomiasis. The disease is common in Latin America, Africa and certain parts of the Far East.

Schistosomiasis is caused by a flat worm, a trematode which lives its adult form in the small blood vessels of the intestine or the bladder. The disease was discovered long ago and we know that mummies in Egypt were frequently infected. Bilharz (1850) was the man who first described the parasite and for this reason the disease is also called bilharziasis.

The eggs of the worms are excreted with faeces or urine. A small snail serves as an intermediate host. It produces cercariae, the infective larvae which are able to penetrate the intact human skin if a person walks or swims in polluted water.

The schistosomiasis patient may suffer from fever, internal ulcerations and bleeding. The result may at least be a loss of fitness, often an anemia and sometimes even a high degree of sickness and disability.

Experience has taught that it is very hard to eradicate schistosomiasis from an endemic area. This is due to the fact that people who work on irrigated lands pollute the water with their faeces and urine. It is also due to the fact that the Asian type of schistosomiasis is not only transmitted by man but also by domestic animals.

Treatment of the patients is possible as there are drugs which kill the worm. As most patients after treatment will return to an environment which is just as dangerous as before, real success is rare. Untreated patients stay infective (excrete eggs) for up to 20 years.

Children and mothers can be protected to a certain extent if they are provided with safe water for washing, bathing and swimming. Small bridges over polluted streams and ditches will also help prevent the risk of infection. Since it is yet difficult to convince people that disease is spread by fresh urine or faeces which reach irrigation water in an endemic area, the disease is more or less considered a professional risk of the worker in irrigated fields. Good long boots would of course protect the skin. Storage of all urine and faeces in pits until the eggs are killed would make night soil much safer. A vaccine has not been developed so far.

Since dams and irrigation projects are badly needed to increase crops, there is a real risk of spread of the disease in many places. Fortunately, international and national health organizations are aware of the risk and are conducting more research to study possibilities of controlling the disease.

Conclusion

In tropical countries there are more endemic diseases which are transmitted by an intermediate host. Mosquitoes can act as a vector in the transmission of malaria, filariasis and yellow fever.

All mosquitoes deposit their eggs close to, on or in water since the larvae and pupae are aquatic. The control of mosquito borne diseases at present is mainly carried out with insecticides (DDT). Extensive eradication programs have been developed in various tropical areas.

Vector eradication is an important factor in the battle against tropical diseases. However, as mentioned before, it is only a part of all what has to be done.

The health status of a population largely depends on social and environmental conditions. Vital requirements for a good health are for instance the availability of doctors and nurses, of drugs, immunization and ambulances; good foods and safe drinking water; good houses and safe sewage disposal; clean habits and hygienic conditions.

In tropical countries the way to better conditions in favour of the health of the population is a long and laborious struggle. For the time being we have to accept that at many places the health status is far from the optimum, maybe even poor. Consequently, ergonomics will have to take into account a not-optimum physical fitness and working capacity of individuals and populations. Inevitably the ergonomic work load evaluation under tropical conditions has to be based on other than 'Western' standards. It is of major importance to intensify health research in the tropics in this respect, in order to provide the data needed for the formulation of more appropriate work load standards and tolerance limits.

Resumen

En las regiones trópicas hay diversos factores que sirven para empeorar las condiciones de sanidad, como por ejemplo la

calidad de alimentación y agua potable, provisión de viviendas y hábitos de vida.

La extensión de enfermedades contagiosas (malaria, filiriasis, fiebre amarilla) puede desarrollarse por la disponibilidad abundante de transmisores convenientes (mosquitos, caracoles, moscas) y la falta de adecuadas facilidades sanitarias (médicos, enfermeras, medicamentos, vacunas). Se da una descripción de cistosomiasis, enfermedad que padecen más que 200 millones de gente en los paises trópicos.

Enfermedades pueden influir aversamente el estado físico y la capacidad de trabajor, lo que hay que tener en cuenta cuando se fijan normas para la evaluación ergonómica de la capacidad de trabajo en regiones trópicas.

Résumé

Dans les régions tropicales, plusieurs facteurs sont responsables de la situation défavorable en matière de santé; il s'agit notamment de la qualité de l'alimentation et de l'eau de boisson, du logement et des habitudes de vie.

La propagation des maladies infectieuses (malaria, philiriasis, fièvre jaune, etc.) peut être aggravée par l'abondance des hôtes responsables de la contamination (moustiques, vers, mouches, etc.) et la pénurie de facilités sanitaires adéquates (médicins, infirmiers, médicaments, vaccins, etc.).

Il est donné une description de schistosomiasis maladie dont souffrent plus de 200 millions de personnes dans les pays tropicaux.

La maladie peut exercer une influence négative sur la forme physique et la capacité de travail, élément dont il faut tenir compte lorsque l'on établit des normes d'évaluation de la capacité de travail en région tropicale, fondées sur la science du travail.

ANTHROPOMETRY IN WORKPLACE DESIGN

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Summary

Reliable anthropometric data, as well as an adequate procedure for design and test purposes, provide the most powerful tool available today for the optimum workplace lay-out of many mass-produced hand tools and machines in agriculture and forestry.

Many hand tools and machines in agriculture and forestry in tropical countries are imported from other countries; this can lead to inadequate working situations, if no attention is paid to the anthropometric and biomechanical aspects of the users. Therefore anthropometric surveys have to be carried out in these countries.

With the aid of these data the designers can formulate the data for an optimum workplace lay-out, including a good working posture, which can contribute to an optimum work load of the operator, as well as a good performance of the man-tool/machine system.

Introduction

Anthropometry can be described as that part of ergonomics that both is engaged with measurements of the human body (static anthropometry) as well as with the mechnical aspects of motions of the human body, considering range and frequency of these motions, in an ergonomic model (dynamic anthropometry) (Roebuck, 1975).

Anthropometric data enable the human engineer to regard the following aspects of dimensions of the workplace:

1) Minimal and maximal distances of controls to a given reference point;
2) Freedom of movements within the workplace of man as a whole and of bodymembers.
3) Forces to be exerted, in relation to 1) and 2).

Static anthropometry regards the dimensions of parts of the human body. A very important question here is how the measurements would be taken. The purpose of the measurements would always be an adequate application for regarding the dimensions of the workplace, and not - as in anthropology - a detailled knowledge of the build of the human body.

Dynamic anthropometry describes the three-dimensional workspace, using one- or two-dimensional data from static anthropometry. Herein emerge also aspects as forces to be exerted, body posture and visibility of displays.

In this paper I will describe the principles of static and dynamic anthropometry, as well as the tools for collecting anthropometric data of man and workplace and for analysing man-machine systems.

1. Static anthropometry

1.1 Body dimensions

Body dimensions can be distinguished in
- linear dimensions: breadths, depths and lengths;
- circumferences.

What dimensions have to be collected, depends primarily on the purpose, which they are to be used for. This may be:
- workplace design
- design of tools
- design of (work)clothes.

Circumferences are especially important for designing clothes. The linear dimensions are however much easier to use and - for this reason - of more importance in designing workplaces and tools.

Analysing the investigations, which have been described in literature, the following measurements appear to satisfy for ergonomic purposes:

- body weight
- stature
- eye height
- shoulder height
- shoulder breadth
- hand height
- hip breadth
- elbow to elbow breadth
- functional forearm length
- knee height
- lower leg length (height of sitting surface)
- upper leg length
- seat depth
- crotch height
- forward reach
- upward reach
- sideward reach
- elbow height (standing)
- elbow height (sitting)
- sitting height
- thigh clearance height
- hip breadth (seat breadth)
- body depth, standing
- foot length

For measuring these body dimensions a clearly defined body position is necessary. Usually this body position is standing or seating erected with the following definitions:

Standing erected:
The person stands with his feet closed and his body vertically erected, while heels, buttocks and shoulders touch the same vertical plane.

Sitting erected:
The person sits with his body vertically erected, while heels, buttocks and shoulders touch the same vertical plane.

It is a matter of course, that these body positions are not very common in the actual working situation. They have been chosen for:
- their reproducibility
- the possibility to define reaches and body dimensions by vertical and horizontal planes through the body. This way of defining makes the use of anthropometric data in practical ergonomics easier.

1.2 Variability of body dimensions

In addition to the question which measurements are relevant it is interesting to know some characteristics of the people which the measurements are taken from. Body measurements differ individually, not only in their absolute sizes, but also in their mutual relations. This means that a statistical approximation is necessary and that rather large samples have to be taken to get reliable results. The minimal sample should be at least 0,5 °/oo of the population (Jürgens, 1975).

The interindividual differences of body dimensions are affected by the following factors: Age, sex, etnic group and race, occupation and socio-economic group. In composing a sample it is necessary to regard that, concerning these factors, the sample reflects the population for which the results are to be used.

Age: the body dimensions change especially during the puberty. The increase of length ends for women at the 18th year, for men after the 20th year. It appears that the end may be later for people from lower socio-economical groups. After this puberty a gradual change of body measurements starts. Roughly spoken the body length decreases and the breadth and depth increase.

Sex: Europese women are about 10 cm smaller than men. Furthermore the female pelvis is broader and the shoulders are smaller.

Etnic group and race: Differences in etnic group and race appear from the whole build of the body, both in the length as in the breadth and depth. This appears to be the same for socio-economical differences.

Occupation: The influence of the occupation on body dimensions appears by two causes:
1) Selection of persons on account of fysical characteristics; for instance stature as a limiting factor in a workplace, heavily build men for heavy work.
2) Influence of the build of the body by the workload: little fat, muscles, but also a bent back.

This factor may also be of great influence on the forced to be exerted.

In addition to these regular factors there are some other factors, which affect body dimensions. These factors are:
- Time of day: body length decreases during the day with max 2 cm, for people with very heavy work with maximal 4 cm.
- Physical fittnes
- Nutrition
- Secular growth: since 120 years in a lot of countries there is an increase of stature and a acceleration of the growth and maturity by children and adolescence. This secular growth results in an increase of the final size of stature. In the last century the average growth was 1 mm/year. One of the causes of this secular growth is better nutrition, especially regarding to proteins. The effect of secular growth for ergonomics is that anthropometric measurements from about 20 years ago give now longer any reliable information.

1.3 The application of body measurements

Almost all body measurements appear to vary with a frequency of a Gaussian distribution, at least if the factors affecting the results are not variable.

For using them in ergonomics, especially for designing and testing workplaces, anthropometric data are given in percentiles. A percentile is the value of a measurement which is not exceded by the given percentage of people. For practical grounds it is useful not to consider the entire variability of the measurement within a population, but to accept certain boundaries. For these boundaries the 5-percentiles and the 95-percentiles have been taken as the lower and upper boundaries. In this way 90 percent of a population is taken into account. The 10 percent skipped population, outside the boundaries will generally have such a large spread that taking this group into account will often in technical terms be very difficult and in economical terms not be very interesting. For this group special arrangements will be needed.

Using the anthropometric measurements, the starting point would always be that the workplace must be adequate for an as large as possible part of the population. This means that a mean value is not always sufficient, and that - depending on the situation - the upper and/or the lower boundaries of the measurements from a given population are to be used.

This can be illustrated by the following example. If the height of a door opening is being adjusted the mean value of the stature of the population, than only 50 percent of the members of this population will be able to enter without bending. In this case the minimal door height would be adjusted to the upper boundary of the population.

On the contrary, it is necessary that the maximal distance to a control to be reached is adjusted to the lower boundary of the measurement for the concerning population.

To determine the optimal place of visual information it is, however, necessary to consider both the upper and lower boundary of the eye height.

2. Dynamic anthropometry

2.1 Introduction

Dynamic anthropometry is especially concerned with describing the dynamic characteristics of the human motion space: The reach capability and the freedom of movement of joints that limit the reach-envelope, the body position, the visual field and the forces to be exerted which shows the relation with biomechanics.

2.2 The reach-envelope

The concept of reach-envelope considers the human body as to be build as a system of rods, that are connected by means of joints. The rods have been defined in their length and the joints in their three dimensional freedom of movement.

The reach-envelope is determined by:

a) The length of the concerning bodymember(s).
b) The freedom of movement of the concerning joint(s).
c) The position of the joint(s) in relation to a certain reference point.

The length of the concerning bodymembers and the position of the joints are static anthropometric data. The freedom of movement depends on:

- training
- age
- clothes.

It should be noticed that we can not speak of the reach-envelope of men, and that the consideration is for a great part analoque to the static anthropometry. This means, that in theory there are many concentric reach-envelopes with the same frequency distribution as one - closely related - dimension, for example the functional forward reach.

The reach-envelope has important advantages in relation to the static measurements:

1) Better knowledge of the entire workspace of man. In this way it is possible to test, respectively to determine the position of controls in any position of the arm or the leg.
2) Possibilities not only to determine the maximal reach capability, but also to accomplish an optimal location of controls, with regard to forces to be exerted and motion efficiency.

Concerning the forces to be exerted the location should depend on the nature and the direction of the forces.

Regarding the motion efficiency a maximal and a normal area to be reached can be distinguished. These areas are defined as follows:

The maximal area can be reached by extending the arms from the shoulders and without moving them. This area is maximal only in terms of maintaining body posture; by leaning forward or sideways a greater reach can be made. The normal area can be reached conveniently with a sweep of the forearm, the upper arm hanging in a natural position at the side (Zander, 1972).

2.3 Body postures

The posture of a human being in performing a task is largely determined by the body position, the location and the displacement of seat and controls, as well as the forces to be exerted. In design for posture the following aspects should be considered:

1) Standing: The standing position is generally considered to be a 'standing and walking' position, where the operator is free at all times to move in various directions.
2) Seated: The seated position is superior to the standing position in several ways, but the way of working is strongly governed by the workplace. The seat must be adjustable - in a fast, easy and safe way - in horizontal and vertical directions to realize an adaptation to the measurements of various population groups.
3) Seated and standing: There are advantages in designing the workplace so that the operator can move between the seated and the standing position. This lay-out permits the operator to shift posture at will and reduces the muscular fatique, which results from prolonged effort in any one position (Zander, 1976).

The actual body posture of man at work is very variable and has a great influence on the body measurements and the reach-envelope. For example, the stature of man in normal standing posture is 3,5 - 7 cm smaller than in a erected posture (Jürgens, 1975).

2.4 Forces

The forces which can be exerted depend on some factors from which the most important are: the group of muscles involved, the body posture, the direction and the size of the forces, the place within the reach-envelope and the duration.

There is a non-linear relationship between the fraction of strength - referred to the maximum strength of the individual muscle - and the length of time that it can be maintained. Maximal strength can only be maintained for a few seconds. Medium strength has an endurance time of about a minute, but is still very fatiguing. Only a value of 15% or lower of the maximum strength gives endurance times of more than 10 minutes (Bernotat, 1976).

Body posture affects the forces that can

be exerted in the following way. On the one side it affects the forces that can be exerted by a certain group of muscles. On the other side it affects the effort that is needed for keeping one's balance. As a result of this one can exert a smaller force with a leg in standing than in sitting, though in standing certain concerned muscles can exert more force. The effort in standing position for keeping one's balance obstructs this for the greater part.

The forces to be exerted, the places of these forces within the reach-envelope and the nature of the forces are highly connected.

2.5 Visibility

Since most information enters the central nervous system via the eyes, sight plays a very important role in man-task systems. Therefore the characteristics of the visual field must be dealt with. These characteristics are:
- eye height, varying with stature;
- optimal and maximal visual angles.

3. Anthropometric measurements

Generally spoken, there are two methods for collecting anthropometric measurements:
- Measuring directly parts of the body;
- Analysing photographs of the body.

For the choise between these methods one should consider a few aspects:
1) The number of measurements that have to be taken from one person and the number of person, that have to be measured. In other words, the amount of time to be spended should be minimized. From these considerations follow the measurement methods using photographic instruments (Roebuck, 1975). When a considerable amount of measurements have to be taken with an anthropometer, it may be desirable to divide the procedure over more measurers, for instance like this: One person takes all measurements in standing posture, the second person takes all measurements in seating posture and the third person takes some remaining measurements and the personal data. A procedure like this has been used in our work in Wageningen in 1977 and 1978 (Ensing, 1978).
2) Generally it will be necessary to make measurements on many geographic places. This means that it should be possible to transport the instruments without much effort and that only low considerations can be paid for the room where the measurements are taken. This aspect may especially in developing countries be of great interest. The instrument as being used by Shahnawaz (Shahnawaz a.o., 1977) might be noticed as an instrument derived from this consideration.
3) The accuracy and the precision of the measurements should be adequate. This means that the measurements should be taken as accurate as is necessary for using the data. Generally an accuracy in centimeters will be sufficient. The precision of the instrument should be of a high quality, so that the measurements can be reproduced in an adequate way.

The procedures for measuring the reach-envelope are all the same in that aspect that in a great many directions the reach capability (a static measurement) is measured (Roebuck, 1975). In horizontal and vertical planes the points can be drawn and be means of interpolation the reach-envelope can be drawn (Damon e.a., 1966). The larger the amount of points, the more accurate the reach-envelope can be fixed the better the results are adequate for quantifying mathematically the reach-envelope.

3.1 Measuring the task

In determining the dimensions which are appropriate it is necessary to have details on location and displacement of the controls for operating the machine, as well as the forces to be exerted.

To fix the location and displacement with respect to a reference point, special measuring equipment and methods have been developed (Zander, 1972). The forces can be measured with strain gaugs, coupled to a recorder. This device records the total time history of the strength effort. This allows the experimenter to examine at any time he chooses the record of the effort. The record of the time history is especially valuable if the raw test results are directly fed into a computer for automatic data processing (Roebuck, 1975).

4. Analysing the workplace

Using the data of both the task and the man who is to execute the task, it is possible to see whether the man is able to execute the task in an adequate way. If he is not able to execute the task then may be searched:
1) In which way the task can be adapted or - if this is very difficult -
2) Which part of the population of men is able to execute the task. Especially when it is not possible to adapt the task within a short time it may be useful to free particular groups of people from executing the task in order to prevent health damage and/or an unsafe worksituation.

Ideally, workplace design should start with the operator, who should have a workplace that will ensure that the posture is adequate, that he can see what he has to do and that he can operate the control in the most effective way.

Very often, the equipment is a fact, and hardly any adaptations to the people who are to work with it is possible. It should, however, be noticed that very often anthro-

pometric data are known about groups of people. A data bank for which a great lot of countries should be cooperating, will be a adequate solution for many cases of unadequate workplaces.

In the course of years different tools have been developed for the application of the principles of anthropometry, in particular the design of the workplace.

1) Tables and drawings.

Even when anthropometric surveys have been conducted and the raw data are available, there are still problems of presentation and application. Some of these stem from the fact that the compilers of the data usually have a background in medicine or biology, but the users have a practical industrial or engineering background. This problem can be overcome by making drawings or transparancies on which the areas for an optimum workplace lay-out are given. This method is not only suitable for testing certain workplaces already made, but can be used also in equipment design (Damon, 1966; Zander, 1972; Diffrient, 1974; Jürgens, 1975).

2) Manikins.

A manikin is a scale model of a human operator, usually in two dimensions only, with swivel points corresponding to the sites at which joints permit movement. These manikins should be of several sizes in order to cover the range of potential users.

In use, a manikin is adjusted to a particular working posture over a scale drawing of the work-place, and the effects of hand, foot, knee, elbow and other locations are marked on the drawing (Roebuck, 1975).

3) Man-models.

A computer model of the human body, representing its various and variable dimensions and its motion characteristics, is a very valuable tool to aid work-place and work-task design. With adequate programming, such a human analog can be manipulated by the designer to reflect different operator sizes, to assume appropriate body positions, and to perform task-related motions at the workplace; it will allow the designer to fit the workplace to the operator on the "computer drawing board" (Hoftijzer, 1975).

4) Mock-ups.

In its simplest form a full-scale model of the work-place is built and various people from the user population try it, their behaviour and comments being taken into account in subsequent modifications of the design. The effects of possible akward body positions, obstructions to hand or tool access, etc. can be assessed in this manner. In its most sophisticated form this technique requires the proper sampling of subjects from the user population and elaborate design of their tasks and of the procedures for acquiring dimensional data from them; the power of the method lies in its versality (Roe a.o., 1968).

5) Check-lists.

The various anthropometric factors which have been discussed can be summarized in the form of a check-list, which could be used by designers whatever the nature of the equipment which is being designed. The use of such a check-list will ensure that most of the points which have been discussed in relation to the design of the workplace will not be overlooked.

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Resumen

Tanto los datos antropométricos exactos como un método adecuado para disenar y probar constituyen el instrumento más potente de lo que se dispone al presente para proyectar las condiciones más favorables de trabajo en cuanto a los utensilios y máquinas de mano fabricados en serie para la agricultura y silvicultura.

Muchos utensilios y máquinas de mano usados en la agricultura y silvicultura de paises trópicos se importan de otros paises; eso puede conducir a situaciones de trabajo insuficientes, si no se presta atención a los aspectos atropométricos y biomecánicos de los usuarios. Por esta razón es necesario hacer estudios antropométricos en tales paises.

Con la ayuda de estos datos los proyectistas podrán formular los criterios para proyectar el lugar de trabajo más favorable, con inclusión de una postura apropiada de trabajar que acrecentará tanto la capacidad activa del operario como el functionamiento propio de la relación entre hombre y utensilio/máquina.

Résumé

Les données anthropométriques fiables, ainsi que les méthodes adaptées aux besoins de la mise au point des plans et d'essais, constituent aujord'hui l'instrument le plus efficace pour la disposition optimale des lieux de travail destinés à la production massive d'outillage à main et de machines pour l'agriculture et la sylviculture.
Beaucoup d'outillage à main et de machines pour l'agriculture et la sylviculture sont importés par les pays tropicaux d'autres pays; cela peut créer des conditions de travail inadéquates, s'il n'est pas tenu compte des aspects anthropométriques et biomécaniques de l'utilisation. C'est pourquoi il faut effectuer des enquêtes anthropométriques dans ce pays.
A l'aide de ces données, les responsables des projets peuvent formuler les données permettant une organisation optimale des lieux de travail, et assurant même une bonne position de travail, ce qui peut contribuer à un rendement optimal de l'opérateur ainsi qu'à un bon fonctionnement du système homme-outil/machine.

TROPICAL WORK AND WORKING CONDITIONS IN FORESTRY

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Summary

Employment patterns in forestry in developing countries differ in wide limits between dry and moist climates or between creating communal forests, establishing fast growing industrial plantations and logging and regeneration of high forests.

Work is mostly done either with primitive hand tools or with modern mechanical equipment, leaving much scope for improved labour-intensive techniques and methods.

Insufficient rural infrastructure renders work and life in remote areas rather unattractive. To recruit and maintain qualified labour therefore requiers an adequate standard of living conditions. Reasonable possibilities for growing food should be provided.

Working conditions only in rare instances meet internationally established and accepted recommendations. Payment is usually low, social security largely missing and fluctuation high. Crucial problems are health and nutrition vis-à-vis physical work load. In logging accident frequency and severity are excessive. For social and economic reasons there is a great need for basic ergonomic improvements.

Background

This paper is based on the author's former work as forestry specialist of the International Labour Office and subsequent links with international and bilateral programmes aiming at improving the social and economic conditions of forestry work in developing countries. Instead of digging up relevant data from literature and presenting and commenting them in the context of this paper the author has come to the conclusion that it would be preferable to give a broad over-all view of the problem. Literature as far as available has never-the-less been considered including the information compiled for the eight World Forestry Conference held in Indonesia in 1978. However, the existing data refer to rather different conditions, are sparse and may not always be reliable.

Scope and kind of forestry work in tropical countries

Various attempts have been made to qualify and quantify the employment potential and the labour requirements of forestry in developing countries (ILO, 1973; FAO, 1974; Sumitro & Sudiono, 1978). As could be expected, the results obtained differ in wide limits. They are mostly expressed in over-all estimations of mandays per hectare and seldom include a detailed break-down in different jobs or job requirements.

Communal forestry

Rather little is known about the extent of forestry and forestry employment in the sector classified as communal forestry (Steinlin, 1978). This aspect of forestry is now receiving more attention especially in the drier parts of the tropics. It is primarily concerned with providing locally needed fuel wood, building materials and protection against soil erosion. Although on a global scale there are vast areas where communal forestry activities could and should be launched, up to now they are restricted rather to pilote programmes -, far from keeping pace with the continuing rapid destruction of remaining natural wood resources.

Forestry work provid under such conditions is highly labour-intensive and seasonal. It is usually carried out by farmers and their families living mostly under traditional conditions in a poor state of health and nutrition. Illiteracy is another common feature. As a consequence, it requires a reasonalble input of technical skill to achieve planting goals (basic forestry, efficient organisation of work) at acceptable effort and cost. Fundamental ergonomic requirements are usually overlooked or anyway difficult to meet such as providing extra food for extra work or using techniques and methods demanding as little energy as possible.

Industrial forestry plantations

Industrial forestry plantations form a

striking contrast if compared with communal forestry. They are mainly established under favourable growth conditions and involve important capital inputs. In recent years accessibility and integration with timber industries have played a more important role in choosing suitable localities for planting fast growing wood species.

The planting and management of industrial forestry plantations enjoys a high level of technical skill and is usually accompanied by research. Where industrial plantations are build up for local conversion and processing of wood this requires mostly an improvement of the existing infrastructure and multiplies employment opportunities. An example of a recently developed large-scale forest plantation and industry complex is the Jari Project in Brazil, where within a dozen years almost 100.000 hectares of Gmelina arborea and Pinus caribaea honduriensis have been planted in order to supply a pulp mill which will start production this year at the rate of 220.000 tons per year (World Wood, 1979).

Such projects need efficient labourers under stable employment and living conditions in order to justify the heavy investments. There are regular seasonal jobs for nursery work, munual planting and tending-often done by women- and permanent jobs for wood cutting and transport which in many cases is done by the aid of machines. Site clearing is also often carried out mechanically. Ergonomic requirements of forestry work under such conditions will certainly be considered in a favourable sense when their application proves to increase industrial efficiency and profits. This has so far probabely been done only to a very limited extent.

Exploitation of tropical high forests

The third area in which forestry activities occur in the tropics is the exploitation of natural high forests followed normally by shifting cultivation and irreversible destruction of the highly sensitive ecological structure of the forest. Protection and management of the ramaining forest and adequate silvicultural treatment are still a rare exception.

Up to now by far most of the forestry employment in tropical countries comes under this catagory which, however, will gradually shrink with the continuing devastation of tropical high forests. Especially in tropical Africa and Eastern Asia this process is advancing rapidly.

More often than not the attitude is to cut out and get out and to recover heavy capital investments in the shortest possible time. Unskilled labour is recruited locally, skilled labour for the operation of machines brought in from elsewhere. Forests, equipment and men are sacrified for profits with little consideration for the future. Where such a situation prevails ergonomics is meeting deaf ears.

Fortunately there are also examples of large integrated logging and forest industries enterprises operating on long-term concession areas which are striving for sustained yield management through natural and artificial restocking of exploited areas. Employment under such conditions can be similar to large-scale industrial forestry plantations.

In logging tropical high forests power saws are commonly used for cutting larger trees, crawler tractors for road making, crawler and wheel tractors for skidding and lorries for road transport. Qualified machine operators are highly demanded but short in supply. Smaller operations and work in smaller-sized wood are less mechanised. In both cases logging tends to be very heavy physical work. Labour turn-over and absenteeism are pronounced. It seems that the working life of a logger seldom exceeds 10 years. The majority of the workers are from 20 - 30 years old, few are employed at an age beyond 40 years. Ergonomics could certainly give many explanations for these phenomena but would probabely have difficulty to provide readily accepted solutions.

The three different cases of forestry employment which have been outlined above are, of course, a simplification of the actual situation which is far more varied. For this same reason it may appear bold to assess the total employment in forestry in developing countries. According to an estimation dating ten years back 10 million man-years were spent in logging and 5 to 10 million man-years in silviculture (Sartorius & Henle, 1968). A recent assessment made in India reveals that in this country alone intensified forest management could create 25 million jobs (Seth, 1978). There are clear indications that wood as a renewable source of raw material and energy will in future receive more attention in national economic planning. As a consequence, there will be in all probability more job opportunities. It would be very desirable to accompany and strengthen this process by appropriate ergonomic measures.

Primitive, intermediate or advanced technology

Until a few years ago, there seemed to exist only two options: Primitive hand tools or modern mechanical equipment. Tools used traditionally in rural activi-

ties such as planting hoes, billhooks or round-eyed axes were initially also taken for forestry work. They were low-cost and often of inferior quality. Such tools were and still are either made locally or specially manufactured by industrial countries for being exported to the Third World. For lifting, loading and transport of wood formerly a heavy input of manpower was essential. Primitive manual working methods absorbed much labour, were difficult to control and caused high expenses in spite of low wages. With the advent of machines for wood cutting, transport and earth moving in the larger-scale forest operations labour was quickly replaced by machines.

Attempts to introduce intermediate technology using improved manual tools, techniques and methods turned out to be extremely difficult for many reasons: The tools needed were not available locally or no more manufactured in industrial countries, specialists experienced in labour-intensive forst work became more and more rare, tool maintenance and rational use required at least basic training of workers. Furthermore fewer workers equipped with machines were easier to control and machines provided more prestige.

Only very recently in the wake of growing unemployment and also because of difficulties to maintain or replace machines more attention is being paid to intermediate technology which is strongly proposed as a third option (Silversides, 1978). In many though not all instances it has definite social and economic advantages. Ergonomics can play an important role to help introducing intermediate technology as was demonstrated in India (Hansson, et al. 1966). Studies showed that by using well maintained cross-cut saws of superior manufacture output could be doubled while energy consumption per output was reduced to half. Such superior cross-cut saws including the necessary maintenance tools are nowadays made in India where they have a growing market (Chandra 1978).

Living conditions in remote ural areas

The rural exodus and the resulting urbanisation are an alarming feature of many developing countries. Poor living conditions in remote rural areas are an important reason for the drift of young people from village to city. Without an acceptable living standard at the village level it is extremely difficult to ensure stable employment and to recruit workers in adequate physical condition who are sufficiently motivated for forestry work. This calls for an integrated approach of forestry development within rural development.

Unfavourable living conditions will therefore be an important concern for the employer of forest workers and action be desirable reaching beyond the working sphere. Where sufficient labour is not available it may be necessary to create settlements meeting the demands and wishes of their inhabitants.

An interesting study made in Teak plantations in Northern Thailand showed that the main interest of settlers of a forestry village was to cultivate land and to grow food rather than doing forestry work (Chiang Mai University, 1974). The same attitudes can be expected in other parts of the world where forestry labour is recruited from traditional agriculture. Wages are mostly so low and families so numerous that the worker can only keep up himself and his family if he is growing at least part of his food himself. He or his family should be in a position to do this. If possible, convenient land should be made available and help be given to improve the cultivation of food in the required quantity and quality. This would ensure at the same time to meet the nutrition requirements of forest work. Agro-forestry offers various further possibilities to combine food production with growing trees. However, a reasonable balance must be kept between forestry and other activities.

Villages should be reasonable in size to permit investments in adequate water supply, shops for basic needs, education, a first aid post and common welfare facilities. Housing standards and hygiene should also be acceptable. Where such aspects are overlooked measures to upgrade working conditions may have disappointing results or fail all together.

Special problems connected with forestry work

Working conditions in tropical forestry are not quite as different as might be exepted from the wide range of forestry conditions. It is mostly left to the man how he does the job as long as the task requested is fullfilled and the equipment given to him is not ruined. He will generally receive low pay and little if any social security. His health and nutrition will ofen compare unfavourable with his physical work load. There is little consideration for adverse climatic conditions. Accident rates are excessive. But as long as the worker can easily be replaced in case of death or disablement and financial consequences for the employer are minimal this will be accepted as an inevitable consequence

of dangerons work.

There are exeptions to this pattern - but they are unfortunately not very numerous. There is wide scope for improvement - but many obstacles have to be surmounted linked with the worker, his village and family background, the employer, the physical conditions of the forest, the forest policy and the level of socio-economic progress of the country. Out of these problems in the context of this paper only some can be considered in more detail which appear to be of particular importance.

Health conditions

A medical examination of 21 road workers carried out during an ergonomic pilot study in Thailand revealed that 16 were in poor health (Eriksson et. al., 1974). The authors concluded in this respect that "simple measures, such as diagnosing and treating certain common diseases, and employing basic principles for occupational hygiene and job organisation, might be expected to give significant - may be spectacular-results."

Similar conditions appear likely in many tropical forestry operations though statistical evidence is scarce. Within a large West African logging enterprise it was found that work days lost through diseases were considerable more frequent than those lost through accidents although the enterprise provided free medical care (Strehlke, 1969). In the rainy season intestinal and other infections were very pronounced. In this respect the provision of safe drinking water and proper personal hygiene were of great importance.

Especially in places where general medical facilities are lacking the provision of some sort of hasic medical aid through medical assistants would appear to be desirable to keep workers in a reasonable state of health.

Physical work load, work capacity and nutrition

Forestry work can be classified as medium heavy (approx. 12 MJ total energy expenditure per day) for most silvicultural jobs and as heavy (approx. 16 MJ total energy expenditure per day) for most logging jobs.

Studies of the physical workind capacity of forest workers in various tropical countries of Latin America and Asia resulted in lower values than for workers from Western Europe which are largely attributed to lower body height and weight (Staudt 1974).

Heath stress is another factor reducing working capacity with rising temperature and humidity (Axelson 1974). At values of close to 100 % humidity and 35° C temperature of the air even light physical work is no more possible.

Finally according to the existing knowledge and experience in many tropical countries widespread insufficiency in nutrition must be expeted to limit the energy amount available for work and thus reduce work productivity. The only study dealing with forestry in this respect provides a rather favourable picture (Staudt & Pieters, 1978). However, one cannot generalise from it and should repeat it elsewhere.

With so many limiting factors on top of which poor health must be added tropical forest workers cannot be expected to reach performances similar to Europeans. They will either have to work fewer hours per day or reduce working speed in order to maintain their physical condition. When changing over from traditional activities to forestry work they must furthermore be allowed some time to adjust their physical condition and their feeding habits to higher physical demands.

Work organisation can in many ways facilitate the workers' situation e. g. by avoiding unnecessary walking to and during work, by providing efficient tools, by reducing working time in balance with the available energy and by avoiding work during the hottest hours of the day. It is surprising to note how little thought is given to such measures and how much the working schedule resembles patterns from industrial countries.

In this connection improved food supply to workers is often mentioned as a crucial factor to increase working productivity. However, energy-saving work organisation is probabely more easy to accomplish. Feeding habits appear to be difficult to change although this may be very desirable. To deliver meals at the working site is not practical. In many places, however, the situation would be a lot better if workers would carry food and liquid along to the working site and eat during a meal break instead of taking food only before and after work.

Accidents

Forest work in most advanced countries exceeds almost all other industries in accident frequency and severity. In high forest logging of tropical countries these rates appear to be up to ten times higher (Strehlke, 1969).

The analysis of accidents reveals largely similar causes than in the advanced countries. The same basic safety regulations should be respected but they seem to be either unknown or more often violated. Lack of training, quidance and control is obvious. Personal protective

equipment is not available, insufficient or not used. Inadequate work clothing such as poor or missing footwear also leads to numerous accidents. All this is even more surprising if one considers the inconveniencies of having possibly a bad injury in regions where medical help is distant or not at all attainable.

To change bad safety habits is already a very difficult task in advanced countries under circumstances where safety requirements govern practically most aspects of life. In developing countries it is even more difficult to educate men to work safely who are continously faced with a general neglect of safety in privat and public, e. g. obstacles on public roads, poor traffic discipline.

Employers tend to be more susceptible to introduce and enforce safety regulations when the loss of costly equipment is at stake such as log trucks. Selection of reliable drivers, training, strict obedience of speed limits, prohibition of extended working hours and alcohol may help to reduce accidents during transport. But it will be much more difficult to reduce accidents in tree felling. More information on accidents in tropical forestry work and continuing training efforts at the worker and supervisor level are probabely the only means to change this picture.

Operation of machines

Operators of heavy machines like crawler tractors, skidders or log trucks are exposed to noise, vibration and outside heat as well as heat generated by the engine and the hydraulic system. Quite often overtime and irregular working hours are expected from them. Fatigue, reduced performance, mechanical breakdown of machines and accidents are the result of this.

Basic ergonomic requirements should therefore be respected when buying new machines. The machines should be provided with the same comfort and safety equipment as for advanced countries. In addition it may be advisable to provide cooling systems for cabs.

Operators should undergo training-which in most developing countries is available nowadays in one form or another-and be initiated in the running and maintenance of each newly delivered machine.

Such considerations might gain importance if relevant enterprises were visited by a versatile specialist able of pointing at possible improvements and savings which would result therefrom (less mechanical trouble, reduced turnover of operators etc). Another type of machines which has become rather popular in tropical countries over the past few years are one man power saws for tree felling - although there are quite a number of cases where they have given again way to hand tools.

Power saws manufactured to-day are much safer and ergonomically superior as those manufactured only five years ago. They still remain a most dangerous machine in the hands of the unexperienced worker. Initial training of power saw operators therefore should be indespensable as well as fitting the saw with all safety devices that are available and providing the necessary personal protective equipment to the worker (hard hat, gloves, adequate footwear).

To conclude, it may be said that most tropical forestry workers are faced with poor living and working conditions. There is large scope for ergonomic improvement which would undoubtedly be accompanied by social and economic progress. However, it will probabely be difficult to find acceptance for this proposition by national planners who are setting different priorities, by employers who may be indifferent to social progress and even by the worker himself who will often be suspicious to change. Research will undoubtedly be helpful to provide further insight and guidance in different ergonomic aspects of tropical forestry work (Strehlke, 1971; Apud et al. 1972).

More important, however, appear practical approaches to introduce basic ergonomic rules as was suggested by van Loon during a meeting of the IUFRO Subject Group on Ergonomics in 1971.

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Resumen

Condiciones de empleo en la silvicultura de los paises de desarrollo dependen en sumo grado de la humedad y aridez del clima, y de la explotación forestal o regeneración de las selvas altas. Otros factores influyentes son el rápido desarrollo de plantaciones industriales y el mejoramiento de selvas comunales.

El trabajo generalmente se desempena con utensilios pr mitivos de mano o con avíos mecánicos modernos, dando muchas posibilidades para la perfección de técnicos y métodos de gran intensidad laboral.

Una infraestructura rural insuficiente hace el trabajo y la vida en regiones aisladas poco atractivos. Reclutamiento y mantenimiento de obreros cualificados por consiguiente necesitan un nivel adecuado de vida. En la mayoría de los casos hay que proveer posibilidades razonables para cultivar víveres.

Condiciones de empleo rara vez llenan las recomendaciones establecidas y aceptadas internacionalmente. El pago generalmente is mínimo; no hay seguridad social, y ocurren grandes variaciones. Problemas críticos son la sanidad y la alimentación respecto de la cantidad de trabajo físico. En la explotación forestal la frecuencia y severidad de accidentes son excensivas. Por motivos sociales y económicos hay gran flata de perfeccionamientos fundamentales ergonómicos.

Résumé

Le travail dans la sylviculture dans les pays en voie de développement diffère beaucoup selon les circonstances:
Le climat sec ou humide, l'abattage et le façonnage et la régénération de la haute forêt, la plantation de végétation industrielle à croissance rapide et l'amélioration de forêts communales. Le travail est le plus souvent fait avec des instruments manuels primitifs ou bien à l'aide d'un outillage de mécanisation moderne. Il reste beaucoup de possibilités d'améliorer les techniques et les méthodes demandant beaucoup de main-d'oeuvre. Le manque d'une bonne infrastructure rurale rend le travail et la vie dans les régions isolées peu attrayants.
Pour pouvoir embaucher et garder de la main-d'oeuvre qualifiée, il faut prévoir des conditions de vie adéquates. Dans beaucoup de cas il faut créer des possibilités raisonnables de cultures alimentaires.
Il est rare que les conditions de travail soient conformes aux recommandations établies et acceptées sur le plan international.
D'habitude le salaire est bas, la sécurité sociale est quasi inexistants et les conditions changent souvent. La santé et la nutrition sont des problèmes essentiels par rapport à la charge du travail physique. Dans l'exploitation des forêts, les accidents sont extrêmement fréquents et graves. Il existe un besoin énorme d'améliorations ergonomiques fonadamentales pour des raisons sociales et économiques.

TROPICAL WORK AND TROPICAL WORKING CONDITIONS IN AGRICULTURE

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Summary

The major differences between the farming systems, often agroforestry systems in tropics and of the temperate zones, are discussed under headings of:-

a) Livestock
b) Swamp and dryland
c) Heat stress
d) Climate, clothing and shoes
e) Anthropometry, diet and somatotypic changes due to climate
f) Hand work tools and the potential for mechanization
g) Scales of farming
h) Motivation and rewards other than economics
i) Hours of work and seasonal work load
j) Occupational diseases found only in the tropics

The main emphasis is upon a theme of extremes not to be found in sub-tropical or temperate zones:-

i) The huge scales of plantations, of up to 100,000 hectares and the minute peasant gardens of 10 ares
ii) The need for specific new anthropometry to quantify the physiques of all such as 2 m tall Masaii to the 1 m pigmies
iii) The extreme humidity of the Monsoons and the dry season's arid Harmattans
iv) The lush prolificity of the rain forest crops and the miserable yields of the near desert.

Introduction

Purist ergonomist might object to the notion that agricultural ergonomics could differ from any other form of ergonomics and that tropical conditions are so vastly different from those to be found in summer in factories of, say, north of the 49th parallel, that a separate topic existed. However, laymen do accept that a difference does exist and their sentiments have been typified by Sir Nöel Coward's song:-

"Mad dogs and Englishmen go out in
the noon day sun."

On the other hand, advocates of agroforestry for the tropics such as Dr. Kenneth King of the International Research Centre for Agroforestry, Nairobi expose

"... the false dichotomy of
agriculture and forestry"

and see the two disciplines as so interwoven and interdependent that, in the tropics, trees, crops and livestock are all components of the same production system.

If one goes out at noon at the tropics, amongst the peasant farmers, one will observe, on the equator, that work ceases at the moment the shadows of the tree trunks vanish. That is at low altitudes where heat and humidity attain a noon value of 2.0 on the Kata scale, requiring 100% rest, according to ILO. It is only in the tropics that the sun and shadows remain constant throughout the year. In the non-tropical agriculture the effect of the seasons is far more pronounced, and farm-working hours vary seasonally with the hours of daylight.

As the scope of this paper covers the work of 40% of mankind, in a wide variety of circumstances, some definition of tropical agriculture is needed. Bene, et al. define the tropics and agroforestry. They cite the International Institute of Tropical Agriculture at Ibadan and the search for trees that can augment agriculture for "on more than half of all land in the tropics although too dry, too steep or too rocky to be classified as arable land, is suitable for the practice of agroforestry." "It is predicted that within the next 25-30 years most of the humid tropical forest as we now know it will be transformed into unproductive waste land, and the deterioration of sand savanna into desert will continue at ever increasing speed...." That is the fate in store for some 2 billion hectares and persons. There are in the world about 1,360 million hectares of arable land in the developed world and this is 36% of the total.

This apparent trespass into the subject matter of Strehlke supra, is intended to allow a return from such contrasts as that of a voracious appetites of some people for newsprint and plywood and of others for rice, beans and yams, to matters of definitions. Fortunately, the organizers did not define agriculture or forestry. The former is assumed to include horticulture, which in North America means any crop which reaches the kitchen in the same condition as that in which it left the field. While in U.K., horticulture is non-field scale production. Orchard tree crops are thus agroforestry = horticulture, and forestry is deemed in this paper to be the production of wood or wood pulp fibre alone.

The tropics are defined as being 23° 27' North or South of the Equator. If one

examines tropical farm work as an ergonomic problem, there is only one peculiarity - sunshine, which uniformly affects all tropical farms and none other in the same way. The general condition is that the sun is overhead at noon and throughout 365 days of a year; 7 a.m. is dawn and 7 p.m. is dusk. According to altitude, proximity to large bodies of water, seas and lakes, so the other climatic conditions can be found with the full variety also to be found in the sub-tropics, temperate and even Arctic zones: with the all pervading "sunshine" difference. The intensity of radiation at noon above the snow-line in the tropics is certainly greater than in, say, Siberia, but the tropical effect of -2°C is for all 12 months of the year and precludes agriculture while in the sub-boreal it may be only 6 months, allowing, say, 100 frost-free days, which will permit some agriculture. At lower altitudes, there are, in the tropics, 365 frost-free days which permit forms of agriculture not found outside the tropics. This is because the plants (and not the people or animals) are more productive, when their cell-moisture content do not freeze. The most significant effect of this is upon the crop calendar, an example of which is to be found in my paper infra. In the tropics, one can find crops in all stages and thus a demand for all farm work associated with these crops occurs simultaneously. For example, in Kenya, citrus fruit and barley can be seen on the same farm being harvested, sown, in flower and at every intermediate stage. Such occurrences are rare without sophisticated and modern agricultural techniques. But the possibility already exists, particularly in irrigated areas for year-around continuous cycles of production.

Livestock

Livestock work in the tropics is usually found at high altitudes and is identical with the work of same type in a temperate climate in the summer, with the exception of the day length. At lower altitudes, livestock are more subject to diseases and the insect pest vectors which necessitate special precautions and controlled environment within mesh or with daily sprays and dips. As with other livestock, the working conditions and tasks are similar to those elsewhere, but the tropical worker is more prone to zoonoses if they exist.

Milking a cow or goat, herding, feeding and watering, pigs or sheep are the same at 10-30°C whatever the latitude. That few 2-level or rotary parlours exists in the tropics and that large herds are rare and few skilled trained workers can be found is a product not of the tropicality of the farms but of the sophistication of the agriculture of the countries in the tropics.

Strangely, there has been a great reluctance amongst the indigenous inhabitants to move to the higher and healthier altitudes. An explanation is that without a knowledge of technologies needed to:

a) manage modern livestock husbandry units
b) keep warm at night
c) find adequate water supplies

The natives preferred the warmth and downstream gravity-supplied stream-water to the potentially much more amenable climate of the plateau.

Fencing for livestock is an occupation almost unknown in the tropics. This contrasts with the author's finding that fence repair, etc. is 5-10% of the total work in Albertan ranching, which figure would be equally accurate for ranching on the equator, at 1000m.

Swamp and dryland work

An obvious difference in work and its environment is between the farms in marshes or swamps and the dry lands of the tropics. The indigenous people prefer the dry land because there are less insects and associated diseases, despite the greater productivity of the land in the marshes. A further advantage of the latter is that paddy rice can be grown and fish farmed to augment the dietary protein. The main characteristic of farm work in the marshes is wading about in knee or waist deep waters and puddling, a chore unknown in non-tropical agriculture. Transport by canoe is probably much more efficient per man-hour/per mile/tons moved than with head-loading.

In the dry lands, the major work-task is preparation of the land, the equivalent of ploughing, using hand-tools. The amount of land which can be broken in the time available is the major limitation to the amount of food one subsistence farmer can produce. This is a direct product of the design of his hoe or other hand-tools, and the baking by the sun of the soil.

It is generally agreed that the major limitation to the productivity of labour in tropical farming is the ability to prepare the soil for sowing. There is a significant difference between tropical soils and other soils. The lateritic and other common tropical soils contain less moisture and less organic material at the time of ploughing than do northern soils with which we are more familiar. There is a harder crust and greater force is required to break the clods.

The next most labour-consuming task is transportation, usually by head-load. In this foot-wear and the pathway may be a significant ergonomic problem. Matheson states that the daily water requirement for East Africa farm workers is 10-50 kg with an average of 40; this may have to be carried 2 km or more depending upon location.

A third major working problem is of post-harvest, the pounding and threshing using pestles and mortars. Some studies have been

made in Senegal of the amount of time required, particularly for millets.

Heat stress

Despite all the forgoing about sunshine, the major working condition of the tropics which presents a difficulty in agriculture is Heat Stress. If some means could be found of making it possible for humans to work in high temperatures and high radiation without stress, the amount of land tilled per farmer could be increased enormously. Until proper physiological studies are made of the types of stress and of the amount of work required, no real solution can be found to the problem imposed by the thermometer.

One solution might be to arrange for illumination so that work could be done in a cool of the evening. Illumination alone is insufficient for snakes and other such hazards exists which are not be found in other zones.

Heat Stress is often presumed to be a major ergonomic problem of tropical farm working conditions. In plantations and other organized labour forces, salt rations and salt pills are often issued/provided. In rural peasant conditions, the requirement for salt is apparently less recognized and sweating rates and other manifestations of heat induced fatigue require investigation.

It is common to find in many countries that the psychological remedy of rhythm is used by many gangs of tropical labours to induce a working place which is far higher than most people would believe possible in the circumstances. Gangs of workers humping head-loads of heavy bags of rice will often assign to one man the task of drummer, paid by the others. This is an instance of work being made "fun" psychologically when physiological conditions are oppressive.

Certain jobs can be assigned to the pleasant cool of the night, such as the pounding of pestles and mortars, a noise commonly heard in the tropics after dusk and before dawn. It is a task which is similar to the post-harvest threshing of many grains: millets particularly and maize, the most commonly grown grains in Africa, both respond to poundings. Efforts have been made to assess the amount of energy and the amount of time used in this way. Williams, in 1967, studied the effects of working heights for such women's tasks.

At first sight, the simple but technologically sophisticated solution is to provide air-conditioning. This can only be applied when devising new farming systems for unpopulated areas and if farming units are to be large and tractors with cabs are appropriate. But as the majority of the hectares in the tropics are already farmed in small units, air-conditioning is economically invalid as either a short or a long term solution: because it implies a sudden removal of the majority of the population to urban areas. An alternative to air-conditioning must be found.

An example of urgently needed data which could be technologically available in 1980, is thermographs. A single camera team for tropical farm work analysis would cost about $¼ million p.a.. The information it could yield would be of immense value in designing of both hand-tools, hours of work and clothing.

Clothing

Much of the equatorial climate has so high a humidity that the cooling power of the atmosphere is insufficient to permit the dissipation of the heat generated by muscular activity of work. Mainly for this reason, the minimum clothing should be worn by tropical farm workers.

What might seem ideal as working clothes in the tropics to some, might appear foolish to others. The bellows effect of the flapping Arab robe is appropriate in low humidities and high temperatures for the shade and flapping loose garment is a good method of inducing heat loss and is favoured amongst those whose religion shuns nudity. The latter condition is, however, preferable near machinery and at high humidities.

On the other hand, in high humidity a loincloth permits a greater surface area to dissipate heat than even a pair of shorts. Yet khaki drill shorts and shirts carrying a social kudos and are worn despite their inappropriateness in physical terms. Shade can be provided by trees, canopies and hats more effectively than by shirts.

Traditionally, a skirt of glass fibre was worn by the short-handled-hoer, the fibres also whisked away the flies which pestered the sweating labourer.

Palm wine tappers and copra harvesters, both of whom climb trees using a 2 m diameter loop of leather or fibre, wear only a minimal loincloth and a large hat, both for safety reasons.

Footwear

Most farmers in temperate areas wear gum boots or field boots: in tropical countries, bare-feet are by far most common. Apart from the dangers of hook worm and jiggers, both parasitic worms, which enter the body often under the toe nail, bare-footedness is more healthy than wearing rubber shoes in hot climates. Whereas it is not impossible to design spades, forks and foot controls for tractors and implements, which would accommodate bare-feet, the current design are both dangerous and painful, even to a hardened sole.

The different stances of the bare-feeted compared with the booted stance of users of pitch-forks and hoes is noticeably more

precautionary for the nuda pedes.

Shoes when worn in the tropics are often topless sandles made of plastic or worn truck or motor vehicle tires.

Canopy

Shade can be provided as has already been mentioned by canopies of hats, tractor cabs, and the leaves of trees. The roofs of wall-less buildings often shade farm work areas, such as nurseries. Agroforestry has an often unrecognized benefit to the worker's microclimate in providing a shade canopy.

Ice and snow and sprays

Permanent ice and snow can be found both in the tropics and in the Arctic and in all latitudes between them. Generally the absence of ice and snow in tropical agriculture distinguishes it from, say, that of Canada. It may be an amusing paradox to contemplate that whereas the design of proper clothing for agricultural workers in sub-Arctic conditions is a matter of conserving heat, and in the tropics of removing heat. That is, in other words, either keeping heat in or getting rid of it. Yet the same design is used for the modern tropical farm worker. This poses special problems when the clothing is protective against harmful sprays. One recent attempt at an appropriate technology has been a very small scale back-pack sprayer for East Africa, the operator of which was clad in a translucent polythene bag. Such is very far from ideal: the obvious ideal is harmless sprays or large scale equipment with air-conditioned cabs. Buildings often shade farm workers such as nurseries. Agroforestry has an often unrecognized benefit to the worker's microclimate in the way it shades.

Hand-tools and mechanization

By far the most significant difference between tropical and temperate farm working conditions is the unmechanization of transport, tillage and cultivation. For transport instead of wheels, the head is most commonly used. Loads of up to and more than 100 kilograms of water, grain or produce are carried many kilometers daily by millions of people. Paths or wheels are not necessarily the solution, redesigned containers may be.

The machete, cutlass, hoe, sickle, mortar and flail are found in many shapes and forms throughout the tropics, though now long since objects of antique curiosity elsewhere. These tools are, in the author's opinion, by far the most fruitful potential source of greater productivity or will at least reduce human effort input if ergonomic design used with modern technology of materials could be applied to them. In many instances, local naturally occurring and locally found scrap materials are still used when superior alternatives are available. More sophisticated designs will, however, imply a less general purpose and more specialized use, which in turn implies greater numbers of tools for each holding.

One example of the potential is the case of a West African meal, named Garri, made of pounded, mashed and fomented cassava. It can be simply mechanized to yield a 400-fold increase in productivity per person hour. In France, highly sophisticate ditch-diggers will, with 1977 mechanization, only yield 100-fold. Modernized milking machines yield about 60-fold. All these ratios are expressed as a factor of the most simple hand-tools' productivity.// Whereas one might imagine that Agricultural Engineers would welcome ergonomists' comments and be aware of potential, their publications confirm the exact opposite.

The Journal Agricultural Engineer of Summer 1978 was devoted to "Are small tractors appropriate?". This edited summary of the discussions of many eminent delegates from over a dozen tropical countries does not mention ergonomics once for the whole proceedings. Yet Matthew's & van Loon's views on tropical tractor driving should be well-known.

Hale & Williams, in 1976 Papua, produced a handbook of many novel new hand tools for farm and household tasks using human muscle power and local materials.

Scale of farming

It may be a platitude to observe that the extremes of the range of scales of agricultural unit are much more pronounced in the tropics than in the temperate zones. The huge plantations of rubber, tea, oil-palm and copra compete on and for terrain equally suitable for market gardening subsistence. 700 persons can be supported on 1 sq. kilometer of arable land in the tropics. Yet the same area will not yield a living wage in say Alberta, where 300 hectares will scarely feed 9 families, in terms of dollars.

As the owners of plantations are generally wealthy and many are multinational corporations, they can be considered as a separate topic from peasant subsistence farming or family farms of under 500 hectares.

The author has attempted to ascertain from such firms as Unilever Ltd., which happens to be highly respected in both Netherlands and U.K. and jointly managed therefrom, if ergonomics is being used to solve the problems of their tropical labour forces. So far no examples of ergonomic solutions have been provided, but that is not to say that the problems are not being solved by the informal applications of ergonomic principles.

The location of such plantations presents distinct ergonomic conditions which the following examples of Motivation, Hours of Work and the Proportion of Labour Force Employed, are intended to illustrate.

Motivation of groups of farm labour in the tropics will be as diverse and varied as in any other industry. This may be illustrated by the case of a Unilever plantation of oil-palm in its wholely owned South Pacific island. Several hundred employees, well fed with locally produced high protein diet are so content with the life they lead that they save most of their wages. The Company shop imports special bikes and other items appropriate to the way of life in this idyllic community. Each home is close to a beach, plenty of recreation facility is provided so that wages and work output are not as closely linked as elsewhere.

By contrast, the near slavery conditions of the Igbo labour force recruited in Nsukka under contract for work on coffee and cocoa plantations on Fernado Poo show that cash is the sole motive. The equivalent to $200.00 was paid on completion of a contract of many months during which minimal pocket money or contact with non-plantation society was permitted in the bachelor community.

A major factor motivating the young workers employed on plantations is the opportunity to learn skills such as tractor-driving.

The proportions of the population by age and sex in plantation or peasant farm work differs widely according to local tradition and the availability of labour. Coffee picking, tea plucking and pyrethrum harvesting require female dexterity and no great physical effort to carry the produce. Digging with a jembe or hoe, long or short-handle, large or small bladed, is considered man's work: as is rubber tapping. Herding cattle is young men's work and milking may be either young men or young women. Herding goats and sheep is generally even younger boys' work. Sadly the proportions of livestock to arable and plantation crops are moving in the opposite direction to the proportions of population by age and sex.

Markets and motivation

Most texts on Tropical Agriculture have sparse contents devoted to labour and allied matters: agronomy diseases and other plant science topics predominate to 95%. But Wood in 1957, gave the average labour outputs to be expected for many farm tasks, most in plantation work. One curiosity is "crow-barring", 30-40 men-days per acre, half using crow-bars to up-root deep weeds: a method not employed on a field scale in western agricultural practice. Wood also quotes 1,000 lb. per day as a target for yam lifting. Tempany & Grist covered the subject of labour from slavery to reluctance of indigenous workers to undertake tasks such as weeding plantations on the grounds that it caused soil erosion and was contrary to 1,000 years established local practices. Kool 1960, devoted a chapter to labour but much of it is on diet and other causes of impaired working performances. McIlory, in 1963, in an excellent introduction to cash crops, ignores labour for the tacit intent is to convert surplus labour into cash.

The purpose in the above disconnected examples from the literature is to emphasize the extreme types of motivators in tropical agriculture ranging from the slave-owners' whip, the concern for soil conservation, the spur of hunger and the basic incentive of being able to eat the fruits of ones' labours and to show cash to be only a part of the overall incentive. And even then, cash is only effective when markets for produce exist in proximity to markets selling consumer commodities which the farmers and workers see as desirable necessities.

One of the few sources of data on detailed work study of tropical agriculture is the Rhodesian Work Study Section, which in 1968, even included estimates of Rest allowances for ground-nut picking etc.. The progress since 1950 when Bovill wrote in a chapter on native labour "... the small amount of cash he (the farmer) requires can be found by occasional sale ... in all he spends no more than 5-6 years as a wage-earner ...." "Target workers" is a name given to those who leave their villages for 6 months intending to return with a certain sum of money. Westernized bonus schemes are quite inappropriate in such circumstances.

Hours of work

Hours of work on a rubber plantation in Malaysia will commence at 5 a.m. just prior to dawn and the workers begin tapping as soon as light is adequate. The shift ends at 11, workers may have an afternoon job in a factory. Peasant farmers in tropical agriculture normally cease work exactly at noon and recommence a few hours before dusk, a time traditionally reserved for sowing seeds and other critical light tasks.

The seasons of work demand may be such that the plantation worker becomes a peasant farmer later in the year. Ergonomic problems in plantations only remain unrecognized so long as this minimized the costs of production. On the other hand, the peasant farmer in conditions of general under-employment, aims at providing an easy way-of-life and an adequate food supply for the family.

These different aims result in quite different attitudes to work hours. For organization reasons, the plantation owner is more concerned with a well fed, punctual and healthy labour force, albeit performing elementary tasks with crude hand tools, than is the traditional head of the family farm, where punctuality is governed by the phases of the moon.

A feature of the tropics is that there are more uniform hours of daylight throughout the year and unlike the temperate and sub-arctic

zones the periods of peak farm labour demands such as harvesting do not coincide with the maximum hours of daylight. The almost monotonous regularity of dawn and dusk and twelve hours night means that without artificial light no field work can be done. This is a major limitation to the area that one worker can farm no matter what the degree of mechanization or scale of his enterprise, unless he can illuminate.

To offset this, there is the possibility of several harvest per year which are often timed so that the cycles of planting and harvesting overlap and occur many times throughout the year. Such is only possible in areas where natural rainfall and irrigation are appropriate.

Occupational diseases

Other papers will discuss the medical aspects of tropical disease occupationally specific to those engaged in agriculture. The major scourges of malaria, riverblindness, trypanosomatisis, tropical ulcers and many other insect transmitted diseases and zoonoses are in many cases potentially controllable when agriculture is well-managed on a large scale. Indeed some might even be eliminated if there was complete discipline over the medication and other precautions needed. With small scale agriculture, no such potential exists, yet the improvement of small scale farming must be the target of ergonomists who with colleagues and collaborators will risk disease themselves.

Stress

Ergonomics is sometimes defined as the removal of stress from work. Rex Gogerty stated in August 1978 that farmers' stress in North America is derived from weather worries, decision making, economic pressures, family problems and heavy work loads. 82% of farmers said farming has become more stressful: nearly 70% blame this on economic pressures and nearly 60% said that it resulted in irritability which could be relieved through watching TV, socializing or taking vacations. Some 17% thought prescription drugs might be the answer.

While such statistics, causes and remedies may apply just as well to the managers of plantations in tropical agriculture, the subsistence tropical farmer is almost completely inured from such major forms of stress and, probably and fortunately, is isolated from most of the remedies. But natural stimulant drugs as "bangh" and "cola" are known to be used by many tropical farmers and plantation workers. Alcohol in farms such as a beer from millet or "pombe" from maize and palm wine are not without effect upon the working conditions of management and labour in the tropics, regardless of the scale of the enterprise.

Conclusion

The purpose of this paper has been to view the whole tropical farm working scene to identify those areas which may merit attention: the following list of some of the priorities is offered as a recapitulation, and to include some items which will have been covered by other speakers. Research is urgently needed to develop

1. Anthropometric data for all regions the existing data is disgracefully inadequate.
2. Protective foot wear and clothing.
3. Design of small hand-tools to commence the chain of changes from primitive local materials to tools using the fruits of modern metallurgical and other technologies.
4. Formulae and policies which can guide the politicians, economists and agriculture administrators in their decision on the optimum target sizes of farm and the proportion of their population to be engaged in agricultural work.
5. Standards for comparison of the effects of working under such contrasting conditions as shade (under agroforest canopy) versus in the open and working with short versus, long-handled hoes and other hand-tools.
6. A means of reducing heat stress.

But the most urgent task is to alert administrators and engineers to the potential benefits of ergonomic studies as an instant means of increasing productivity at low cost.

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Resumen

Las diferencias más importantes entre los varios sistemas de agricultura, a menudo sistemas de agro-selvicultura en los trópicos y las zonas templadas, están tratadas en las secciones de:-

a) Ganado
b) Pantano y tierra seca
c) Tensión de calor
d) Clima, vestidos y zapatos
e) Antropometría, régimen y cambios somatotípicos debidos al clima
f) Utensilios de trabajo manual y la capacidad para mecanización
g) Básculas agrícolas
h) Motivación y recompensas no económicas
i) Horas de trabajo y trabajo de temporada
j) Enfermedades profesionales encontradas únicamente en los trópicos

Se da mucha importancia al tema de extremidades no encontradas en zonas subtropicales o templadas:-

i) Las haciendas inmensas de hasta 100.000 hectáreas, y los insignificantes jardines campesinos de 10 áreas
ii) La necesidad de una nueva antropometría específica para medir tanto los Masaii de 2 metros de alto como los pigmeos de 1 metro de alto
iii) La humedad extrema de los monzones y la aridez de los Harmattans en la temporada seca
iv) La exuberancia prolífica de las cosechas de la selva de lluvia y las producciones mezquinas del casi desierto.

Résumé

Les principales différences entre les systèmes d'agriculture et souvent des systèmes agroforestiers, dans les tropiques et les zones à climat tempéré sont traités dans les chapitres suivants:
a) Bétail
b) Régions marécageuses et sèches
c) Influence de la chaleur
d) Climat, vêtements et chaussures
e) Anthropométrie, changements d'alimentation et somatotypiques résultant du climat.
f) Instruments de travail manuel et le potentiel de mécanisation
g) Echelles dans l'agriculture
h) Motivation et rémunérations autres que d'ordre économique
i) Heures de travail et répartition du travail par saison
j) Maladies professionnelles trouvées uniquement dans les tropiques.

L'accent le plus important tombe sur les extrêmes qui n'existent pas dans les régions subtropicales ou à climat tempéré:
i) les énormes superficies des plantations, jusqu'à 100.000 hectares à côté des jardins exigus de 10 ares des petits fermiers
ii) le besoin d'une nouvelle anthropométrie spécifique pour classer tous les aspects physiques, de ceux des Masaii de 2 m de taille à ceux des Pygmées qui mesurent seulement 1 m.
iii) l'extrême humidité des moussons et la sécheresse aride des Harmattans.
iv) les cultures luxuriantes et prolifiques des forêts de pluie et les récoltes misérables du désert avoisinant.

ACCIDENTS - THEIR CAUSES AND PREVENTION

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Summary

Good ergonomic planning is a tool against accidents. Accidents are commonly believed to be caused by "the human factor". Human behaviour, however, is determined by ergonomic factors as workplace characteristics, information and job instructions, situational/organizational factors as well as individual factors. These factors can often explain why people take risks.

As countries have different socio-economic systems, level of education, degree of mechanization, climatic conditions, also these factors are discussed in relation to what preventive ergonomic approach against accidents is to be taken.

Introduction

Mr Smith is a logger who has been working in forestry for ten years. The day when the accident happened he was working on the last part of a compartment. The next day the group of loggers would be moving to a new cutting area. The loggers were paid by a mixed renumeration system with a 60% piece-rate part. It was the end of the day and he was felling the last trees in the compartment. He was in a great hurry because the others were waiting for him. The wind had increased but as there were severe demands on directional felling he had to fell the tree against the wind. As he was in a hurry, he happened to saw through the "felling comb" and the tree went in the opposite direction to that intended and fell on him. He got a contusion and a broken arm.

Let's use this accident as a starting point for discussing why accidents occur and how to prevent them.

A common belief is that about 80% of all accidents are due to "the human factor". But what is the "human factor"? What we know is that man is always variable. Why it is so will be more apparent if we look at factors which have an impact on human behaviour.

Factors determining human performance reliability

Individual factors

Age. As people get older, they become less physically active and take longer time to make a decision in a critical situation. But younger people (less than 25 years of age) have a higher rate of accidents than older people.

Experience at work. When new entrants to jobs are studied it is usual to find an increase in the number of accidents after about three months. The number of accidents will then slowly decrease and after a year they will be on the same level as experienced workers[1].

In general, more experience means less accidents. However, experience often seems to be specific to a certain task - or workplace. This means that if you move to a new task or workplace you ought to be seen as a newly recruited man and hence have the training and introduction he gets. In a Belgian coal-mine for example, it was found that if an experienced coal-miner was moved from one workplace to another, the risk of an accident increased ten times.

Personality. Personality has been a very popular subject in the history of accident research. The concept of "accident proneness" is based on the assumption that there are people with certain types of personality who are more likely to have an accident. Thirty years of research have shown that the concept is a myth. What we know, however, is that we all from time to time act as accident prones, due to internal as well as environmental factors.

Intelligence, psychomotor performance. No correlation has been found between intelligence and accidents. As regards psychomotor performance it is usually said that people with slow muscular reaction etc often have more accidents. On the other hand, it has been shown that people whose muscular reaction is faster than their speed of perception are prone to more frequent and severe accidents.

Motivation. Our motivation to work safely and quickly has a great impact on safety. It is shown, however, that we often weigh in our minds the demands from production against the demands for safety.

Social norms. In our society to-day it is of a positive value for man to take risks - we learn this from childhood. This is reinforced by movies and television, where all our heroes are big, strong and brave. As a result the safety conscious worker is often

seen as a "namby-pamby" person. This causes a great impact in safety, because societal norms have to be broken.

Characteristics of the workplace

Demands created by the workplace have an impact on safety. A good ergonomic design of the workplace does not only decrease the workload but also has an impact on human performance reliability.

Perception. Different work tasks will lead to different perceptual demands on senses as i e hearing, smell. High demands on perception will lead to fatigue and therefore a higher chance for errors. Working with a power saw sets high demand on sight in order to control the sawblade and also on kinestetic sense in order to detect if the saw will get stuck. Other types of perceptual problem are being created in new forest and agricultural machines. In general, the more technically advanced machines usually create higher demands on the operator, e g being able to perceive a lot of information from computers in poor light conditions. This may lead to errors, which later may cause accidents.

Decision making. Increased mechanization in forestry and agriculture has led to tasks which require rapid decisions in critical situations. This, in turn, has led to an increase in the likelihood of errors. In addition, human beings find great difficulty in deciding on two things at the same time. Machine designers often fail to take this into account.

Motor requirements (speed, strength, precision). Some workplaces place high demands on speed and others on strength. High speed especially together with precision is very fatiguing and will lead to errors. The need for strength in jobs is not as common as it used to be (not logging), but there are still, even in more mechanized jobs, certain work phases where strength is needed, e g maintainance jobs, heavy lifting. It is often in these work phases that accidents occur.

Design of machines, tools, materials etc. Today we still have a lot of design faults in machines due to the lack of application of the most elementary ergonomic principles. However, this will be dealt with in other papers, so I won't go into details here.

In this section of the paper only a few factors in workplace design which have an impact on human behaviour have been mentioned. The general principle for preventive action in this field is that the work task should be designed so that instruments can be read, that tools, fixtures or equipment etc should be designed to take into account the limitations of the human being - in short that they are designed from the knowledge how the human being functions - not how we want him to function.

Information and job instructions. The presence and contents of job instructions have also an impact on human behaviour. On one hand there are job instructions to show how to work as quickly and easily as possible to keep the production high. On the other hand there are safety instructions for doing the job as safely as possible. Often these two types of instructions contain conflicting messages - especially when the safety instruction is not part of the job instruction. It is also important that the instructions are written, so that the worker can consult them after some time, on a new job. A follow-up of the safety instructions is also important.

Situational characteristics

The environment is also of importance as a factor influencing human behaviour.

Work environment factors. Factors such as temperature, air pollution, noise, pesticides etc have all an impact on human behaviour. Low temperatures for example make people fumble and insensitive in their finger-tips which makes it more difficult to detect and prevent a risky situation. High temperature will on the other hand give rise to physiological stress which will together with need for high performance lead to fatigue etc. There may also be more subtle impairment which will affect human performance reliability. For instance it is suggested that the peripheral vision deteriorates with increasing temperature which might lead to more "surprise accidents".

Fog and air pollution result in risks not being detected quickly enough. Noise can affect behaviour in many ways. It can prevent signals from being detected, i e you don't hear a cry when felling a tree, and it can also give rise to deafness.

Solvents and pesticides can, apart from their poisoning effect, give rise to longer response times, which in critical situations can lead to accidents.

The tidiness of the workplace is also a factor. If there e g is much shrubs or cut-offs in the workplace the risk for falling, slipping etc increases.

The working schedule is another important factor. The number of errors seems to increase during night-shift, but does not always lead to an increase in accident frequency as most of the risky jobs, i e service- and maintenance jobs are done in day-time. Shiftwork has been shown to increase the number of accident during the first half hour of the shift due

to the new workers on the shift, reorganizing their workplaces.

The work environment seen in a broader perspective means studying factors such as the role of management, work mates and unions. Many studies show the significance of the management and especially the supervisors' attitudes towards safety. A supervisor's attitude to safety has a great impact on the individual workers' attitudes towards safety. But the supervisor in his turn must have the management behind him in his work to create a safe working-place.

The action of the unions are just as important. Support of the union is important in getting the safety steward to take action and to influence his work mates.

The work organization seen apart from the characteristics of the workplace will also have an influence on human behaviour. An example of work organization is a remuneration system which encourages workers to take risks. In Sweden a change from straight piece rate system to a monthly paid salary in both the mines and forestry has led to a lower accident frequency. A piece rate system often leads to a very irregular workpace. If something has gone wrong in work, the worker has to work extra hard in order to reach his normal income. This will lead to a high workpace and at the same time he will get stressed. If the worker is stressed, his behaviour will get disorganized, i e he will fumble, have difficulties in thinking straight etc - in other words not in a very good condition to manage the increased workpace.

But a piece rate system can also have an impact on the workers' behaviour in another way. The idea behind the piece rate system is the quicker work the more pay. As a result the worker will not have time, in other words cannot afford to use safety equipment guards or to practise new, more safe-working methods.

The solution to many of these problems is often said to be mechanization. In more mechanized work the impact of environmental factors as heat, temperature etc is often less than in manual work. At the same time the demands on the human beings' mental capacity increase but the work itself is often very monotonous and understimulating. This will consequently reduce the human beings' performance reliability. A higher degree of mechanization also inevitably leads to a higher utilization and the result will be shiftwork. In France the relation between degree of mechanization and safety have been studied. In highly mechanized work fewer but more severe accidents were found than in less mechanized work. Another result was that accident to and from work increases due to shiftwork and more monotonous work. But so far studies about the relation between safety and degree of mechanization are few and more research have to be done before a conclusion can be drawn.

Situational characteristics, job instructions, workplace characteristics, individual factors are all parts of what we call ergonomics. If we want to diminish the number of accidents we cannot explain accidents with "the human factor". Instead the aim must be to apply ergonomic knowledge on human being behaviour in order to design a non-accident prone environment.

Why risk-taking?

Let's go back to Mr Smith and his accident and see how this can be explained. Why did Mr Smith behave in the way he did?

1) Mr Smith first has to know that felling a tree against strong wind is extremely dangerous and the smallest mistake might lead to an accident. To teach people about risks through instruction, training and information is therefore very important in order to reduce accidents.

2) Let's assume that Mr Smith knew that it was a risky situation. But he thought that it was not risky for him as he had numerous times felled a tree against the wind and nothing had happened. His attitude that "this won't happen to me" is very difficult to fight against in safety work. If, by the aid of statistics, one want to show that a specific task or work situation is dangerous, the message is often contradicted by the workers' own experience as he had done the same thing lots of times without having an accident. A change of this attitude, however, can be attained by the worker's reporting of so called near accidents.

3) But did Mr Smith really have a safe way of handling the situation? A prerequisites for safe work would have been to use an aid for felling the tree in the right direction, but since his work mates were waiting he had to hurry and had no time to go and fetch the aid. It is often found that even if there are rules and regulation for safe work and even if the worker wants to work safely, in practise he has no choise, as there is no safe alternative. As long as there are no realistic alternative for safe work it is of no use to ask people to be careful.

4) Last but not least the high flexible part in Mr Smith's wage was also a factor which might act as a reward for risktaking. However, a wage system is not the only factor which can be a reward for risktaking. If a worker has to walk far to find an aid, he will get tired. The more tired he gets, the less he can produce. Thus, if a task can be done

with less physical energy output, he will choose to do it that way.

Preventive ergonomic approach

The knowledge we have about different ergonomic factors influencing human behaviour cannot, however, be directly translated into preventive actions as countries have different socioeconomic systems, level of education, degree of mechanization etc. These factors have to be considered too. What actions to take in a certain country therefore have to be considered in relation to

- existing knowledge
- existing technology
- laws and regulations dealing with safety at work and legal sanctioning system
- norms (attitudes)
- economical aspects
- power relation between the labour market parties.

To give an example - the effect of a law depends on both the attitudes to it and the sanction system. In Sweden power saws are not to be sold without kick-back guards or chainbrakes. But when the same saw is exported to other countries, especially outside Western Europe, the safety guards are removed as the safety laws in the importing countries are not as strict as in Sweden.

The conclusion to be drawn from the above mentioned factors is that preventive measures cannot directly be transferred from one country to another. To produce an effect the measures have to be adjusted to the present status of a country.

Preventive measures can roughly be divided into technical, organizational measures and those directed at human modification.

Technological measures

The following technological measures can be used in a existing work environment.

- Technical safety guards, redesign
- Elimination of physical factors in the work environment, which influences the individual's possibility to an adequate performance
- Protective devices

The first of the three points above aims at eliminating already known risks, either through placing a barrier between the man and the potential risks, e g guards or by redesign of machine and tools. The effect of the measure, however, can be reduced or even fail to appear if it means an additional effort to be expanded by the worker as well as causing the worker some discomfort. Apart from the loss of operator efficiency the result may even be that accidents of a new nature may occur.

Safety guards and redesign are by far the most used preventive measure. It is often more expensive though to make up with safety guards on a machine than if the safety guard is built into the machine. The initial higher cost for a safer tool or machine is in the long run outbalanced by the costs of safety guards and the cost for the unavoidable accidents. This later statement applies under the condition that the costs of the accidents burden the enterprize and the society and not only the worker.

Elimination of physical work environment factors aims primarly to diminish the risk for individual errors. An example of this kind of preventive measures is to ameliorate sight conditions in tractors.

Often it is not possible to change a machine, a workplace etc. Instead you have to protect the individual through protective devices. When discussing protective devices two factors have to be considered, namely availability and comfort. Swedish studies have shown that if protective devices are not easily accessible, both in terms of costs and place, the devices are not used. The study also showed the same results where comfort problems became too annoying.

In a heavy physical job as in forestry, the wearing of protective devices as hard hats, even in Sweden appeared to give an increase in the workers' skin temperature. Thus the comfort problem in tropical countries is of a much bigger dignity and therefore safety equipment may be a measure of very little preventive value in these countries.

Human modification

Preventive measures directed at human modification are the following.

- Selection and placement
- Introduction, education and training
- Persuasion and propaganda (motivational campaigns, competitions, posters etc)

The traditional approach in accident prevention is on the worker himself. Instead there ought to be a melding of all three approaches so the best aspects are considered and the mistakes, when each is narrowly defined, are avoided.

The main problem in selection, placement and training can be summed up in three statements.

1 The content for selection and training programs is rarely based on a thorough job and task analyses.

2 Evaluation of selection and training program are conspicuously absent.

3 Many times selection and training are used

to compensate for other organizational problems completely unrelated to employee knowledge or skill.

No general criteria can be recommended for selection of employment applicants to reduce the overall accident rate. However, in order to reduce human errors, there is a need for job and task analysis of the particular job in question. The obtained requirements, though, must be validated as selection criteras. Another problem with selection is on one hand that you need a pool of applicants to select from. (This is growing problem today in Western European countries.) On the other hand, if you have a big group of applicants there is a strong tendency to overselect and overtrain, resulting in motivational problems for the worker. This may lead to a high turnover if the country has a flexible labour market.

Safety training should mainly be directed at critical situations. But it is also important that safety training is part of the usual training program. Introduction is another important tool in safety work. Introduction is needed not only for new job applicants but also every time there is a transfer between jobs. Training as a preventive measure has its highest effect when the overall training for a job is low. If the present worker training in a job is about average, only a limited amount of improvement in production performance, however measured, can be achieved by increasing the average level of training to good or excellent.

Motivational campaigns etc are another often used safety tool, i e Zero Defect Program. Usually you get a decrease in the rate of accident when using this method but the improvement is only temporary. This does not mean, however, that motivation is unimportant. But when management attempts to manipulate worker motivation by telling people to work safer, the method is not efficient, because it fails to uncover what the cause is of most of the errors. Thus a motivational campaign must aim at both getting safer work practice and to get information about how to change the work environment.

Organizational measures

The following preventive measures can be taken from an organizational point of view, namely

- change of administrative systems for human behaviour control, as production planning, remuneration system, supervision and inspection etc
- the organization of local safety work.

Very often when different kinds of preventive measures are taken the produced effect is not the expected. In Sweden the introduction of new safety regulations on felling, forbidding the workers to use risky methods, did not result in the use of less risky methods. A study showed that the main reason was that the forbidden risky methods were far more rapid and demanded less physical effort. Saving time is equivalent to better earnings when working in a piece-rate system. A straight piece-rate system also influences the workers' motivation to use methods that are less physically exerting. Thus, if a pay-system is used in a country where a worker has to fell a high number of trees in order to get his payment for the day, this will lead to risktaking. Thus, technical and individual measures alone will not suffice to cut down the rate of accidents. Attention must also be paid to changing those factors which control the workers' behaviour in a direction that will minimize the workers' risktaking.

The organization of local safety work is another important measure for preventing accidents. In Sweden according to the new Work Environment Act of 1978 there are very strict rules for local safety work. The law says that employers and employees shall collaborate in order to establish healthy and safe conditions. At every working place with more than five persons employed one or more of the employees shall be appointed safety steward. The coordinating organ at the local level is the safety committee, consisting of representatives for the employer and the employees (with the employees in majority). Its main responsibility is to plan and supervise safety work throughout the place of employment. This means dealing with matters concerning occupational health services, planning of new premises, equipment and work methods as well as matters concerning information and training on the subject of industrial safety.

This very elaborate safety system cannot of course so easily be transferred to other countries. But in order to do meaningful safety work there are certain minimum requirements. A local safety organization must have resources for

1 collecting and providing statistics on the number of accidents

2 investigating and analyzing the causes of the accidents and using the knowledge for preventive measures

3 first aid and rehabilitation of injured worker.

The basis for this paper has been that the human being is a part of the man - machine - environment system, but also a commanding factor. In this capacity the worker is what usually is called an information processing system.

This view means that the worker is assigned the determining part in the interplay between the different components. That the worker has the commanding role and is the dimensioning factor should not however be expressed in terms that the malfunction of the system should be solved by measures aimed at the worker. Instead this problem has to be solved through ergonomic changes to the machines and work environment, even if human modification through i e training can partly be achieved.

If the work situation and environment provide all the information the worker needs in order to avoid or prevent risks, then his behaviour will be in accordance. It's very seldom that a worker willfully and consciously exposes himself to an obvious risk.

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Resumen

Una buena planificación ergonómica es un remedio contra los accidentes. Se cree vulgarmente que accidentes son causados por "el factor humano". La conducta humana depende sin embargo de factores ergonómicos, como por ejemplo carácteristicas del lugar de trabajo, información e instrucciones de trabajo, factores circunstanciales/organizadores, igual que factores individuales. Estos factores a menudo pueden explicar porqué la gente se expone a riesgos. Ya que los paises tienen diferentes sistemas socioeconómicos, niveles de educación, grados de mecanización, condiciones de clima, tambien estos factores se examinan respecto al método preventivo ergonómico que se ha de adoptar contra los accidentes.

Résumé

Une bonne planification ergonomique peut prévenir des accidents. En général on admet que les accidents sont causés par "le facteur humain". Cependant le comportement de l'homme est déterminé par des facteurs ergonomiques, tels que les caractéristiques du lieu de travail, l'information, les instruction de travail, des facteurs dépendent de la situation ou de l'organisation et des facteurs individuels. Ces facteurs peuvent souvent expliquer pourquoi les hommes prennent certains risques. Comme les systèmes socio-économiques, le niveau de formation, le degré de mécanisation, les conditions climatologiques diffèrent d'un pays à l'autre, ces facteurs sont étudiés par rapport à l'approche ergonomique et préventive à choisir pour éviter les accidents.

THE SOCIAL DIMENSION OF THE ERGONOMIC APPROACH

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Summary

The planned process of change from an actual towards a desired state of "Interaction between man and his working environment" needs some sociological analysis as well, since "working environment" in itself represents a pattern of social action. One problem of ergonomics is the specialist's inclination to use oversimplified sociological concepts while assuming to avoid them at all.

As an example on the micro-scale, the role of magical arguments among a labour force in a tropical country is explained. As a further example on the macro-scale, the role of ergonomic arguments during a racial conflict are analyzed.

Cooperation of natural and social scientists on the local level is encouraged.

1. Introduction

The process of planned interaction between "man and his working environment" puts some unavoidable questions to the sociologist - expecially in tropical countries. This happens, because we cannot start from man as an isolated entity (homo clausus), as philosophers may construct him, in order to demonstrate the source of "free will", or engineers, in order to demonstrate a mechanical object for "absolute" or "technical determination". All of us know that there are no two families or working teams alike, both in their personal interaction and in their respective environment. Therefore, sociologists try to find out about the regularity of those different interactions. Trying this, we are used to the idea that face-to-face interaction is but a very special interaction, and most interaction is done via means. Those - social - means are standard gestures (e.g. greetings) and standard speech (e.g. in English) and standard tools and techniques. Thus we interact by means of instruments. By instruments we produce (and destroy) things and give and take, by instruments we socially exchange our necessities of life. And even when we fight nature, as in primary production - agriculture, fishing, mining, or forestry - we do not do this as isolated entities, but as specialists by division of labour, working for (or against) others. This is constituting 'society'. Starting from this position, as a sociologist I assume for our purpose:

1.1. Intercations between man and his working environment are always interactions between men. Our difficulty is now, that we need an analysis of a stream of interdependent social actions, an analysis of a process. There is no moment of 'rest' in the interdependent exchange of man's actions with other man - and be it via "working enviroment" (v.Borries 1979).

On the one hand, we are used to the idea that men are always changing. We know that in practice we do not work with standard 'man', but, permanently with a 'labour force'. A labour force is a very complex, multi-purpose, and culturally shaped challenge. Complex, since already number, age, experience on the job and experiences with the planning authorities vary; multi-purpose, since no group or indeed no single member has goals identical with the planning authority - the group is already acting differently on a workday and on a sunday. Culturally shaped it is and this again puts a very complex problem to the engineer or technician working overseas. You know this problem very well, and you know as well, how many risks are involved, if you are to proceed by rule of thumb.

On the other hand, it is even more disturbing that the 'working environment' in itself never comes to a standstill. It is changing in itself due to social processes, and therefore it is as well very complex, multi-purpose, and culturally shaped. It is complex, already due to human intervention: The place where you work, the conditions of transport, the looked-for quality of wood is already a resultat of interdependent and very often controversial human activities - exhaustion of natural reserves due to industrial production and/or war, accessible routes, consumer markets. Multi-purpose it ist, already, if you think of the fact that natural ressources are

not a gift of nature to you, but an operating part of the export policy of a tropical country, of labour policies of government, of trade unions, and of labour migrants; and thus they are influencing the costs which the agency or firm you are working for must calculate. Environment ressources are culturally shaped, because all your work depends very much on the investment policy, on the political and on the legal power which prepare the frame of your work. Therefore, hidden by the so-called 'working' or 'technical' environment there is again - man. Neither "technique" nor "working conditions" act by themselves, nor indeed inter-act.

1.2. "Planned change" necessarily asks for some simplification both in the definition of situations, and in the means of procedure, or else this complex stream of interactions would be unmanageable. The priorities we think of when planning are socially defined aims, and they are likely to come across other aims. In order to plan, we cut off those analytical niceties which we consider to be minor important for our aims. Below a thertain threshold of risk we tend to ignore it. For practical purposes, then, a risk of say 0.5% is neglected, as if it were 0.0%. That will be a source of future surprise we put up with.

But, usually there is a professional blindness which understimates certain risks systematically. These are the risks we are not traditionally trained against. Technicians, engineeres, agriculturists &c. (as everybody) prefer neglegeance in those fields where they are not specialists. Very often, their respective disciplines have traditional ways of simplifying social problems. These ways are taught by introducing remarks or sarcastic asides during lectures, or by omission. This depends on our own cultural and educational traditions. Therefor, there are biassed simplifications which will again and again mean unexpected results: in the social field.

Finding and discussion

2. Unexpected results, then, will be accepted only in terms which are not very refined in the respective disciplines. Only rude terms will help the technician &c. to explain that it is neither his fault nor a fault in his branch of knowledge. At best, those rude explanations are given to another specialist, e.g. to a sociologist, for refinement purposes; and in the meantime the technician may soldier on. There is a snag: If the sociologists accept this division of labour, both might fail to help one another.

2.1. Most of us know some typical explanations which shift the problem into a kind of limbo, where it may linger on without bothering us. I shall give some examples:

- We are modern. They are traditional.
- We are rational. They are emotional.
- We are sensible. They are "half devil and half child" (as Kipling has put it).

You will well remember some of these explanations. If a local labourer has ruined a machine, how easy ist it to say: "Those natives don't have the feeling for a technical gadget". But this is a cultural blinker.

2.1.1. They have techniques which you have no 'feeling' for (you would be a poor smith or ploughman using the techniques of their line of development.) So you see their faults alright, but your explanation is simplified and biassed in the wrong direction. By following this line of guessing, you will make yourself helpless against the very next 'unexpected result' = ruined machine.

2.1.2. On the other hand, in those countries the local labourer is much less 'primitive' than you judging social situations. You will find him very clever in spotting your prejudices and weaknesses, your position between colleagues and superiors, your hidden fears. In a non-industrial culture one's life depends on this kind of shrewd social judgement, and very often they are eager to grasp, and we are slow.

One problem of ergonomics seems to me to immunize ourselves against prejudices of a social kind. Social prejudices are not just racialism or sexism. The most effective ones hide in our technically or physically oriented way to 'handle the working environment'. They are usually more simplified than the images and prejudices concerning technicians &c., which are held by the local labour force.

2.2. In order to exemplify the impact of images, I use the concept of "witchcraft" in case of work accidents. Doing research in Zambian primary industry (mining) I have tried to find out, how far work accidents and typical deseases (as pneumoconiosis) are understood by the local miner as to be

due to 'risks of the kind of work', or due to magic interference by enemies or evil powers (Clausen 1968). I only give some results.

Very soon I had to recall the findings of Mitchell (1966) and Marwick (1965) that magic belief is by no means due to a kind of 'primitive' thinking which cannot even understand "causality". We tend to think of superstitious practices as of negligeance of the laws of causality. But this is not so. It may sound odd, but magic arguments pay indeed tribute to the idea of causality.

If a trammer underground has been slipping, and falling down the shaft, and if at this very moment a stone hits his safety chain cutting it, we explain 'everything' by physical events, and the fatal coincidence, we baptize it 'ill luck'. A Zambian miner would have been inclined to ask: Why this man among all? Why at this very moment? Why this combination of slipping and rockfall? He would be anxious to explain 'the rest of causality' which we prefer to neglect - because this 'rest' is very small, and its complexity is of the highest degree.

Since the African worker was much more used to analyze the social conditions of every individual, he traced down the victim's competitors or enemies in 'private life'. He could detect ill meanings and feelings there. How suggestive it was, then, to combine the well-know field of the victim's social conflicts with our unexplained 'rest of causality' - and quite often it was done: N.N. met an accident. We know his enemy. Therefore, his enemy has used witchcraft, adding its bad influence to the risk of industrial work - which is quite familiar to the miner.

Generally, in cultures without strong scientific traditions, magic causation is widely accepted. In our own culture, it is well spread, but it is socially accepted only in such professions, where the 'rest' of causality is too complex or is 'too big' for scrutiny; for instance among soldiers at war, sportsmen, professional and amateur gamblers, sailors, actors,and students facing their examinations.

'Superstitious' arguments bring in those concepts of interaction we already know: There is direct (face-to-face) interaction, and there is interaction via tools and - on the most abstract level - interaction 'with' the working environment. But, if you hear arguments of this kind, you better try to find out about social enmity or competition in the background, which has been crystallizing into a certain accusation of witchraft. Very often it is possible to say that the social cause behind magic arguing is apt for analysis. There might be - e.g. - very trivial causes: political, unionist, or leadership conflict. Analyzing and treating these conflicts, you might be able to explain magic objections against technical and ergonomic implementations.

Unfortunately, the very first step of analysis is quite a problem: to learn about a single accusation of witchcraft or about a certain magical belief. Often these are hidden to the European technician or engineer, hidden by a sullen resentment against certain techniques or a certain approach. It is the resentment, which on a micro-scale is all too easily put down to dullness.

3. But, there is as well the macro-scale aspect: The ergonomic approach might have different results dependant on the socioeconomic system of the country where it is to be applied. Because ot this macro character, the personal 'knack to handle local people' won't make good for neglegeance of social processes. "Socio-economic system" denotes interaction between men on a national and international level, concerning basic issues as development politics, terms of trade, independence, public welfare, and so forth. In a general way, we accept these issues as a frame to ergonomic work, but rarely there is a bridge between this recognition of ours and the problems of organizing interdependence between men and their work on a local level, and for special purposes.

3.1. I shall start with another example of interference from a national level: Few of you might have had experiences with forced labour, be it with convicts, or with people under forced contract. It might be that some of you have been forced to work themselves as prisoners of war or as political internees. But you will accept the everydays experience that forced labour is poor labour.

Forced labour is a very harsh example indeed, but you might agree with me that the poor results of forced labour (think of carelessness, of pilfering, and of shirking at wood cutting, harvesting, or road construction) are not in the first line an ergonomic problem. In the contrary, the authorities consider it usually to be a problem of discipline and punishment.

The harsh and - let us hope - farfetched situation of forced labour

(= poor labour) is by no means a situation totally strange to our own, normal problems. The problems of forced labour exist as well under very much 'softer' conditions, and there is a broad spectre of social power, be it force actually used, or be it only felt, or be it successfully hidden in conditions of the environment.

The softer conditions are, the more likely our problems will be cloaked by social customs and usage. Now, it is typical for an anthropologist or sociologist, to look at social customs in a twofold way: They hide our problem and show them, at the same time. (You know it: Think of the custom of joking. To make fun of somebody may hide a certain cause of more serious grudge; but if it is done customarily, it will show - to the careful observer - that there is 'something in it'. Think of the customary joking at school, when you were pupils, or - on a macro-scale - of political jokes under dictatorship.)

So let us look for customary usage of ergonomic arguments at contract labour.

3.2. I shall take the struggle for advancement, and I use my own research experience as a main example.

I have encountered the fact of interfering social factors on a macro-scale in the former British Central Africa, which is now the country of Zambia. Those factors interfered with work analysis of a kind, which you can correctly call "ergonomic" (even if the term was not en vogue by then). Before Indenpendence, which took place in 1964, Zambian industry had developed much more after the Southern Rhodesian and South African model than e.g. after the East African. The Zambian Copperbelt, a chain of seven mining towns based on copper orebodies south of Katanga, had built up a colonial and at the same time racial style of industrial management, which generally left the lower strata of work to the Africans, and the upper ones to the Europeans (Whites), and which had, moreover, closed the upper ranks against African advancement. This had happend in spite of the British postwar Labour Government, in spite of a strong African union movement, and in spite of different political experiments to lower the colour bar, between 1954 and 1964 (Roberts 1976). In fact, there was a three-cornered-fight, along lines, which are unusual in many European industries (Clausen & Kester 1970).

First, there was the African labour force, recruited from some seventy tribes, at that time poorly qualified, and with no substantial hope for advancement. Another part of the labour force, the European one, was - secondly - allied with the mining companies against this great majority of Africans, closing their jobs and their ranks even against those with the will and even with the training to advance. In the third corner, there was the colonial government, mostly siding with the Europeans, but much more sensitive concerning the "wind of change" blowing over Africa.

In this social conflict, most 'fighting' within industry took place along the border line between the least qualified Europeans (with a strong Boer element) and the most ambitious and best trained Africans. There was wildcat strikes, quarrels at work, absenteeism. Government tried - together with the top echelons of the companies' managements - to keep up production and earnings and to avoid industrial unrest. Therefore, several Royal Commissions were installed, to find out,by analysis of the working conditions and environment and technical outfit, which jobs could be given to Africans without alienating European labour.

It was a tricky job, in a heated-up atmosphere, and the Commissions turned to elaborated and very technical evaluations of the different jobs underground, in the smelters, and in the refineries, and eventually produced long lists of very accurate and again technical descriptions of jobs (cf. Forster Report 1954, Branigan Report 1956, Morison Report 1962).

Backed by this, and encouraged by government, the companies opened up some careers to Africans. The lower strata of the European labour force were not backed by a European farmer population at a scale as in Southern Rhodesia (which could carry the rebellion of 1965 against the Crown). So they bowed to Company decisions: After all, an African could be a loco driver inside the plant area. On the other hand, you might imagine that any technical job description was discussed over and over in the canteen or beer hall, and could be an issue at union meetings, in the press, and on Government level, and even at the Companies' Headquarters at London. Quite so: Any technical definition about 'skills' or 'dexterity' at a certain job had a socio-political and socio-economic impact surpassing any locally limited ergonomic scope.

This did not belittle the ergonomic

analysis. But it made acceptance of any ergonomic finding a matter of politics and of interests, and brought in the 'social' angle.

You can deduce that in general the African labour force accepted the job analysis. This meant, the less educated and less industrially experieced (and even tribally organized) part of the labour force accepted the 'modern' approach. It helped them.

In general, the European labour force was much more reluctant. After all, there would be a sharp competition in their lower strata, and once the dam was broken nobody would know where the flood was to be stopped. This reluctance was visible, in spite of the fact, that the Europeans were better educated and industrially trained, and came from countries with a long industrial history. You may call it paradoxical that 'modern' methods were more easily rejected by the more 'modernized' labour force - in this case, at that time.

Naturally, it was not quite as clear cut as that. The higher up the line the European was, the less alarmed he was, the more he did accept the Commissions' findings. The lower down the line the African was, and the poorer his chances were to gain something by personal advancement, the less he would embrace the findings. He would be more interested in a general rise of pay. But in the border areas of conflict, the 'paradoxical' attitudes prevailed that the more traditional group preferred the ergonomic approach.

The later answer to this social as well as ergonomic challenge was characteristic.

The more traditional labour force (the African one) took to more schooling and training, and often tried very hard to qualify. The more modern labour force (the European one) answered in quite another way: They did not intensify their training efforts, but they stressed the argument that part of any job was its "responsibility". Now, "responsibility" had the halo of a virtue which Africans possibly could never learn, or only after quite a time ("2000 years" were colloquially preferred). And it is fascinating to see that this "responsibility" was by no means as accurately defined as e.g. 'dexterity', or swiftness', or other skills. If it were to be defined in an elaborated, technical way, it would have been the weaker an argument. European foremen, stressing the argument of "responsibility", did follow unknowingly Talleyrand's word concerning constitutions: " A constitution must be short and vague." Therefore, "responsibility" had to do with Loyalty to the Company, with a Sensible Outlook on industry, and - as everybode knew - with power.

Soon the African Staff Unions started to complain that advancing Africans would get a split job, with all technical tasks to be fulfilled, but with "responsiblility" taken from it and put one rank higher - and payment therefore reduced. It seemed to them, that this was the managements' way out. (Cf. Clausen 1978:70-76)

Now, 'power' in this sense is not a central ergonomic concept, sometimes it is no ergonomic concept at all. As 'social power' it belongs to the 'frame', within which the ergonomist may move around. But, in that Central African contect "power" and "responsibility" were amalgamated in order to defend the tradition of the colour bar within industry, so they represented a set of traditional values, held up by those one might have had expected to be modern and not conservative.

This was just a very special historical situation which I have tried to explain. In this - Zambian - situation an ergonomic approach on the micro-scale of job analysis say of a timberman underground was embedded in a social conflict on the national scale, and any analyst might have encountered reactions on the spot (in the companies), which were likely to puzzle him, because their motives were not part of his job and any micro-scale approach.

Especially, since the usual and prejudiced answer "I am modern, my critics are traditional" might have been silenced by the fact that he might have got applause from the 'wrong' corner.

Why was it the 'wrong' corner?

3.3. It was the 'wrong' corner, because in European or North American context job analysis and ergonomic studies usually find another constellation of social power. This constellation gives the background to so many ergonomic efforts that it is very often not discussed at all as an ergonomic problem. Which it is.

In - e.g. - Northern Italy you will find militant unions and labourers fight the ergonomist, even hindering his work on plant level, because they fear he might advise the Company how to extract more work from them, and how to keep down the number of employees by investing in new technology. Very often the ergonomist is hurt

if he is accused like this. He feels that somebody does him wrong, that he is not understanding his motives, and that his counterpart acts irrationally. Again, he might overlook that he is up against a nationwide social constellation, i.e. the social process of mechanization and automation of production, in the face of rising expectations and rising costs of human labour.

But this constellation is much more convenient to him, than in Africa. He is a well trained man with a good educational background, and government agencies or managements who call on him, are socially much closer to him than the protesting employees (which include unskilled blue collar workers and semiskilled white collar workers). The ergonomist can see himselve as progressive, as against traditional and less rational attitudes. Especially, as he might encounter people who won't argue with him, but blame him personally or sabotage his work by sullenness and resentment. For them he has sided - in their social conflict, concerning work and pay - with The Other Side. In the Zambian context, the same unskilled labourer might have felt that he has sided with him.

In fact, I try to strengthen the point that there is no socially 'neutral' position for the ergonomist. If he conceives of his job as studying the interaction between "man" (who is admittedly never neutral) and his "working environment" (which seems to be a neutral and 'purely technical' or 'physical' matter), he might think there is a neutral approach for him since he looks from the 'technical angle'. But the working environment never fails to have the social dimenskon. In social interaction there is no neutrality. Neglecting this, one will produce "unexpected reactions".

4. All specialists - or else they were no specialists - try to keep their working field 'clear', and try to see "environment" under a ceteris paribus clausula. This happens tacitly, or not. Anyhow, it may spare some frustration to include the social dimension as well, when planning for an ergonomic change.

How could it be done? Biassed, as I am - as a sociologist - I do not prefer an individual approach. I do not want to add some more terms to the university years of a student of forestry or ergonomics, or to add some more examinations in sociology. I prefer an organizational approach. Ergonomic studies should be undertaken by a staff which includes the social scientist, as well. The division of labour cannot be neglected, and if only they are able to accept one another's findings, we may bring together specialists. Perhaps, this symposium might help.

I am not quite pessimistic about this.

The natural and the social scientist in a common team are not quite usual in European universities. It is much more easy in the tropical country, especially if the social scientist is from the country itself. Remember how it is, if natural and social scientists meet at the spot, at local research institutes, at conferences over there, and at government resthouses. In those situations, they are much more used to the idea of snatching ideas from another, which will help them to cope with their respective problems. Often it is done secretly, because we do not like to let out questions, which trouble us, but which we fear make us seem incompetent to others.

We can overcome this common fear. We need not accept the problems I spoke about as problems of technical know-how. They are problems above the individual level of ergonomic competence. It will keep the own field of reasoning clear, if we accept the social dimension - there are even others as well! -,and by bringing the specialists together we all might work on a more adequate level.

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Resumen

El sistema proyectado de la transformación de un estado actual en un estado deseado de "interacción entre el hombre y su ambiente de trabajo" necesita analisis sociológico, ya que "ambiente de trabajo" en si mismo representa una norma de acción social. Un problema de la ergonometría es la propensión del especialista a usar conceptos sociológicos demasiado simplificados, tratando al mismo tiempo de evitarlos completamente.

Un ejemplo en la escala "mikro" es la explicación del papel de argumentos mágicos desempenados entre los obreros de un pais trópico. Otro ejemplo en la escala "makro" es el analisis de la importancia de argumentos ergonómicos en un conflicto racial.

Se estimula la colaboración de científicos naturales y sociales en el plano local.

Résumé

Le processus projeté de changement d'une situation de fait pour une situation souhaitée d'"Interaction de l'homme et de son milieu de travail" demande aussi quelque analyse sociologique, puisque "le milieu de travail" représente en soi un modèle d'action sociale. L'un des problèmes qui se posent à la science du travail est la tendance manifestée par les spécialistes à utiliser des concepts sociologiques trop simplifiés tout en considérant qu'ils les évitent totalement.

Comme example à micro-échelle, l'auteur explique le rôle joué par les arguments magiques au sein de la population active dans un pays tropical. Puis, comme autre exemple à macro-échelle, il analyse le rôle des arguments fondés sur la science du travail au cours d'un conflit racial.

La coopération des spécialistes des sciences naturelles et des science sociales est encouragée au niveau local.

ERGONOMICAL RESEARCH IN TROPICAL AGRICULTURE AND FORESTRY

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Summary

Ergonomics can be seen as the precondition for the safeguarding of the vital and social interests of the working man and for reaching the optimum production going in line with it. Ergonomical activities appear of superior importance in those cases in which the human situation is less developed and where appropriate production methods are still in the process of searching and developing. This is considered the case for the range of tropical agriculture and forestry.

Precondition for ergonomical activities is ergonomical research. In this respect, to begin with, fundamental questions regarding the situation of the working man have to be cleared up to reach - in the course of application - an optimum for the human situation as well as for the production process, covering as far as possible all relevant factors.

As for tropical agriculture and forestry a strong increase of activities is to be expected for the near future. The special conditions of the countries in these regions in many cases will give capital-extensive and labour-intensive production methods precedence. This will lead to an increase of those working methods which will have to be termed hard physical work.

Therefore at the start ergonomical research will have to give superiority to the physiological aspects since in this range the greatest direct dangers for the working man will be found. This must, however, not lead to neglecting the psychical and social part of human existence within the work.

General aspects of ergonomical research will be dealt with as well as special research projects and goals of the individual scientifical disciplines of ergonomics. By way of a theoretical example of a small institutionalized research-unit attempt is made to demonstrate for one the time-related possibilities of ergonomical research and for two those objects considered to be necessarily investigated.

Ergonomical Research in Tropical Countries

Introduction

Article 23 of the "Declaration of the Human Rights" outlines the right of every human being for adequate and satisfying work conditions. Out of this demand clearly rises that work has to be adapted to man in such a way that it duely respects the physical, psychical and social needs of man and that not only to a minimum extent, such as it is given in the protection from overstrain, but in such a way which proves to be satisfying to man.

In work science activities exist which have, to be sure, their roots in the consideration of the human conditions involved in the work process, but which, only mean the protection of the "production factor work". Ergonomics does not start from the materialistic question, how the production factor work can be brought to its highest possible effectivity, respectively how it can be managed to keep it free from damages; ergonomics much more starts from the point of the vital and social interests and demands of man, which are to be realized and safeguarded at the working place, in the enterprise and in all of the working fields in general.

Sometimes it has been critizised that the competence range of ergonomics is set relatively general as well as relatively far reaching. If, however, the human well-being in the ergonomical sphere of interests and the creation and safeguarding of this well-being is within this scope, then e.g. the man involved in a work conflict also sets the boundaries of ergonomical questionings.- So also the concept "Humanization of Work", which stems from the social-political range and nowadays is a common and world-wide demand, in its essential parts is assigned to the working-field of ergonomics.

It favours the application of ergonomics that all positive results of its endeavours at the same time also are positive results for production and economy if viewed in a larger frame, for: only the healthy man is able to employ his work-capacity all his life long and only the contented man is ready and motivated (except of cases of fear and compensative behaviour) to employ his full work-capacity within the individually possible frame.

It is an essential principle of ergonomics not only to view and criticize existing conditions in the working-field analytically but also to create and safeguard

actively desirable work conditions. - And since ergonomics is a science it has to call in question each existing condition it finds.

Ergonomics not only lays out the individual work place but also whole work systems (e.g. enterprises). It considers a rational way of production in accordance with the humane work-conditions, a principle of economy which is just as important for the working man as it is for the economical result of the enterprise.

This symposium deals with the ergonomical aspects of forestry and agriculture in tropical regions and thus with human work in rural districts. For the topic "Ergonomical Research in Tropical Countries" there exists a considerable commonness, in particular because of some detrimental conditions for the working man, namely

- insufficient physical condition of man
- open-air work under unfavourable climatical conditions
- high proportion of physically hard work due to the capital-extensive ways of production, which also will have to be considered a fact in the future.

The following statements will pay due consideration to the particular conditions in the tropics - although theynecessarily will contain in substance commonly valid comments.

The Sense of Ergonomical Research

Ergonomical research is a precondition for

- the improvement of the situation of the working man as well as for
- the improvement of the enterprises economy, by way of adequate design of organization and techniques.

Up to now there exists to the reporters knowledge no continuated ergonomical research in tropical regions. This is deplorable for double reason, namely since

1. the people of these regions have far more unfavourable preconditions for physical work and
2. the environmental conditions limit physical activities to a larger extent than is the case in moderate climatical zones.

Therefore, among other things, it is the sense of this symposium to embrace the opportunity for a beginning of ergonomical research in tropical countries.

Kinds of Ergonomical Research

Ergonomics is an interdisciplinary science. It has and needs many research approaches for the very heterogeneous aspects for studying the interrelations between man and work under changing conditions.

Normally one differs between

1. basic research in ergonomics, studying the human conditions for work and
2. applied ergonomics, analyzing actual states of work and developing desired states of work.

Applied ergonomics puts into practice the findings of basic research and in the end develops a complete work system according to the respective optimal possibilities.

ad 1): Among basical research in ergonomics are counted

- work-physiology, -anatomy, -hygienics
- work-psychology
- work-sociology
- work-pedagogy

ad 2): Among applied ergonomics are counted

- work-technology and
- work-study

These terms oftenly can be used synonymously. Also such terms as industrial engineering and human engineering have to do with work-technology and work-study.

Starting from the usual practice research activities can be subdivided into:

- short-termed programmes and
- long-termed programmes.

Short-termed programmes can be considered the typical way by which experts of other countries normally conduct their studies in the tropics. These programmes as a rule serve the clearing up of special and limited questionings, i.e. they can be considered so called case-studies.

The technical conditions are unfavourable since one expert as a rule only has one set of research equipment with him. This equipment oftenly is not adapted to the test conditions prevailing in tropical field studies. Therefore it must be taken into account that because of this reason much of the rare time - due to the limited character of the programme - will go up for adaptation, repairs and waiting for spare-parts. - Because of the short time available and the overpacked programme the chances for a know-how-transfer to the tropical country cannot be suffiently used.

Long-termed programmes mostly are institu-

tionalized forms of research activities. They can be called to life less spontaneously than short-termed programmes. As a handicap they mostly have to face the following facts: political problems, financial problems, lack of trained staff, suspicion of ergonomics (e.g. that it represents a particularly subtile way of capitalistic exploitation) and others more.

When case studies can only deal with limited part-problems and when the verity of such findings as a rule also is limited, findings can be expected of studies, conducted within the frame of a long-term programme, having a high degree of generalizable results. The pronounced lack of fundamental knowledge in tropical regions in any case asks for an institutionalization of ergonomics which will enable a continuous and covering-all-relations research. Such institutions need not be limited to a national level as they partly will create general results and findings being valid for large geographical regions, such as on working-capacity, working-traditions (e.g. the region of the Andes or the low-lands in the tropical zone of South-America).

Techniques of Ergonomical Research

Ergonomical studies in the rule are conducted as

- experimental studies and/or as
- work studies.

All questions of principle character normally are cleared up by experimental studies. That normally are studies conducted under standardized conditions and the results of which are to give a generalizable statement (e.g. human performance capacity, climate).

Work studies always refer to real states of work. These can be either individual work places or whole work systems. It should be the goal of such studies to analyse existing conditions and to develop them optimally according to the findings obtained.

Objects of Ergonomical Research

A split-up of the objects of ergonomical research within the problem-range of "man-work" is arbitrary. In our case they shall be arranged according to the goals of the individual disciplines[1]; in this context it must not be forgotten that applied ergonomics, first of all work-design without preceding clearing-up of fundamental questions by way of basical research in ergonomics, as a rule is not possible.

In the following report anatomy, respectively anthropometry, hygienics, pedagogy and nutrition will be excluded from the general considerations as they are dealt with under other topics of this symposium.

Work-Physiology

Subject of the scientific interest is man as a biological system under the various influences of his work place. It is the goal of research to explain the biological situation during work and to work out balanced conditions.

The physical aspect comes the more to the front the heavier a work is for the man and/or the more encumbering the influences of the environment are.

A fundamental question of work-physiology is, what an extent of physical work capacity a man has. This capacity - and that especially goes for hard physical work, such as in agriculture and forestry - decides what kind of work a man can be subjected to and over what period and with what intensity he is able to do that kind of work. The limiting values for the expectations vary, but they range in similar dimensions. With this limiting value attempt is made to enable man to accomplish his work free from fatigue. In this context fatigue does not mean that degree of exhaustion showing up in the course of a normal work day involving light work and for which man is prepared; it much more means that kind of exhaustion which shows up as a result of disproportionate physical reactions of the body to overburdening.

In detail here the following determination-values are of importance which can be taken under conditions prevailing in field-studies.

1. Physiological capacity

Under physiological capacity we understand the capability which the human body is able to realize on the grounds of the possible power of his physiological systems. It normally gets expressed by the capacities of the circular system and the respiratory system. For their determination tests are applied during which the physical reactions to defined loads are measured.

2. Endurance-capacity-limit

When the physiological capacity gives fundamentals as to the physiological performance capacity of the biological system "man",

1. An all-ergonomical goal-minded bearing would make the below arrangement appear adequate:
   1. man
   2. environment
   3. work

it is the endurance-capacity-limit that aims for the question, important for work on the job, to find out which load a man can be subjected to permanently without impairment.

Applying the usual methods of measuring techniques the endurance-capacity-limit can be determined as

- energetic endurance-capacity-limit
- circulation endurance-capacity-limit.

The determination of the endurance-capacity-limit by way of the energy consumption (energy-output) mainly bases on a balance concept which is to say that normally nutritioned and trained workers can invest 8.4oo kJ (that equals roughly 2.ooo kcal) per work day in their actual work. As the measuring techniques do not allow all-day studies one normally relies on short-term measurements, which are expressed as minute-values.

For industrial countries relatively unimportant, but for most of the tropical countries of eminent importance is the relation between physical work and the nutrition situation.

As for industrial countries one can well say that the efficient utilization of the physiological capacity is not limited from the side of nutrition. This certainly is not the case in most of the tropical countries as is well known from all existing tables regarding the nutrition situation. This topic, however, will be dealt with in another report in the course of this symposium. So at this place mention only shall be made that for the input - output consideration, respectively the balance-calculation between energy-output and energy-input, it is not advisable to proceed strictly numerically; if one takes for instance 18 kJ/min (4.2 kcal/min) as the tolerable limit for an 8 hours work day and if one finds an energy-output of 36 kJ/min for a specific work then it very certainly is wrong to say that this work can be carried out over a period of 4 hours. The real permissible time will be around 3o minutes only, taken that the work will be done without any interruption.

The circulation endurance-capacity-limit tries to find that work intensity which the blood-circulation can manage without an overproportional increase of its activities. Measurements normally are conducted by way of taking the pulse-rate. The pulse-rate is - in contradiction to the energy-output - a more sensitive but also a more complicated measure for the real load the man is exposed to, since it is not only influenced by the performance itself but at the same time by other factors. As for such studies in the tropics of particular importance seems the relatively strong reaction of the pulse-rate to high temperatures and at the same time its dependency on air-humidity. This interdependence mainly can be explained by the fact that for the upkeep of the thermal balance within the human body the circulation system is strongly involved.

3. Physical work capacity

The physical work capacity results from the physiological capacity in general and the endurance-capacity-limit in particular, with due consideration of all actual events during the work process.

Besides of the nutrition - which already has been mentioned - it will be the climate, respectively the climatical conditions at the work place, which plays the most important role.

As a general principle the climatical situation has to be studied to be able to explain and quantify the interrelations of the physical reactions to climatical influences and as a consequence of such findings work out appropriate counter-measures at the work place.

The climatical tolerances of the human body are relatively narrow. The so called "comfort-range" has been studied; it must, however, be viewed relatively since it depends to a large extent on the activity of man. Seen under work-physiological aspects in this context the most important question is, how man is able to keep the warmth balance of his body in an optimum range. In this respect it naturally is important what kind of work the man is doing, respectively how much warmth he does produce himself by metabolism.

The physiological reactions to climatical influences, which can be taken by way of measuring techniques, are

- pulse-rate
- core temperature
- skin temperature
- sweat production

These data are measured and evaluated separately as well as together with the following climatical data, to size up the situation of the working man:

- air temperature
- air humidity
- warmth energy of radiation
- air movement

The thus resulting aspects of research are very comprehensive and not representable in detail. All of them are very important since they deal with the absolute limitations a man can be subjected to. Just

to give an example mention be made of the very high water-loss of the human body (sweat) during work in tropical climate. Dehydration leads to a pronounced loss of work capacity within a relatively short time, as can be seen from the following data: a liquid-loss corresponding 1 per cent of the body weight leads to an increase of the body temperature of about 0.2 degree centigrade and an increase of the pulse-rate by about 1o beats per minute.

Because of the fact that it practically is not widely known, in this context mention be made at this place of the possibilities to combine measures to eliminate dehydration, that means drinking, with measures against the lack of nutrition. It has been contemplated - and the theoretical possibilities already have been cleared up - to produce a drink for the work time by way of soluble instant-tablets (which would also solve the transport problem), which in each litre of liquid will contain 1.7oo kJ and also the regionally needed enzymes.

The physical work capacity indirectly also can be limited by the choice of the production method. Mechanization partly has had such an unfavourable effect on man that it limits the possibilities for his employment. - The most important influences of mechanization in agriculture and forestry are given by vibration, noise and exhaust gases of machines. By its effects the exposition-time for man - and that is his effective work time - gets more or less, partly even pronounced, limited. It can be taken that these technical influences are of general importance, that is to say that the experiences gained in industrialized countries to a large extent can be applied to tropical countries too.

Work-Psychology

As already has been said ergonomics' concern is the comprehensive design of work. One can well say that physiology brings the indispensable pre-conditions for well-being. It can, however, not in the end lead to a humane work-design without the employment of psychology and sociology since human conditions cannot be reduced to the physis only, that means to the mere animalistic range.

An essential import of work-psychology rests in the individualistic viewing of the working man. When in the physiological range it was still possible to view the work-capacity of man materialistically, the psychological aspect - as one perhaps may say - puts the personality of the "production factor work" into consideration.

For work-psychology a great number of subdivisions exists. In our case work-psychological research is not to appear as an independent matter but under the aspect of an all-ergonomical concept. Therefore the following simple sub-division is chosen:

1. pre-conditions for human performance
2. pre-conditions for human work-behaviour
3. pre-conditions for the human well-being at work

(This sub-division does not indicate preferences.)

ad 1: Pre-conditions for human performance

Under psychical pre-conditions for the performance in this context abilities and skills are to be understood (not, however, the decision for a certain kind of behaviour - see point 2.). These abilities and skills are to be seen relative to the work demands, which is to say that they are related to the work place. As for agriculture and forestry a versatility can be considered typically since there hardly do exist work places with strongly limited duty-spheres as that partly is the case in industries. For the necessary execution of a work-task, that is for the performance, certain skills have to be developed (pedagogics). Pre-condition for these are certain abilities, such as intelligence, concentration-ability, dexterity etc. As for the question, what has to be inherent and what can be acquired, a psychological work-analysis has to be conducted. The answer to this question falls under "applied ergonomics".

If there is a disproportion between the demands on the one side and the skills on the other side, malfunctions are to be expected. These malfunctions find their expressions among others in

- accidents
- fatigue
- poor performance

Therefore this object of psychological research is to be given great importance not only with regard to the humane but also to the production-minded point of view.

ad 2: Pre-conditions for human work-behaviour

The study of the pre-conditions and of the kinds of human behaviour is an important object for the explanation as well as for the understanding of existing situations within an enterprise.

The pre-conditions for human behaviour are extremely multiple and reach e.g. from the historical-cultural to psycho-analytical approaches, which means from very general down to extremely individual aspects.

Among the important pre-conditions for

human behaviour are to be counted:

- the relationship of man with work and
- the relationship of man with the social sphere.

The relationship of man with work covers his attitude to the job in general, to work - that is to the work-place and to the work-task - and often not the least to techniques.

These attitudes are relatively strongly influenced by general cultural backgrounds as well as by topical political, national and regional characteristics. The latter therefore can be objects of psychological research too.

The relationship of man with the social sphere mainly concerns colleagues and superiors but likewise the private sphere (family). In this case attitudes of man seem mainly culturally determined in as much as mainly behaviour-expectances and normative conceptions are concerned. - This aspect gets especially topical if experts from industrialized countries or of any foreign country in general work together with the native rural population in tropical countries. In a case like that psychological studies are important as early as in the very phase of collaboration.

Regarding these aspects - i.e. performance and kinds of behaviour - a considerable trend of research has been developed and that in general psychology as well as in work psychology.

Motivational Research

It makes endeavours to explain the causes for human behaviours and to make its various kinds understandable. This mainly concerns kinds of behaviour and conduct, which e.g. are not rooted in certain abilities and skills, but in inherent, personally-conditioned events and attitudes.

Each goal-minded conduct bases on a motivation for this conduct. The extent and strength of motivation depends on the motives. Principally in motives inducements, stimuli and wants can be seen creating a kind of tension and expectation aiming for fulfilment and gratification. - Motivation can be termed as the expectation and the state of inner tension evoking a decision and an action.

ad 3: Pre-conditions for the human well-being at work

Human well-being at work and on the job, oftenly also termed as "work-satisfaction", counts among the most important objects and goals of work-psychology. That involves the

- pre-conditions for work-satisfaction
- measures to obtain work-satisfaction and
- determination of the degree of work-satisfaction.

This satisfaction can refer to e.g.

- operational conditions (work-place, work-demands, organization, etc.) and
- social conditions (social atmosphere, colleagues, style of management, acknowledgement of the performance and of the job, etc.)

Work-satisfaction is closely connected with a general life-satisfaction. It has to be borne in mind that negative situations within the private sphere may well show affects on the work-sphere too.

Within the endeavours for the "humanization of work", work-satisfaction can be considered one of its most important goals. It is a touchstone of all psychological work-design.

Work-Sociology

The individualistic consideration of man finds its limitations for the well-balanced and complete ergonomical viewing in the social range: the community, in which a man normally lives and works, is a pre-condition not only for his performance but also for his well-being.

The object of work-sociological research is the social import of work. That concerns

- the effects of work on the social live of man as well as
- the effects of the social life on work.

These aspects of social research refer to

- the non-operational social structures and processes and
- the enterprise as homogeneous social structure.

Sociological research in tropical rural regions at its start is making endeavours to outline typical ways of life, including their cultural relations as far as possible in collaboration with cultural-anthropology. This involves not only structural points of view, such as classes, family structure, kinds of settlement and housing, but also the reasons for typical common ways of behaviour (norms) of the various holders of social roles and of the groups as a whole. That would give a more or less differentiated picture of the social structure and also of the dynamical processes within the society of a region and thus first possible consequences for ergonomics: e.g. group- or class-minded re-

cruitment of workers and personnel, operational regulations under due consideration of the general social life-rhythm, choice of proper locations, supply facilities.

Within the scope of a non-operational consideration mention should be made of an object, oftenly studied by sociology, which has a strong relation to work problems: the social mobility. In this case social phenomena cannot be viewed locally in relation to work, but they much more can lead to an over-national social-political purport. An oftenly cited example for tropical countries is: rural exodus on the one side and foundation of slums in the outskirts of cities on the other side. One can well say that in the endeavour to increase agricultural and forestry activities not only the production but likewise social-political ideas play a role.

The aspects of work-sociological research are so manifold that at this place they cannot be dealt with in detail. Some of them, which to the rapporteur seem important because of their relation to ergonomical research and general contemplation, shall be mentioned in catchwords:

Non-operational aspects:

- social history of work (related to the region)
- professional ideology
- tradition
- occupational rise
- choice of occupation
- occupational status and its effects
- work and property
- occupational institutions
- occupation and family
- sociology of the labour market
- scientifical aspects of a progressive social strategy
- reflections on social-cultural "shortsightedness" of those having to make decisions in work life
- analysis of social situations with respect to work
- analysis of political situations with respect to work

Operational aspects:

- work situations
- working groups (formal - informal; structure - dynamics)
- work conflicts.

Applied Ergonomics

There is a great number of namings for that discipline of ergonomics applying its fundamental knowledge and designing work. In our case we shall use the naming:

Work-Technology

Objects of work-technology are not the general statements as to pre-conditions and situations but the concrete work situation which is to be studied and improved. The approach to that goal is split up into the detection of the

- presently existing state of work by means of analytical research and the development of the
- desired state of work.

To achieve this goal all fundamental knowledge of the individual disciplines is made use of and partly also of their research-techniques (e.g. cardio-respiratoric load- and strain-studies of a certain work).

The objects of work-technology are in detail

- man
- work-place
- work-substance
- working-methods and -organization
- social environment

This review on purport, kinds, techniques and objects of ergonomical research in tropical agriculture and forestry cannot be considered complete. It is meant to give an impression of the complexity of ergonomical aspects. In particular the practice of field-studies in the tropics would be a worth-while object for longer comments since the very simple every-day experiences, which up to now are still rare, are of vital importance for the success of programmes.

The comments necessarily lead to the question, what kinds of ergonomical activities should be conducted in a tropical country in the fields of agriculture and forestry. Therefore annexed there will be a plan basing on a relatively small institution (3 to 5 researchers plus technical personnel). The subject-proposals are grouped in a subject-related and in a time-related sequence basing on the assumption that ergonomically relevant knowledge for the time being does not exist. The temporal grouping in phases is to say that for each phase a period of 3 to 5 years has to be calculated; because of the usual difficulties at the very beginning, the first phase

will have to be given a longer time than the following ones. - The research-plan in this proposal is combined with a training-plan. To talk about that will exceed the topic of this report. It is, however, considered useful and necessary as it makes sure that the findings of research directly can be transferred to practice and that at the same time research steadily gets impulses from practice and thus can optimally fix its position.

Resumen

Puede considerarse la ergonomía como la condición necesaria para proteger los intereses esenciales y sociales del trabajero y para conseguir la producción máxima que va unida. Actividades ergonómicas parecen ser de suma importancia en casos en los que la situación humana está poco avanzada y los métodos apropiados de producción aún están siendo examinados y perfeccionados. Este es el caso de la esfera de agricultura y silvicultura trópicas.

Condición para actividades ergonómicas son las investigaciones ergonómicas.
En primer lugar hay que aclarar las dificultades fundamentales respecto a la situación del trabajero para que se consiga en la ejecución el grado óptimo de la situación humana y del sistema de producción, comprendiendo en le posible todos los factores pertinentes.
En cuanto a la agricultura y silvicultura trópicas un fuerte aumento de actividades es de esperar en fecha próxima. Las condiciones especiales de los paises en estas regiones a menudo darán prioridad a métodos de producción que extenderán el capital y reforzarán el trabajo. Esto dará una amplificación de tales métodos de trabajo que hay que calificar de arduo trabajo físico. Por tanto las investigaciones ergonómicas al principio tienen que dar prioridad a los aspectos fisiológicos, ya que en esta esfera se encontrarán los mayores peligros immediatos para el trabajero. No hay olvidar, sin embargo, lo psíquico y social de la existencia humana dentro del trabajo.

Se tratará de aspectos generales de las investigaciones ergonómicas tanto como de proyectos y objetos particulares de las individuales disciplinas científicas de la ergonomía. Por medio de un ejemplo teorético una tentativa ha sido hecha por un instituto menor de investigaciones de mostrar de un lado las posibilidades de investigaciones ergonómicas relacionadas al tiempo y de otro lado los proyectos que se considera necesiten investigación.

Résumé

La science du travail peut être considérée comme la condition préalable à la sauvegarde des intérêts vitaux et sociaux du travailleur et à l'optimalisation de la production en fonction de celle-ci. Les activités en matière de science du travail paraissent avoir une importance majeure dans les cas où l'homme se trouve dans une situation de développement moins avancé et les méthodes de production appropriées en sont encore au stade des recherches et du développement. On considère que c'est là le cas de l'ensemble de l'agriculture et de la sylviculture tropicales.

La condition préalable aux activités en matière de science du travail est la recherche dans ce même secteur.
A ce sujet, il faut commencer par clarifier les questions fondamentales concernant la situation du travailleur afin d'atteindre - en cours d'application - à une situation optimale tant pour l'homme que pour le processus de production, en tenant dans la mesure du possible de tous les facteurs (qui s'y rapportent).
Dans le domaine de l'agriculture et de la sylviculture tropicales, il faut s'attendre dans un proche avenir à une forte augmentation des activités. La condition spéciale des pays de ces régions font qu'ils donneront, dans nombre de cas, la priorité à des méthodes de production extensives sur le plan des capitaux et intensives sur le plan de la main-d'oeuvre. Cela conduira à un accroissement des méthodes de travail que l'on décrit comme travail physique dur.

C'est pourquoi la recherche sur la science du travail devra donner une plus grande importance aux aspects physiologiques de la question, puisque c'est ce domaine qui présente les dangers directs les plus graves pour le travailleur. Ceci ne doit cependant pas mener à négliger la partie psychique et sociale de l'existence humaine dans le travail.

Les aspects généraux de la recherche en matière de science du travail seront étudiés ainsi que des projets et des objectifs particuliers aux disciplines scientifiques diverses de la science du travail. Au moyen d'un exemple théorique d'un petit groupe de recherche institutionnalisé, on s'efforce de montrer, d'une part, les possibilités par rapport au temps de la recherche en matière de science du travail et, d'autre part, ces objectifs que l'on estime devoir nécessairement étudier.

Appendix

Plan of activities of an ergonomical research and training institution for tropical agriculture and forestry

Research Unit	Training Unit
	First phase
Physiological studies: - physiological capatities - living conditions - climatic conditions - nutrition - endurance-capacities - physical work-load	- inventory of current tools and equipment; elimination and/or supply according to the regional situation (e.g. know-how of workers and personnel) - inventory of services for tools and machineries - contacting manufacturers of tools and machineries for ergonomical, technical and economical adaptation and improvement - survey of educational state of personnel and workers - formation of a training group for demonstration of "perfect and modern" work
Psychological studies: - environmental influences - qualifications: intelligence, learning - fatigue, accidents - man-work relationship - motivation: cultural background	
Sociological studies: - social structure of rural population - living attitudes (background) - mobility - labour market	
Work studies: - time - working procedure - work out-put	
Technical studies: - adaptation and/or development of investigation-equipment - tools and machineries	

Appendix

Plan of activities of an ergonomical research and training institution for tropical agriculture and forestry

Second phase

Research Unit

Physiological studies:

- prove and control of work-improvement
- "static" work-load
- vibration and noise
- radiant heat and clothing
- cataloguing "desired states of work" of all working procedures
- feeding and cooking advices

Psychological studies:

- analysis of typical requirements (e.g. communication: demands, satisfaction, frustration)
- learning: concentration, quickness, retardation, fatigue, perceptation
- motivation: improvement

Sociological studies:

- group dynamics (formal and informal groups)
- leading and cooperational behaviour
- absenteeism, failures, mal-production
- conflicts (e.g. strike)
- changes in living conditions caused by increasing agricultural and forestry activities

Work studies:

- work-process-organization
- organization of operations

Technical studies:

- improvement of tools and machineries: importation/adaptation and development of new tools and machineries for better effectiveness
- improvement of tools and machineries under the aspect of accident-prevention

Training Unit

- planning of courses for personnel and workers (subjects, methods, materials etc.)
- conducting courses: evaluation of results for improvement of further courses

- working out teaching instructions
- working out working instructions
- working out instructions for accident-prevention

- feeding and cooking instructions
- installation of 'flying courses' with the training personnel
- contacting and preparation of activities in agricultural and forest industries

Appendix

Plan of activities of an ergonomical research and training institution for tropical agriculture and forestry

Research Unit	Training Unit
Third phase	
Physiological studies: - special fatigue-studies for accident-prevention - evaluation of physiological working standards	- preparing teaching material for technical schools and other teaching institutions - editing periodicals for instruction of workers and personnel - formation of training personnel of other regions
Psychological studies: - psycho-physical rhythms and performance, work-rhythms and accidents - satisfaction by work and profession	
Sociological studies: - arising norms related to job and profession - work as social process: social rise, status, prestige etc.	
Work studies: - work evaluation (scaling jobs) - evaluation of organizational systems	
Continuous activities in all phases	
- medical examinations should be provided regularly - physiological investigations of all work and working conditions - psycho-sociological investigations related to general problems (background questions etc.) as well as to actual situation (e.g. conflicts, accidents) - work studies related to theoretical and to practical situations - improvement of operations by way of establishing "desired states of work" - technical studies to improve tools, equipment and machinery - screening international literature	- training at any level - preparing of training material

GENERAL ASPECTS OF TEACHING ERGONOMICS

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Summary

Basic aspects of the ergonomic education and its problems are reviewed. Following items are discussed.

* Ergonomics is considered being a distinct science, characterized by a specific interlace of human and technical aspects.
* Three educational levels and the relevant aims are described.
* The importance of integrating Ergonomics in relevant teaching subjects at all levels is stressed.
* At the higher levels it is recommended to teach Ergonomics as a distinct subject.
* Specified teaching programs are discussed, as well as extra-curricular courses.
* As to teaching methods the use of checklists, case studies and various exercises is reviewed.

Ergonomics, a science

As to the definition of Ergonomics various descriptions are used, which all show on the one side a general correspondence in the main elements, on the other side differences in accents and borderlines. Relevant discussions are hardly useful, because all arguments may be sound, and no final solution will be found which is completely satisfying to everybody.

For the present review it will be sufficient to formulate the heart of the matter. The most simple but nevertheless adequate characterization of Ergonomics is "fitting the job to the worker". A newer formula is: "optimizing man-task-systems in view of the worker's health, well-being and efficiency".

This basic idea has given birth to a new science describing how and why it should be done. Consequently, the major elements of Ergonomics are:

- the technical part, labelled as "Applied Ergonomics", implying the practical aspects of optimizing work places, machines, tools etc.
- the human part, describing the physical, mental, psychological characteristics of man, for instance in terms of measures and reactions, capacities and limitations.

The relevant human knowledge, provided by research in the fields of Anatomy and Anthropometry, Physiology and Psychology, is an indispensable basis for formulating the ergonomic directives for the practical application.

The question whether Ergonomics might be called a science also meets a considerable difference of opinion. There are some arguments in favour of it. The unique marriage of human and technical aspects causes specific problems which are tackled and solved in specific ways. The ergonomic analysis, evaluation and optimization of man-task-systems and man-machine-systems definitely is an independent specific approach. This may be reason enough to promote teaching Ergonomics as such, as an independent teaching subject to those students who need a thorough ergonomic knowledge.

Educational levels and aims

Next point then has to be a discussion of the aims of the teaching in relation to the educational levels. The general aims of the ergonomic education are: developing an "ergonomic eye", ergonomic thinking and skilful use of ergonomic methods and techniques.

As to "Ergonomics in Agriculture and Forestry" schematically three educational levels may be distinguished:

1. A primary level: the practical level of the lower vocational schools and courses.
2. An intermediate level: professional technical education and training; higher vocational schools and courses.
3. A highest level: university education.

This simplified scheme may be useful for characterizing the essential educational differences.

Based on this scheme, the aims of teaching Ergonomics may be indicated in following rough description:

1. At the primary level the student should learn how to perform the work in an ergonomically adequate way and how to avoid risks, detrimental influences, fatigue and errors.
2. At the intermediate level ergonomic know-how should be transmitted with which the student will be able to detect ergonomic problems and to contribute to an ergonomic design of the work place, machine, environment etc.
3. At the highest level experts should be educated who will contribute to the development and realization of Ergonomics in education, research, design and management.

Finally, the ultimate practical result of the education i.e. a farmer or forester, a teacher or research worker, a designer or manager, may greatly influence the actual program of teaching.

Ergonomics in the curriculum

From the preceeding paragraphs it may be concluded that "Applied Ergonomics" is an important feature of all educational levels.

Considering the way of its presentation, first of all, it should be stressed that the most effective approach is "ergonomizing" other relevant teaching subjects i.e. integrating Ergonomics as a natural and compelling aspect in all subjects where work situations, machines and operations are discussed. Such subjects are for example "Agricultural Engineering", "Forestry Operations", "Work Study" etc. Ergonomized subjects may be useful at all educational levels and the integrated presentation is essential and indispensable for a successful realization of Ergonomics in the practice.

At the primary educational level it may be sufficient to present Ergonomics only in this integrated way. It will include at most some rudimentary ergonomic background information. Introducing more basic ergonomic knowledge in an other subject will meet difficulties, partly because of the limited time available, partly because of the fact that human details and arguments proceed from an other scientific discipline, being discording elements which hardly fit in a technical program.

Consequently, in cases where more than a rudimentary background information is desirable, the need of teaching Ergonomics as a proper subject arises. In many schools at the second level this would be very useful. Particularly for those students who eventually have to deal professionally with human work and work situations, an adequate ergonomic education is highly desirable. The higher the educational level, the more an extensive treatment of the subject will be needed.

According to this view, in all higher education in the field of Agriculture and Forestry Ergonomics should be taught as such at full extent and thoroughness. University graduates who will handle ergonomic problems need a profound knowledge of the human aspects. They should be familiar with ergonomic philosophy. They should be trained in using ergonomic methods and techniques.

It is much easier to formulate the requirements of the lowest and highest levels than describing the whole range of educational varieties in between. In principle, it seems to be possible to conceive an appropriate ergonomic teaching program for every specific situation. However, at the intermediate level it is often difficult to find an opening in the curriculum for introducing a new teaching subject. A solution may then be presenting the required lessons by a supplementary course. Such courses may also be very helpful and effective for the additional education of older workers, particularly teachers at vocational schools in Agriculture and Forestry.

Teaching programs

If Ergonomics is included in the curriculum as a distinct subject, the question arises how to present it. The problems to be discussed then are the basic design of the teaching program and its specification in details.

When reviewing existing programs, a striking variety is noticed. The whole range of various conceptions is obviously the result of different historical developments, greatly influenced by the disciplinary background and interests of the involved teachers.

Considering the matter in general and sticking to the statement that "Applied Ergonomics" is the heart of the ergonomic education, it will be clear that the teaching program should reflect that predominant position. Consequently, even in the most extensive programs the human part, how important and indispensable it may be, can not be more than a complement. Therefore, it should principally be rejected to present the relevant background information by human chapters such as "Anatomy", "Physiology" etc. There is little sense in teaching for example physiological details separately and disconnected from their function and significance in practical respect.

The most adequate presentation is an appropriate interlacing of the human and technical aspects. Also from a didactic point of view it may be clear that Ergonomics will be understood better, if these aspects are taught together in their relationship.

The most useful approach as to the theoretical part seems to be basing the program on a work load specification (Table 1). The scheme given here is simple and convenient. The order of the items is arbitrary. Every item constitutes a distinct and complete chapter which includes the relevant technical and human features in an inseparable connexion (Tables 2, 3 and 4).

This program and its detailed specifications are only examples giving a general indication. The lists may be reduced or enlarged ad libitum, depending on the educational level, on special interests or on the time which is available for the subject.

When analysing existing teaching programs, for example at Technical Universities, in many cases the same basic conception of a work load approach is found. Maybe the scheme of the presentation is different. Generally, there is little advantage in using special schemes.

So far only the theoretical part of the ergonomic education has been discussed.

Table 1. Example of an ergonomic teaching program based on a work load specification.

* General introduction
* The energetic work load; rest pauses; mechanization
* Working posture and movements; anthropometrics; locomotor strains; work place design
* Climate; clothing
* Visual perception; light
* Information processing; perceptive and mental work load; displays and controls
* Psychological influences and strains
* Noise
* Vibration
* Toxic gases and fluids
* Dust
* Safety
* Overall work load analysis and evaluation; case studies; systems approach

* * *

Table 2. Example of a specification of the Chapter "General introduction".

* Historical development; definitions; aims and effects
* Survey of the field and its limits; basic disciplines
* Man and work, work place, tools, environment etc.
* Work load and its effects
* Working capacity; adaptation and failure
* Influence of age, sex, race, disability
* Work load analysis and evaluation
* Exposure limits considering health, performance and well-being
* Work optimization: approach, methods and effects
* Interaction of influences; systems approach

* * *

Table 3. Example of a specification of the Chapter "Energetic work load".

* Physiological processes during muscular work
* Physical working capacity, training, fatigue, recovery
* Measurement of the energy expenditure; methods and equipment
* Heart rate recording; methods and equipment
* Applicability of the measurements and results
* Evaluation and classification of the physical strain; limits
* Directives for optimizing the work load
* Organization of rest pauses
* Influence of mechanization

* * *

Table 4. Example of a specification of the Chapters "Noise", "Vibration" etc.

* Technical specification of the work load and circumstances
* Measurement of the work load and circumstances
* Functional and pathological effects on man
* Measurement of the effects
* Evaluation of work load and effect, according to the basic criteria
* Directives for optimizing the work situation
* Technical measures and its effects
* Other measures (personal protection, work organization, selection of workers) and their effects

* * *

Table 5. English books presenting an introduction to Ergonomics.

Edholm, O.G.	The biology of work Mc Graw - Hill Book Comp., New York 1967
Grandjean, E.	Fitting the task to the man Taylor & Francis, London 1969
Murrel, K.F.H.	Ergonomics Chapman & Hall, London 1965
Shephard, R.J.	Men at work Thomas, Springfield (Ill. USA) 1974
Singleton, W.T.	Introduction to Ergonomics WHO, Genève 1972

* * *

Teaching methods

As to the theoretical part, the subject matter is ordinarily presented by lectures illustrated by projection of slides or overhead sheets. Under the present generation of students there is an increasing dislike of listening passively. An alternative approach is giving them an appropriate textbook and using the lecture hours partly for additional comments and illustrations, partly for discussions and maybe even more extensive contributions of the students themselves. The success of this approach however, depends on the availability of an adequate textbook, and on the involvement of the students.

An essential complement to the theoretical part is the practical ergonomic education. It includes demonstrations of ergonomic methods and techniques. Sometimes it is supplemented by relevant exercises and training by the students themselves. The latter approach may be questionable to some extent. Being more familiar with an ergonomic method will indisputably contribute to a better understanding of its usefulness. However, how far can agricultural and forestry students be expected to understand the essential problems of specialistic physiological and psychological techniques?

Heart rate recording for example is a simple measurement. Everybody can easily determine the heart rate of workers by means of a stopwatch only. And everybody who has practised it may think to be master of the method. In fact he is not aware of its pitfalls. It is hardly possible to apply such a method adequately without a more extensive physiological education. Consequently, this basic education should be considered a prerequisite in cases where relevant exercises and training is part of the program. The same applies to psychological methods.

As to the practical part of the ergonomic education there are some other useful approaches to be mentioned, such as for example performing case studies. In a case study the students get in touch with the complexity of a work situation, the interaction of factors and the practical limitations. A case study may be a useful exercise in problem solving.

Special attention should be paid to the use of ergonomic checklists. A checklist is an indispensable expedient for exercising an ergonomic analysis and evaluation. Moreover, a checklist can be successfully used in the practical education, particularly to demonstrate ergonomic details.

University students have to study books and other publications. Therefore on the highest educational level relevant exercises in reading and evaluating research reports and articles critically are highly recommendable. The students should learn to evaluate the design of an investigation, the statistical aspects, the presentation of the results and the justifiability of the conclusions. That requires a specific training, which is also important with regard to Ergonomics, because there are some criticizable publications in this field.

In a preceeding paragraph it has been mentioned that extra-curricular courses may be useful for the additional education. In principle, the theoretical part of such a course can also be based on the standard program which is given in Table 1.

At the intermediate level an adequate introductory course can be realized for instance by a corresponding program during 1 week, or during 4 days or 8 half days of successive weeks. The complementing practical part comprising demonstrations, ergonomic analysis and evaluation by means of checklists, and case studies will take some days in addition.

More elaborate courses in the scope of a supplementary professional education may be built on the same scheme. The extent and thoroughness of its presentation depends on the character of the course and its specific purpose.

Final remarks

In this paper it has been tried to review some basic aspects of the ergonomic education and its problems. It is hardly possible to give a complete review, nor to present appropriate solutions for all educational situations.

Some aspects have not even been mentioned, such as the required qualifications of the relevant teachers. Another open question is for instance: would it be useful, or even desirable, to educate not only "ergonomized" workers, managers, designers, teachers etc., but also pure ergonomists?

Finally, it may be left to the next speaker and to the following discussion to complete the subject.

Resumen

Se estudian aspectos fundamentales de la educación ergonómia y sus problemas. Los siguientes asuntos son discutidos.

- Se considera la ergonómica una ciencia distinta, caracterizada por el entrelazamiento específico de aspectos humanos y técnicos.
- Se describen tres niveles educacionales y los propósitos pertinentes.
- Se recalca la importancia de integrar la ergonómica en temas pertinentes de ensenanza a todos niveles.
- A niveles más altas se recomienda ensenar la ergonómica como tema distinto.
- Tanto los programas especificados de ensenanza como los cursos extracurriculares son discutidos.
- Een cuanto a métodos de ensenanza se examina el uso de listas de control, estudios de casos selectos y varios ejercicios.

Résumé

Les bases de l'enseignement de l'ergonomie et les problèmes dans ce domaine sont traités. Les points suivants sont passés en revue:

- L'ergonomie est considérée comme une science indépendante, caractérisée par la relation spécifique entre les aspects humains et techniques.
- L'importance d'intégrer l'ergonomie à tous les niveaux dans les disciplines concernées est soulignée.
- Il est recommandé d'enseigner l'ergonomie aux niveaux supérieurs comme une science indépendante.
- Des programmes d'études détaillés sont traités ainsi que les cours qui ne rentrent pas dans le cadre des études normales.
- En ce qui concerne les méthodes d'enseignement, l'emploi de listes de contrôle, l'examen de cas spécifiques et plusieurs exercices sont passés en revue.

TEACHING ERGONOMICS IN TROPICAL COUNTRIES

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Summary and Introduction

In this paper a series of examples is given of attempts made by Swedish ergonomists to select the relevant facts for Ergonomics teaching in tropical countries, mainly within the forestry sector. Furthermore it is discussed how to present these facts effectively in the teaching situation and mention is given to other factors related to the establishing of an adequate Ergonomics teaching. Emphasis is put on circumstances which characterize intermediate and high educational levels.

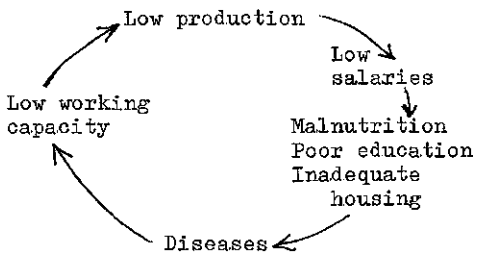
The task - to meet the needs

As professor van Loon stated above, the heart of the Ergonomics matter may be characterized as "fitting the job to the worker". Or, to use a newer and more detailed formula: "optimizing man-task-systems in view of the worker's health, well-being and efficiency". To approach these different goals one has to concentrate one's efforts to a best possible optimization, using knowledge from fields as far apart as technology of different kinds, anatomy, work physiology, experimental psychology, social psychology, etc.

The human being is a very adaptable creature, as stated by professor Edholm in his excellent introduction to Ergonomics, "Biology of Work". Man can adapt to inadequate arrangements of climate and ventilation, illumination, accoustics, etc, and by applying strange body positions he can even manage badly designed machines and working equipment, etc. He can also adapt to monotonous or extremely heavy tasks. This type of adaptation of man to work may be anatomically, physiologically and psychologically necessary in the working situation, but when frequently repeated it brings unfortunate effects on the efficiency of work as well as on the safety, health and well-being of the man.

In order to put the Ergonomics subject into a total picture of a tropical reality, the so-called "Economic Cycle of Diseases" might be useful as a starting point. See Figure 1.

Figure 1. The so-called "Economic Cycle of Diseases"



The "Economic Cycle of Diseases" constitutes an unsophisticated model, ignoring the problems and the possibilities related to the distribution of wealth within a nation and between nations. Therefore, the relation indicated between economical development and health is in reality much more complex than shown in the diagram. In this context, however, it may serve the interest of clearness to start from such a simple model.

As many tropical countries are characterized by the vicious circle of low production, low salaries, malnutrition, diseases and low working capacity (for individuals as well as large groups of the population), the task of the Ergonomics research and teaching should be to try to contribute to the breaking up of this circle. The contribution of Ergonomics might be indicated by the definition of the subject, given by professor van Loon and cited above: "optimizing man-task-systems in view of the worker's health, well-being and efficiency". It is here suggested that the Ergonomics concept should be applied, above all, in improving worker's health and safety, working methods and tools, and in controlling and improving the work environment. The latter point, concerning the environment, is of special interest and importance considering the negative effects of the mechanization and industrialization process, that have occurred in the industrialized countries.

Problem areas

A series of highly prestigious reviews of the important Ergonomics research areas in tropical countries are presented under the heading "The Tropical Worker". Approaching the teaching of Ergonomics, some additional statements will be made here about the content of the teaching. Which problem areas and what kind of facts should be selected for the Ergonomics teaching?

Even if different tropical countries have reached different levels of economical development, nutrition and health constitute an important problem area, that should be considered in Ergonomics research and teaching activities in most tropical countries. Closely related to the worker's nutrition and health is his working capacity. These problems are especially important in the agricultural and forestry sectors, where a great deal of the work done is manual or semi-mechanized work.

Christensen (1966) suggests that low energy content of the food might constitute a factor of at least the same importance as the heat stress when explaining low productivity of workers in tropical countries. Nothing is more expensive for the industry in a country than undernourished workers. It is a catastrophe not only for the individual worker, when the great part of the food's energy content is needed for preventing him dying of starvation. This also makes it almost impossible for a country with increasing population ever to come out of such a situation. The energy reserves necessary for production relatively seen get smaller and smaller, at the same time as an increasing production is the only remedy for the disaster. Professor Christensen suggests that a rationally arranged supply of meals to the manual workers might be a decisive factor for production in many developing countries.

In this connection it may be mentioned that, according to the Food and Agriculture Organization (1976), the food production per capita has decreased during the period of 1970-1975 in India (9%), Bangladesh (12%), Africa (6%) and Latin America (3%). During the same period the food production has increased in the industrialized countries of the world (5-10%).

In an ergonomic pilot study of Thai workers in heavy road construction activities, Eriksson et al (1974) found that 16 out of 21 workers had some symptom of poor health, although all persons studied were young. Furthermore, they were recruited from an area in which the National Health Services seemed to be better developed than in rural areas in Thailand in general. The findings included malaria, anemia, ongoing infections and post-infectional weakness, intestinal parasites, frequent headache, low back insuffiency, etc. Evidently such conditions are likely to affect the working ability in a negative direction. The studies gave several indications of occupational health measures which could be recommended for future use.

Rennie (1977) reviewed a series of studies on forestry and civil construction workers in India and Indonesia and came to the conclusion that the working capacity (the maximal aerobic capacity) is reduced in proportion to body size, but sustained working capacity is decreased further by the effects of disease and malnutrition.

Heat stress is per definition a classical problem related to manual work in tropical countries.

Data in the literature on the influence of heat on output during prolonged physical work are scarce. There are, however, studies by Wyndham (1970), which are of great interest in the present context. He found that an influence on output of work begins at an effective temperature of about 25°C. At 27.5°C the decrease was about 5% and at 32°C it was about 30-40%, different levels being obtained for different air velocities. The accelerating decrease of output with increasing effective temperature, illustrates the necessity of making quite comprehensive observations in the practical work situation, if one wants to evaluate the influence of heat on work output with a reasonable degree of accuracy.

An analysis by Axelson (1974) has thrown further light on these problems. Using data provided by Wyndham and a trial and error approach, Axelson suggests a reasonably unsophisticated formula for predicting the productivity reduction due to heat stress in moderate and heavy physical work. For rough approximations the formula might be taken as

$$R(t)\% = 0.5\ (t - t_0)^2,$$

where R(t)% is the %-reduction of working capacity at temperature t° ET, and t_0 = 24° ET.

Working methods and tools represent another problem area worthy of Ergonomics research and teaching in tropical agriculture and forestry.

Hansson et al made an Ergonomics study of men and tools in Indian logging operations (1966), as a part of a United Nations Special Fund Logging Training Project. They were able to indicate several ways of achieving higher productivity and occupational health and safety at low cost through fitting the work and the tools to the man and his environment. Here are

some of the results:

-Tests on Indian forest workers showed that their working capacity per unit of body weight was comparable to that of Scandinavian forst workers. The body weight of the Indian forest worker was only about 70% of the Scandinavian's, and his ability to perform heavy muscular work was about 65% of that of the Scandinavian. Logging tools with high physical demands which are suitable in Scandinavia may be impracticable in India, for example, the Swedish one-man crosscut saw.

-Physical measurements in logging operations in the Kulu Valley and Kansro Range showed that the relative work intensity of the workers was about the same as for Swedish forest workers. In continuous work, about half of the maximum aerobic working capacity was used. Felling by saw, lopping of standing trees, turning of logs and loading of timber cause a very heavy local load on the back-muscles, and hence a risk of injury.

-Special studies on saws, axes and work technique resulted in the following recommendations, among others:

.Bowsaws were more effective than other manual saws, and can be recommended for felling (two-man work) and cross-cutting of trees (one-man or two-man work) for dimensions of up to 12". For larger dimensions, a two-man crosscut saw is the most suitable manual saw.

.In felling and cross-cutting large hardwood trees, a power chain is preferable to manual saws, principally because of the limited physical working capacity of the Indian forest worker. This implies the building-up of a service organization, and training in work-technique, etc.

.The need for practical filing equipment and training in using these aids, was clearly shown by the measurements and observations.

.Rolling, turning and pulling logs, loading timber on to trucks and lopping standing trees were, by the physiological measurements, found to be very heavy work, and sometimes also risky. Recommendations were given to carry out more thorough studies, and, in certain cases, to use special tools, for example, pike poles for turning logs.

Prevention of accidents and occupational diseases represents a fourth problem area, here proposed to be included in any Ergonomics teaching programme in tropical agriculture and forestry. This broad and important area is closely related to earlier mentioned areas of heat stress, working capacity, working methods and tools, etc, and furthermore deals with risks of accidents and diseases caused by poorly designed work processes and operations, dangerous materials, air pollution, noise and vibrations, etc.

Teaching

Hitherto very little has been said about teaching Ergonomics, although that is the topic of the paper. Most of the text has dealt with research data from different ergonomical problem areas of supposed relevance to tropical forestry and agriculture. This may be considered as an attempt of the author to underline that Ergonomics teaching -especially on intermediate and high educational levels- should be very closely related to active research. And, in fact, the basic intellectual process involved in applied research is very much the same as in good education.

Traditionally, research might be defined as the systematic search for new knowledge and new ideas, whilst education might be defined as the systematical transmittance of new and old knowledge and ideas. These definitions have the disadvantage of establishing a limit between the search for knowledge and the transmittance of knowledge. The precondition is that one process (research) is finished before another process (education) starts. It is here suggested, however, that good education requires an active search for knowledge by the student, rather than a more passive receiving of transmitted knowledge. Even the teaching situation should include a continuous evaluation, criticism and questioning of theories and empirical material.

How should this tasty cake be baked? The suggested recipe is: Confront the theories with practice! It is an oversimplified recipe, but it may allow the identification of some essential ingredients in good Ergonomics teaching.

-First of all, the teaching situation in itself might be regarded as a confrontation between theories and practice. The organizers, the teachers and the educational material (textbooks, etc) representing the theories, the students and their actual or future jobs representing the practice. If the organization of the education allows students participation in different planning stages, the process of education is likely to develop not only more smoothly but also more efficiently. In addition, students participation might be considered as a mean for democratization of the educational process, and therefore being a goal in

itself.

Different goals and procedures must be linked to the students participation in the planning of education, depending primarily on the student's earlier experiences from working life. In vocational training of students with no experience from working life, the initial planning will get a stronger and more adequate injection if the students are replaced by, for instance, representatives of former students or representatives of the adequate professional association.

-The student's earlier experiences from working life is a factor of basic importance to the teaching process. Ambitious courses on Ergonomics, Industrial Hygiene, Occupational Safety, etc, have been included in many vocational school programmes, giving highly unsatisfactory results. It is sometimes said that the students were lacking motivation for the subject in question. This, however, often gives the teacher the idea that he has been a poor pedagogue, which is not necessarily a meaningful and fair explanation. The students' experience from working life is such a basic requirement for Ergonomics teaching, that if it is non-existent it cannot be replaced by even the best teacher and pedagogue.

If the students have no or little experience from working life, but there are possibilities to spread out the theoretical training over a longer period and also include practical training in the course, such a course may be very successful. The confrontation between theories and practice may be even more fruitful if it can also be arranged so that the students are allowed to make a case study, special assignment, etc, performed during the practical training and presented and discussed during a final, theoretical training period.

-Also in a course with no period of practical training involved, there are methods for confronting the theories with practice. Professor van Loon has suggested case studies and the use of checklists, amongst other things. As an example of how to apply and combine these methods, here is described an exercise that has been arranged successfully as a part of many Ergonomics courses given in tropical countries as well as in Sweden.

.Topic

Ergonomic evaluation of work processes, work operations, work places and/or machines and working tools

.Aims

To experience the problems and possibilities related to the application of ergonomic thinking. To stimulate further studies.

.Duration of the exercise

At least one day, if possible one-and-a-half or two days

.Pre-requisites

The exercise should occur in the middle or at the end of a course, after studying the basic fields of Ergonomics and the principles of the methods and techniques to be applied.

The exercise has to be carefully planned by the responsible teachers, officials at the working place and also by the students.

During the exercise, the students should have access to necessary checklists, handbooks, simple tools for measurements and material for presentation of the findings (big sheets of paper, over-head-projection-material, etc).

For more complicated measurements, the teachers should provide the expertise. If available, photographic or video-presentation of work operations may be a very useful part of the preparation of the exercise and at the final discussion.

.Plan of the exercise

1) 1-2 hours of information and discussion about such factors as organization, economy, production prospects, work force situation, etc, should be carried out in relation to the actual area of work, industry, plant or production process.

2) 3-5 hours of observations, measurements and interviews at the work place in question. The students should be working in groups of 2-5 persons. The teacher assists.

3) 2-4 hours of analysis of the observations and planning the coming presentation of the analysis (drawing sketches of the work place, preparing over-head-projection, etc). This should be done separately in each group of students, eventually assisted by the teacher.

4) 2-4 hours of presentation of the analysis (including proposals for change and action) and final discussions. The presentations are made in front of all students, the teachers and representatives of the workers and plant in question (for

Table 1. The need for basic education in Ergonomics and Occupational Health, according to Lundgren (1971), modified by Lundgren & Elgstrand 1979

	Number of hours			
	-30	-60	-120	120-
Engineers, etc				
Students of technology	(x)	x		
Students of forestry	(x)	x		
Students of agriculture	(x)	x		
Industrial safety and hygiene engineers				x
Forestry safety and hygiene engineers				x
Agriculture safety and hygiene engineers				x
Public health engineers		x		
Work study engineers		x	(x)	
Machine constructors		x	(x)	
Industrial designers		x	(x)	
Production engineers		x	(x)	
Ergonomics specialists				x
Medical personnel				
Medical students	x			
Occupational health physicians				x
Occupational health nurses				x
Physiotherapists		x		
Public health physicians		x		
Company and staff management				
Managers at high levels	x	(x)		
Students of economics	x			
Personnel administrators and economists		x		
Labour inspectors				x
Research personnel				
Production research workers		x	(x)	
Medical and physiological research workers				x
Psychology research workers				x
Others				
Workers	x	(x)	(x)	
Work supervisors, foremen	x	(x)		
Pupils of primary school	x			
Pupils of secondary school	x	(x)		
School teachers	(x)	x		(x)

instance, a forestry engineer, a production engineer of a dairy or a head of a purchasing department). The final discussion should give the students a feed-back about the quality of their observations and proposals. It should give them an idea of the reliability and validity of their observations and whether their proposals are practicable or not.

-The composing of mixed, heterogeneous student groups may be a way of ensuring a valuable confrontation between theories and practice, at least when dealing with education and training of adults. For instance, the above mentioned exercise in Ergonomics might have been enriched if the student groups consisted of a mixture of production engineers, machine constructors and designers, trade union representatives, etc.

Teamwork in multidisciplinary fields as Ergonomics, Occupational Safety and Occupational Health has distinct advantages, and is even necessary. Efficient teamwork calls for good communication between team members and an understanding and appreciation of each others' work and achievements. This calls for practicing teamwork and, if possible, education in the principles of communication and of group dynamics.

-Evaluation of an educational programme is often made using, among other things, a questionnaire allowing the students to comment on the training undergone and its relevance for their actual and future job or tasks. The results of such a questionnaire, when it is given in written form, should be considered only as preliminary, until they are penetrated in a discussion between the students and the teachers. Such a discussion is likely to reveal a lot of valuable information about the real meaning and the applicability of the results of the questionnaire.

-Adult students -participating in vocational training, postgraduate courses, etc- often make the criticism that a lecture, a book, the teaching of a certain subject or a whole course is "too theoretical". This may be an opening statement that leads to a valuable interchange of information between the student and the teacher, but it does not necessarily mean that the course really has been "too theoretical". Of course, the training might have been unfit for the participant, or vice versa. The information about the course, its content and aims, might have been poor, or a mistake might have been made when selecting the participant in question. Furthermore, the problem areas selected for the course, or some of the lessons given, might have been irrelevant for the participant because of lack of experience of working life. Other explanations might be poor information about the reasons for the teaching in question, mistakes when selecting the problem areas or lessons, or unsufficient pedagogical competence of the teachers. Finally, "theoretical" is sometimes used as an ugly word when talking about education. (Thus ignoring that a good education should allow the student to understand and use new, good theories in order to change bad practice). The idea behind the complaint "too theoretical" might have been, for instance, "too much sitting in the lecture room, which I haven't been used to for a long time".

Professor van Loon has explained the general principles for Ergonomics teaching at different educational levels. In addition, it might be said that the volume needed of Ergonomics education and training should primarily consider the students occupational category and their future influence on the work, working tools and work environment. For instance, engineers and technicians of all kinds have a large influence on the work and working environment of the working population, and consequently do need education and training in Ergonomics.

Lundgren (1971) made an anlysis of the need for basic education in Ergonomics and Occupational Health for different occupational categories in Mexico. A summary of his analysis is given in the following, Table 1.

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Resumen

Se trata la ensenanza de ergonomía en paises trópicos. La discusión se basa en experiencias recogidas por ergonomistas suecos con el propósito de contribuir al desarrollo de la ensenanza ergonómica en regiones trópicas, particularmente en los sectores de silvicultura y agricultura. Se dan ejemplos de tentativas hechas para eligir los hechos oportunos y su presentación efectiva. Se le concede mucha importancia al nivel intermedio de ensenanza: educación y formación profesionales y técnicas.

Résumé

L'enseignement de la science du travail dans les pays tropicaux est mis en discussion. Celle-ci est fondée sur des expériences réalisées par des spécialistes suédois de la science du travail, qui s'efforcent de contribuer au développement de l'enseignement de la science du travail dans les zones tropicales, surtout dans les secteurs de la sylviculture et de l'agriculture. On donne des examples d'essais visant à sélectionner les faits offrant un intérêt et à leur présentation efficace. L'accent est mis sur l'enseignement au niveau intermédiaire: enseignement technique professionnel et stages de formation.

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1. The relevance of agriculture and forestry to the development of countries

In the course of the last years a significant change of emphasis has taken place within the policies of developing-aid. Once the economical and social development in the third world mainly was tried to be reached by industrialization. Now emphasis is laid particularly on the technical aid for the agricultural sector. A priority of rural development is clearly shown in the programs of national as well as of international developing-aid institutions. That does, however, not mean that industrialization no longer is pushed forward. First of all the development countries themselves give industrialization a high rank, as recently has been seen at the UNIDO-Conference at Lima 1975 (KERCKHOFF 1978).

The goal for the promotion of agriculture in the tropics for one is to improve nutrition by increasing food production. Moreover the agrarian economy should be extended for a better supply of raw material for the own as well as for the world economy. In this respect land utilization can serve as essential contribution to reduce unemployment, to lessen the rural exodus and to develop the rural districts.

According to the strategy-document of the United Nations the goals of development policies are to advance the economical and the social progress of the development countries, to improve the living conditions for all people and to secure a minimum of decent life-standard (cit. after DITTMAR and SCHWEFEL 1977). Food, health, education, housing, working conditions and social security are counted conformally as basic needs. Effects of auxiliary measures can be rated by the result to what extent the basical needs are satisfied directly or indirectly as well as by the number of people benefitting from them.

In this respect, those projects dealing with the improvement of land utilization - in its widest sense - offer good preconditions. The share of the population, working in agriculture, amounts to an average of 67 per cent - in contradiction to industrialized countries where it only amounts to 4 - 15 per cent (KEBSCHULL et al. 1976). Despite the high percentage, however, this part of the total population is not able to supply the rest of the people sufficiently with food, not to mention to grow a surplus of crops. On the other hand agriculture has to guarantee nutrition for a steadily growing under- or falsely nutritioned population.

An annual increase of the food production by 3.9 per cent would be needed to meet the demands set by the increase of the population and income. Facts, however, are that the average increase amounts to only 2.7 per cent per year (KEBSCHULL et al. 1976). Endeavours therefore must be made to increase the food production by a great number of various measures, but at the same time also to increase the production of raw material to meet the own and foreign needs. This should be combined with the goal to offer that big part of the population, living in the country, a job with wages which at least will enable them to satisfy the satisfaction of their basic needs.

Apart from agriculture forestry plays an important role in this context. There is an intimate relation between both of the two as seen from the area they cover. As a rule the forest offers ground to agriculture. This, however, does not happen voluntarily in all cases. The forest protects agriculture from wind, erosion, inundation etc. and thus contributes to the increase and safeguarding of the production. Forestry supplements agriculture in as much as it offers the seasonal workers of agriculture additional work for the rest of the time and thus enables an employment all the year round. On soils, which cannot be used for sustained agricultural production, often combined forestry and agricultural cultivation systems - the so called Agroforestry - offer promising possibilities to ensure nutrition for the local population, raw material for their own needs as well as raw materials for local and regional industries. The development of rational methods, adapted to local conditions, instead of the uncontrolled "shifting cultivation" is given steadily increasing importance.

Agriculture and forestry will play a steadily growing role in the development of the countries in tropical and subtropical zones. To what extent ergonomics will be able to contribute to these endeavours will be shown in detail in the following considerations.

2. The consideration of the production factor work

Out of the three classical production factors soil (resources), work and capital in this context work interests most. The factor capital only is of interest as it is exchangeable in replacing human labour force by mechanical working means, such as machines, with the factor work.

In tropical as well as in subtropical countries some statements can be made concerning the production factor work, which are valid for most of these countries, as they in their majority can be counted among the development countries.

- normally a surplus of labour force prevails, whereas capital mostly is lacking.
- employed labour force in many cases shows low productivity, since too many workers are employed (hidden unemployment), the input - output relation is poor, the efficiency is low.
- physical work mostly is given a fairly low social esteem.
- physical work gets badly paid for since there is an abundant labour force and since work itself is not highly respected - but often the reason also is that quality is poor and performance low.
- the quality of work is not quite what one could wish, since training, instruction, comparison possibilities, control, incitation and ambition are missing and since adequate tools are lacking and the way of its proper use and maintenance is not well known.
- work in agriculture and forestry in most cases is hard physical work, in the tropics even more so due to climatical influences bringing man soon to the limitations of his physical abilities.
- performance therefore is poor since apart from the heaviness of work and performance-impeding climatical conditions, sifficient nutrition, as a vital precondition, is lacking. Above that wages do not offer a sufficient incitation, adequate tools and the knowledge of its proper application and maintenance are lacking. Also the proper working methods are nearly unknown as all kind of training for the job is not carried out. And last but by no means least the ambition to perform is oftenly not existing.
- accident risk is high; it is by all means higher than in industrialized countries. Fatal accidents are ten times higher than in industrialized countries. Forest workers in tropical South-East-Asia and in West-Africa in the average suffer two accidents per year (STREHLKE 1974).
- the production factor work is given no consideration since it exists in abundancy.
- that directly affects the working subject, the man, who as a rule ranks at the lowest step of social esteem.

3. The possibilities of ergonomics to positively influence work

Ergonomics has the goal to optimally fit the relation between man and his work, to employ human labour force economically and to fit the working conditions to the physical and mental properties of man, without overburdening him (EISENHAUER 1978). In tropical agriculture and forestry it finds an almost virginal field of application. Its foremost possibilities, respectively tasks, to favourably influence the production factor work, shall be named:

- development and/or introduction of adapted working means. In the first place one should think of hand tools, which are fitted to the physical properties of the worker and which at the same time serve the job. It is particularly in the fields of forest operations that good results can be obtained at the level of hand tools employed. The change to horse-power or to mechanical working means depends on the social, technical and economical situations as well as on the tasks.
- development of adapted working methods. This is closely related to the before mentioned point. The working methods must be planned as efficiently as possible and they at the same time must be fitted to the worker, the working means and the task of the job. When introducing new working means the working methods must be planned for matching these new demands.
- improvement of nutrition - in the first place quantitatively to give the energetical basis for a higher possible performance -, but also qualitatively to make optimal use of the rare nutriments, respectively to compensate for lacking basical nutriments which should be included into the own production.
- training for the job which up to now to a large extent has not been carried out but which is a vital precondition for the quantitative and qualitative improvement of work with its many positive effects for the worker as well as for the employer.
- justified wages - as payment for the performance by way of correctly calculated performance-tarifs, basing on work- and time-studies. The level of the wages should be adapted to the heaviness of the work and it also should bear in mind the needs of the worker. Together with a

better performance it thus may serve as a sound basis for a gradual improvement of the social situation of the forest worker.

- improvement of the living conditions by building housings fitting the family, infra-structural measures, schools, medical care etc. Only by doing things like that rural exodus can be stopped and the population can be domiciled.
- explanation of the importance of the production factor work and the possibilities to influence it positively to all those involved, to workers and in particular also to employers - as well as to state officials having already an influence on the planning of work (or who could have or should have such an influence).

4. General measures

All attempts should be made to call into mind the importance of agriculture and forestry for the development of a country in tropical and subtropical regions as well as the possibilities to support such a positive development by way of applied ergonomics. This must be considered a political task for which development countries, industrialized countries and the international organizations or institutions such as FAO, Worl Bank, ILO, OEA are called. Endeavours should be made in the first place to weaken the opinion of many influential people in development countries as well as in industrialized countries according to which only industrialization is considered the one and only way for economical and social growth. It is, however, only the procedure in which the organization of agriculture and forestry for safeguarding of food, for the production of exportable agriculture products, for the creation of work places in the rural districts and for the increase of wages are matched with the organization of the industrial sector, which in the long run will show to be promising (KEBSCHULL et al. 1976). In the development of agriculture and forestry ergonomics only will be able to help partly. No mention can be made in this context of the measures for influencing production on the part of legislation, agriculture, silviculture, etc.

All applicable practical means must be initiated and carried out by the developing countries.

To achieve this:

- the necessary understandings of those responsible have to be roused. In this respect international and national institutions as well as respected experts can do good services.
- the needed personnel at management level must be adequately trained. That can be done in the native country, eventually with the aid of foreign experts, but it can just as well be done in another country having the necessary facilities.
- the thus trained persons must be given the chance to apply their knowledge by forming the respective organization and by their assignment to the respective positions.
- a sufficient number of persons at planning-level as well as at middle and lower performance levels have to be adequately trained for the accomplishment of their jobs. To achieve this it is necessary that special branches at universities, high-schools, training centres, etc. be installed. In the starting phase of this project it is advisable to rely on the personal assistance of experts from abroad.
- as basis for future works studies have to be carried out for the special ergonomical problems, e.g. habit, condition, climatical influences, performance capacities, nutrition, wage basis, work layout, development of best working methods, application of machines, social and economical effects of mechanization, etc.
  Above that studies have to be conducted regarding employment, problems pertaining to the effects of work on employment, unemployment and underemployment.
- training centres have to be installed, mainly for the middle (technical) level and the lower (vocational) level, since these - other than universities - mostly are not yet existing.
- correct wages have to be calculated, which duely respect the individual performance.
- employees' unions have to be formed to take care of the interests of the workers and to give their interests better weightings.

5. Special measures

Out of the vast number of the measures described so far, to end with some shall be named. To my understanding these will have to be realized the earliest possible. They enclose projects in which the managing organization, together with other international organizations and on the ground of bilateral agreement must become and can become active.

1. Prosecution of ergonomic-symposia in the various development regions on the ground

of experiences gained at this first symposium at Wageningen. The future meetings should be planned in such a way that representatives of countries speaking the same language could participate to bypass the difficulties and the costs for translation. For speakers such experts should be chosen who have good command of the respective language and who have special experiences on their field of work for the countries concerned. Such symposia should serve as breeding-cell for the future work in that region. High-ranked representatives of leading state or semi-state, but also of private institutions and universities should participate in these symposia. It would be of great value if these already have knowledge of ergonomics or if they are interested in getting such knowledge or if they are intended to be given jobs in this field. The program should be fitted to the particular problems of that region. Such a place should be chose, starting from which practical problems and eventual solution possibilities can be easily demonstrated. This purpose best would be served by a university with attached agricultural and forestry research facilities.
If at such a symposium agriculture and forestry shall be dealt with at the same time or not, will depend on the results gained at the first combined symposium at Wageningen. There are good reasons for both of these solutions. The more chances one is given for a detailed handling of the questions, the more a separation seems to be recommendable. That mainly goes for the complex of work planning, whereas the work physiological part likewise can be dealt with for forestry and agriculture.
For the next symposia let me recommend the following data:
1980 Latin America
1981 Africa for francophone countries
1981 South-East Asia
1982 Africa for anglophone countries

The organization should be carried out by CIGR - IUFRO - IAAMRH in collaboration with regional organizations, the FAO and the host-country.

To finance the symposium attempts should be made to get funds from international (FAO, World Bank, ILO, etc.) and national developing-aid organizations.

2. Education of experts at university level at adequate universities in industrialized countries. Scholarships of various national and international donator organizations should allow for a prolonged stay at a foreign university for a postgraduate study.

3. Lecturings of foreign guest-professors at universities to fill the gap until adequate local experts have finished their own studies.

The proposals made under points 2. and 3. could be carried out within the framework of two collaborating universities. In such a case advantages will be on either side, since the guest-lecturer will be able to complete his own knowledge on his field by studies and experiences gained in the hosting country. A collaboration of both would prove to be very fruitful - best to be carried out before the beginning and after having finished a project.

4. Carrying out common research projects. For researchers of non-tropical countries, who are interested in the study of ergonomical problems in the tropics, it is very difficult - if not impossible - to realize such projects because of the high costs involved.

In a case like this a collaboration would bring advantages for either side, if the researcher of the industrialized country would conduct a research project together with a less experienced colleague in the development country. The best way, in a case like that, would be that the research plan be worked out by the guest-researcher, whilst the conduction of the research work be laid into the hands of the local colleague. As for the results obtained, evaluation and publication best should be made together by both of them. Such a work eventually may serve as basis for a master graduation or for a doctor-promotion.

In such a way urgent problems of a country can be given an early solution. Besides of that such works much better serve the country than works on problems of the country in which the promotion for master or doctor is to take place.

5. To build up new, or to extend already existing training centres or certain training programs, multi- or bilateral aid is needed. It is most of all the technical field which lacks at schools. And where these are already existing, the field of ergonomics is hardly represented. It is, however, just this field, which needs better knowledge. Because of the great demand, by way of short-courses training-staff should be made acquainted with the most important findings of this field; that in particular should go for the resulting practical application of these findings. For the technical aid this certainly is a very fruitful working field.

6. In the fields of training in agriculture and forestry help is still more urgent, since up to now only very few countries have started on this subject. It is, however, necessary that a stock of trained people is available before work can be started in this field on broad scale. As to this matter detailed information already has been given. Therefore it is not necessary to deal with it at this place.

   For the organization and pursuit of these measures from the side of forestry it should be the FAO, Division 3, which has to take the initiative. Already at the IUFRO-Meeting at Oslo in 1976 proposals have been made for activities of the IUFRO on the fields of tropical forest utilization (EISENHAUER 1976). A first step in this direction is made by this symposium. Much, however, is left to be done. I consider it quite useful to recall these proposals, made in Oslo, dealing with the future activities, hoping that they will be given a soon start.

Among others the following proposals have been made:

The already existing working group "Tropical timber harvest" is to be transformed to the working group "Tropical forest utilization" to enlarge the field of activities. The participation of researchers of related fields, such as silviculture, ecology, timber industry is searched for. The chairman should be a member from a tropical country. Intimate collaboration with international associations, mainly with FAO and ILO, is necessary.

This working group formulates a research program, which will have to be in line with the most urgent practical needs.

At the meetings of the working group Spanish will be considered an official language.

Institutions of industrialized countries should participate on consulting and helping levels in the newly set up as well as in the extension of the already existing institutions in tropical countries. This should be done by way of guest-activities as lecturers and researchers; it also should be done by providing work places for supply-personnel of tropical countries. Methods- and basic research also can be carried out at the institutions of industrialized countries; applied research, however, must be carried out "in the field" in the tropical countries. It is on behalf of financial reasons that the activities of researchers of industrialized countries as a rule are restricted to advice in the phase of developing, planning and evaluating the tests. The actual test-work must be carried out by the members of the institution of the test area.

The members should make endeavours to build up partnerships which will be financed by either bilateral or multilateral aid. For the time being they represent the best way of collaboration.

The results of the commonly conducted studies should be published in the homelands of those having participated in the studies.

The sections of IUFRO and also influential individual members should make for the governments of the countries of tropical zones that scientific institutions for forest work and forest techniques be installed and advanced.

An own paper for the publication of the problems of tropical forest utilization is to be recommended. Contributions should be printed in Englisch, French and Spanish and detailed summaries should be given in both of the two other languages.

A meeting on the problems of tropical forest utilization should be held in a tropical country to exchange experiences and to set priorities for future activities.

The FAO, being the responsible organization of the United Nations for food, agriculture and forestry, still keeps the task and the responsibility to help within its limitations for the realization of the proposals. Without the financial and personal aid of FAO, other national and international developing-aid organizations and the actively interested collaboration of the institution of the countries directly concerned, all proposals will not be more than blackprint on white paper.

The steadily growing understanding for the importance of rural development in the tropical and subtropical countries raises hope for active help and understanding - and that goes for industrialized countries just as well as for the countries directly concerned.

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Resumen

Uno de los propósitos del documento de estrategía de las Naciones Unidas es promover el progreso económico y social de paises trópicos, mejorar las condiciones de vida de todos y conseguir un nivel de vida mínimo. Alimentación, sanidad, educación, condiciones de trabajo y seguridad social se consideran igualmente necesidades fundamentales.

Ya que el trabajo en la agricultura y silvicultura de más en más va desempenando un papel en el desarrollo de paises trópicos, la ergonomía puede tener mucha parte en mejorar las condiciones de trabajo en estas esferas. Las posibilidades y capacidades de la ergonomía de influir favorablemente el factor del trabajo humano en la agricultura y silvicultura son mencionadas y tratadas.

Se da una descripción de las medidas que los paises trópicos y las organizaciones e instituciones internacionales tienen que introducir y realizar. Sugerencias para actividades futuras (educación e instrucción, proyectos de investigación, simposios, finanzas, etc.) se nombran y discuten en detalle.

Résumé

L'un des objectifs du document-stratégie des Nations Unies est de promouvoir le progrès économique et social dans les pays tropicaux, d'améliorer les conditions de vie pour tous et d'assurer un niveau de vie minimum. L'alimentation, la santé, l'éducation, les conditions de travail et la sécurité sociale sont considérées naturellement comme des besoins essentiels.
Les travaux agricoles et sylvicoles jouant un rôle croissant dans le développement des pays tropicaux, la science du travail peut avoir un rôle important dans l'amélioration des conditions de travail dans ces branches. Les possibilités et les tâches de la science du travail, cherchant à exercer une influence favorable sur le facteur main-d'oeuvre humaine dans l'agriculture et la sylviculture, ont été évoquées et ont fait l'objet de débats.
Une description est donnée des mesures que doivent prendre et mettre en oeuvre les pays tropicaux et les organisations et institutions internationales. Des propositions pour les activités futures (éducation et formation, projets de recherche, symposiums, finances, etc.) ont été présentées et examinées en détail.

RECOMMENDATIONS, 5TH JOINT ERGONOMIC SYMPOSIUM "ERGONOMICS IN TROPICAL AGRICULTURE AND FORESTRY", 14-18 MAY 1979, WAGENINGEN, THE NETHERLANDS

The Symposium "Ergonomics in Tropical Agriculture and Forestry" - a joint arrangement of the Ergonomic Commissions of the Commission Internationale du Génie Rural (C.I.G.R.), the International Association of Agricultural Medicine and Rural Health (I.A.A.M.R.H.) and the International Union of Forestry Research Organizations (I.U.F.R.O.) - brought together 45 persons of 17 countries from all over the world.
The scope of this Symposium was to describe and to discuss the various ergonomic aspects of Agriculture and Forestry, which play such a very important role in most tropical countries.

Ergonomics is: "Optimizing man-task systems in view of the worker's health, well-being and efficiency".
It is neither likely nor necessary that any human being should be able to adapt himself indefinitely to any task. For this reason Ergonomics should be considered as a fundamental subject and an absolutely essential part for the improvement of the working and living conditions and thus productivity, efficiency and incomes in Agriculture and Forestry in tropical countries and all their inhabitants' diet.

At previous symposia Ergonomics in Agriculture and Forestry of industrialized countries was discussed. At this Symposium there were 4 themes, at which 14 invited papers, as well as 17 voluntary papers, were presented and discussed:

Theme I : The tropical worker

Theme II : Tropical work and working conditions

Theme III : Ergonomic research and teaching in tropical countries

Theme IV : Ergonomics in tropical countries

A full day excursion for visiting an Institute for Ergonomic Research, as well as some demonstrations, made up the program of this Symposium.

The following Recommendations of this Symposium were approved and supported by the participants:

GENERAL

a. Promotion and understanding

Considering that about 70% of the working population of the world works in Agriculture and Forestry - using mainly hand tools, animal traction and, in limited cases, a few machines - their productivity can often be improved substantially, and the work load and the dreariness of the daily routine should be reduced by using ergonomic applications.
It is thus necessary to concentrate teaching, research and extension on Ergonomics to make this work more humane. So a detailed strategy must be prepared and carried out.

b. Education and training

It is necessary that a Working Group develops an adequate model for teaching Ergonomics in tropical areas, in particular for a basic course.

In view of the crucial importance of Ergonomics as an instrument to break the vicious circle of diseases, poverty and inefficiency of the rural population in many tropical countries, it is necessary:

- To carry out pilot studies and training projects to demonstrate in a simple straight-forward manner and in a practical way what can be achieved by Ergonomics.
  Many specific examples are to be found in the proceedings of this Symposium.

- To give due consideration to Ergonomics in the curricula and handbooks or syllabi for professional, technical and vocational training, as well as to provide suitable teaching aids for this purpose.

- To provide for a general extension of a knowledge of Ergonomics at all levels of society.
  For the well-being of the rural population in tropical countries the ergonomic specialists should assist the extension services in their task to transfer knowledge.

c. Research

It is necessary that a Working Group develops an adequate model, including the personnel and physical facilities, for ergonomic research in tropical countries to design opti-

mum working and living conditions, considering health and work load, as well as the safety and performance of all working methods.

Documentation activities should be stimulated, including the preparation and distribution of relevant abstracts.

Special emphasis should be given to:

- The design and manufacture of adequate hand tools and equipment for tropical countries.
- Safe and efficient working methods for use.
- The worker's nutrition and health.
- Heat stress - which is not the same as research for protective clothing and/or devices - is one of the major subjects to be studied in tropical countries.
- To launch comprehensive multi-disciplinary and long-term ergonomic research at regional levels into the fields of anthropometry, work physiology, sociology and technology of the rural population in tropical countries.
- Work accidents should be regularly reported and these records should be evaluated.

INTERNATIONAL COOPERATION

The results of future training and education, as well as the results of ergonomic research, should be regularly and frequently disseminated via journals, magazines and other publications, as well as via symposia, seminars and technical meetings to key-personnel in tropical countries. Such meetings give the opportunity for the exchange of ideas, knowledge and experiences between workers in the field of Ergonomics. Moreover, policy-makers, designers, manufacturers, managers and administrators can be informed about Ergonomics and the results of that work at such meetings. Particular benefits can be derived from the cooperation of institutions of corresponding nature such as universities and research stations.

FUTURE ACTIVITIES

Urgent attention should be given to organize regional, international meetings for key-personnel from Latin America, Africa and Asia, with a view to establishing a coordinating, regional research centre at each.

It is necessary that a Working Group, which is supported by the Ergonomic Commissions of CIGR, IAAMRH and IUFRO, develops an adequate model, including a detailed strategy, for (i) education and training - i.e. curricula, handbooks and training projects -, (ii) research - i.e. personnel and physical facilities and coordination of research at the regional centres - and (iii) extension - i.e. organization of regional, international meetings - of Ergonomics in Tropical Agriculture and Forestry.

This Working Group should be responsible for the development of an adequate model, the preparation of the operations and the organization of the meetings, according to these recommendations.

International bodies such as: Commission Internationale du Génie Rural (C.I.G.R.), International Association of Agricultural Medicine and Rural Health (I.A.A.M.R.H.), International Union of Forestry Research Organizations (I.U.F.R.O.), as well as Food and Agriculture Organization of the United Nations (F.A.O.), International Ergonomics Association (I.E.A.), International Labour Office (I.L.O.), United Nations Development Programme (U.N.D.P.), World Health Organization (W.H.O.) and International Standardization Organization (I.S.O.), as well as the Governments in several countries and national Institutions in- and outside tropical areas, are strongly recommended and encouraged to action and to continue action on the improvement of the working and living conditions of the working population in tropical countries.

Developing countries should give a high priority to Ergonomics as a matter of urgency.

Wageningen, the Netherlands
18th May 1979.

Part B - Voluntary papers

ERGONOMICS OF WEST AFRICAN AGRICULTURE

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Summary

The major traditional farm implement used on West African farms is the Short Handled Hoe which at first sight is the strong candidate for the award of the world's worst ergonomic design of hand tool. The ways in which the West African Short Handled Hoe (WASHH) can be improved are discussed as are some of the other ergonomic problems of Igbo mound farming, which might also seem to have been designed with almost total disregard for even the most primitive ergonomic concept or principle.

A crop calendar and assessment of the amount of labour required for certain crops is included.

Introduction

The format of this paper will follow that of the author's general discussion of Agricultural Working Conditions, supra. Specific examples of the extremes to be found in the tropics of humidity and dryness occur in West Africa particularly.

This paper is restricted to the author's personal experience of farming systems in Sierra Leone and Nigeria. In particular the Igbo farming system in the area formerly known as Biafra. It should be emphasized that in most of Africa, as in the rest of the world, the range of types of farming systems are most broad. For example, ranching conditions at Obudu in the Nigerian Camerouns have almost the same ergonomic problems as the ranches of Southern Alberta, Kenya or South Devon, U.K., not surprisingly for the latter is the native homeland of the Obudu South Devon herd.

The particular focus of this paper is the mound farming system and the Short Handled Hoe (SHH) which differs from the "jembe" used in East Africa, which has a long handle. There are many subtle difference between the systems of mound-farming in West Africa and space only permits a description of that of the Igbo plateau.

While many other agricultural tasks can be seen in West Africa, mound farming of yams and other basic foods is one of the major key factors inhibiting productivity. It dictates the proportion of the population engaged in subsistence farming. Readers should recognize that many other types of farming occur in West Africa. The Fulani cattle producers, Hausa and other tribes near to the desert use horses and herd goats and have donkeys. But in the most densely populated areas, mounds are the factor indentifiable by Pareto's Law and principle of units of regularity as the major focus of non-productivity.

Description of Igbo farming

The Igbo plateau between the Cross and the Niger Rivers has a dense population of between 234-400 persons per cultivable sq. kilometer. Typically the farmers live in clusters of about 20 families whose homes are along a shady ilo or strand of some 100 m by 10 m this area being faced by their front gardens, with houses set back on plots of about 20 ares. A young farmer might own only a tenth of an older richer farmer's land, who might have, say, 4 hectares in 8 "fields". A farmer, who can grow 1,000 yams is regarded as a sucessful master farmer and is given a title, "Iwo", an ancient form of motivation. Each yam requires a mound of just over 1 m square and about 40 cm high.

The area adjacent to the houses is divided into four equal plots, for rotation. One for yams: another for coco-yams: another for vegetables which will be intercropped with the former: and yet other for cassava. Further cassava and yams may be grown in outplots further from the houses, where the old forest is burned and cleared and later when it becomes infertile it reverts to forest. The area around the home is shaded by trees such as coconut, palm kernel, oil-bean-seed and mangoes. Bananas and citrus will be near the house. Most crops except cassava and coco-yams are grown in a mixed cultivation, beans, tomatoes, millets, etc. are sown together around each mound as a superstituous form of insurance against the main (yam) crop failure.

The purpose of mound digging is to:

a) increase the effective depth of the soil
b) invert and restore to the surface, nutrients which had leached down in the previous year's rains
c) bury the carbonaceous manure usually ash and trash
d) prevent the erosion of soil and/or drowning young seedlings by keeping run-off to definite channels
e) demarcate the area for access during weeding, etc. after the full growth has commenced
f) provide a suitable soil moisture and temperature for germination.

Mounds are constructed by using the WASHH

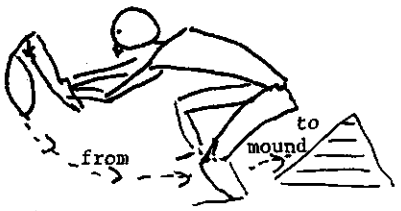
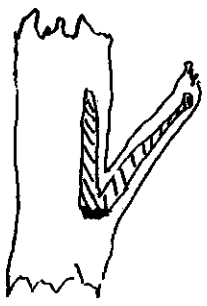


Fig. 1

(see Fig. 1), which is used by dragging earth from in front of and between the legs of the farmer and throwing it through his legs to a mound immediately behind him, in a cone. The size of the cone will be 1-2 sq.m and ½-1 m high. It is larger in low clay soils than in sandy soils in higher area, see Fig. 2.

Short-handle-hoe

The WASHH has a metal-blade but was probably wooden when first invented. It is primitive and designed not for ergonomic convenience but because materials are readily available as scrap of natural wood products. The handle is the branch of a tree and the blade or blade support is a part of the trunk of the tree above the branch (see Fig. 2).



Tree trunk
& Branch

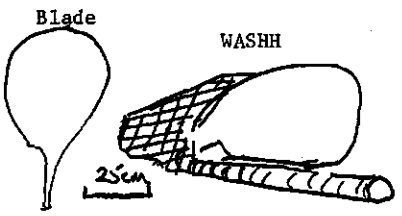


Fig. 2

Various sizes, suiting the various strength of users of a blade, are made by smiths from scrap. A small blade for a child and a very large blade for the large and famed Abakaliki man. The angle between the blade and the handle is a product of the genetics of a hard wood tree and not of the ergonomic convenience of digging.

Modern technology could undoubtedly improve upon this design. The size of the blades and the length of the handle can surely be modified in sucessive stages to increase the productivity and reduce the cost per mound-dug in terms of human energy and of metallurgical reprocessing.

Clothing

The normal garb for digging is and "owo", a towel about 70 x 30 cm. woven from local cotton. It is worn around the wrist: this is far cooler than short pants and its only detraction is its simplicity and the dangers of immodesty. Neither hat nor shoes will be worn.

Output and motivation

The quality of work differs markedly between employees and the self-employed.

Table 1. Motivation and mound output.

	Mounds output in 3 hours a.m.
Self-employed farmer with large family	20 carefully made good quality
Task workers paid @ $6 per 200 mounds	50 badly finished
Workers paid $2 per week	8

Rest and fatique

Mound making is very exhausting and at least 100% rest is needed, it is usually taken as a midday nap or siesta. In addition there is 20%, one day holiday in five. The Igbo calendar has a 5-day week and all farmers and workers are expected to attend the market upon pain of penalty. No matter what the urgency of weather this ju-ju will stop all mound-digging as does funeral and births for a full week for close relatives.

Seasonal work load

Tables 2 and 3 show the seasonal work load derived from Uwakah and Nwosu. Irwin provides descriptions of the crops and Okigbo a description of the growing of monoculture maize at Nsukka. Maize is an alternative carbohydrate crop which can be mechanized and grown on levelled and contoured/terraced land, and does not require mounds.

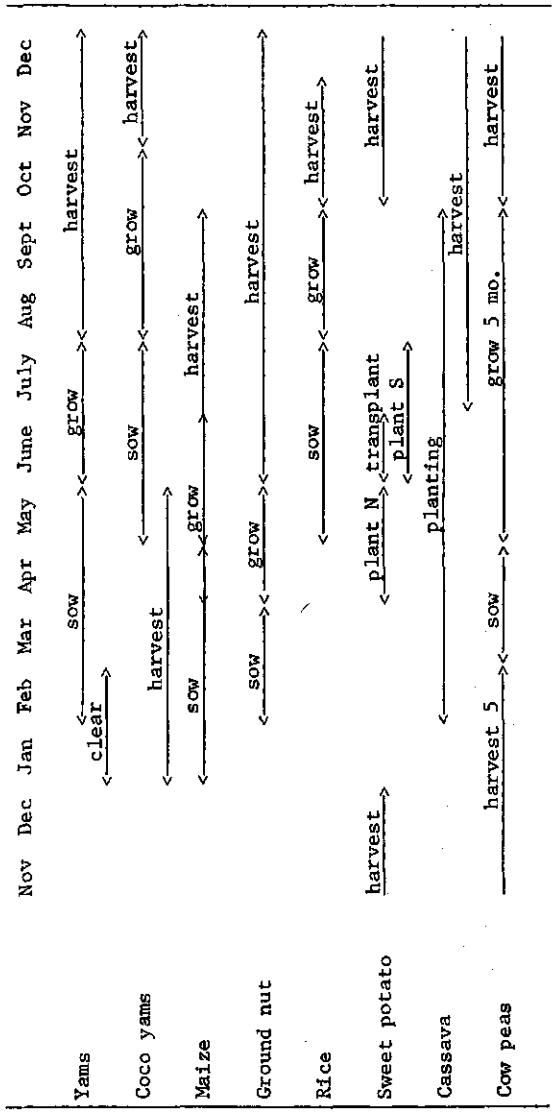
Division of labour

Specific tasks are assigned to each category of worker, women, youths, hireling young men, owner-farmers: Weeding to the former two and mound-digging to the two lat-

Table 2. Burn and brush - shifting cultivation estimates of man, days per hectare (after Uwakah & Nwosu)

	YAMS	COCO YAMS	CASSAVA	SWEET POTATOES	MAIZE	PADDY	UPLAND
Yams (Dioscorea spp)							
Coco yams (Colocassia esculentia Xanthosoma mafaffa)							
Cassava (Manilot utilissina)							
Sweet potatoes (Ipomea batatas)							
Maize (Zea mays)							
Rice (Oryza sative)							
Total	170-200	102	97	90	68		
Stump	?	?	?	?	?	?	16
Clear	24	50					20
Burn				50			1
Till	30		20	25-30	25	10	
Ridge	22						
Puddle						20	28
Prep.	14	8	8	12			
Plant	36						
Fertilize	3		3	1			
Bird-scare							
Stake	10-36						
Water							
Weed 1	6	8	16	12			
2							
3	25						
Harvest	40						
Shell							
Husk							

Table 3. Approximate and typical crop calendar (after Nwosu).



ter: Planting yams to the owner etc.. A wife will hire a young man to harvest coconut trees given by her husband as her marriage portion.

Certain tasks such as thatching houses are group projects, neighbours, cousins and other contributing according to need and availability. Younger farmers have access to outlying communal lands for cash crops which are grown in amounts controlled by incentive and the available labour for digging in the planting season: after yams the priority crop have been provided for. Okigbo has shown the attractiveness of maize in the area over the more traditional cassava crop for outlying areas.

Conclusion

It is a simple matter of logistics to calculate the proportion of the population needed to provide the food needed from the information given herein and in the texts quoted. Nevertheless, in the past decades the migrants to urban jobs have been mainly young men, who traditionally do the major part of the digging and the other heavy work at peak labour demand seasons. Some means of increasing the productivity of the residual labour force is urgently needed for the older farmers have almost reached the age of retirement. The key task is building mounds.

The author lacks both the resources to test his ideas and the space herein to describe them all. The several possible alternatives which range from a bicycle pedal type "snail" to an aluminium-tube-handled-special-mound making-spade-cum-hoe, with intermediate technologies of two-wheeled tractors with augers of post-hole-borer-type-construction. These are never likely to reach even the phototype stage unless funds and personnel for making and testing them are provided to institutions somewhere in West Africa in rural areas, such as the Nsukka campus, of the University of Nigeria.

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ANTHROPOMETRIC DATA FOR THE SUB-TROPICAL REGION OF TURKEY

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Introduction

Agricultural mechanization has increased considerably over the last ten years in Turkey and so the man-task relationship has become more important. Since sufficient anthropometric data were not previously to look into ergonomic problems in mechanization, this work was carried out in the Çukurova region, where the level of mechanization is the highest in Turkey.

Anthropometric data have great importance in ergonomic studies. The role of anthropometric data and standards in solving ergonomic problems has been accepted internationally. These data can be used to describe the man-machine relationship in the man-task system. For instance, the higher level of performance of a tractor driver can only be maintained if the anthropometric qualities are suited to the work-place dimensions of the driver.

The control areas of the driver - on both vertical and horizontal planes, intersecting at the seat reference point - were developed to find out the optimum lay-out in the man-task system.

Besides linear measurements of the body, movement ability and limitations for hand and foot, should be determined. The maximum and minimum limits of the control areas can be found by taking the 5th and the 95th percentiles of the population. The linear anthropometric dimensions can be taken either by the direct or the photographic methods.

Materials and methods

Anthropometric measurements have been carried out on samples (Age: 20 - 40 years), living in the southern part of Turkey.
In anthropometric studies the determination of the optimum sample size is very important. In order to select the best sample size, the 19 linear dimensions were firstly measured in 40 individuals; then the number of individuals in the sampling group has been calculated.

In these anthropometric studies 5 mm has been chosen as the accuracy of the measurements.

From the measurements of the pre-sampling group, the number of individuals has been calculated. Eye height in sitting position was found to be the measurement which would give the maximum number as 278; so 290 individuals were selected and 30 measurements, including body weight, were completed.

The measurements have been carried out on a special seat, under the following conditions:

- The person should rest back;
- Hip should be as near as possible to the seat reference point;
- The upper leg should be horizontally.

Some of the linear dimensions cannot be measured directly, but some calculating methods may be applied using the mean values. In this work some data have been found with these methods.

Hands and feet have limited the reaching points in space and these points make a special surface; intersection of the horizontal and the vertical planes and the special surface give the control areas boundaries.

The boundaries of the control areas were established, using the following assumptions:

- Horizontal and profile planes are passing through the seat reference point.
- Eye, shoulder and hip centers were measured in relation to the seat reference point; all other dimensions were taken in reference to these measurements.
- Since the distance between the eye center and the seat reference point cannot directly be measured, this distance is assumed to be equal to the chest depth.
- The eye center is in the middle of the line between the two eyes on the horizontal plane and is placed on the nose bridge.
- Visual control areas are determined in reference to the eye center.
- Hand and foot control boundaries are first established by specific points and then the points are connected with suitable lines and curves.
- Optimum control area boundary is obtained from normal movements when sitting comfortably, but for the maximum areas the body should be stretched.

Results and discussion

Maximum deviation has been found in foot angle, shoulder center height, distance of the heels, hip center distance, hip center height, distance between knee centers and the body weight. The individuals were asked to sit back and be comfortable, but this was a relativ concept and therefore each individual would pay relative attention. This behaviour causes the greater deviation in some dimensions, but for more absolute positions of the body dimensions variations are far less.

Relative values of lineat dimension to both the eye height, in sitting position and the body height, are found; with these values, all dimensions might be predicted from the reference dimensions for future studies.

A Comparison of this research work with Dutch, German and American resluts has been carried out, especially on the body height and the eye center height in sitting position. Both dimensions are rather smaller than the results obtained by other studies, carried out in the above-mentioned countries.

Control area boundaries are explained and the drawings are made for the profiles and the horizontal planes. These figures can be used in designing the work-place lay-out for agricultural tractors and other equipment in Turkey. For the most comfortable operators work-place lay-out, all controls have to be in the optimum control area; this is especially necessary for the most frequently used controls.

(abridged version)

WORK CAPACITY, BODY COMPOSITION AND ANTHROPOMETRY OF CHILEAN FORESTRY WORKERS

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Introduction

In developed countries there is a considerable volume of literature related to physiological and anatomical characteristics of different populations. From a theoretical point of view, most of the models followed in industrialized countries could be applied in developing countries. However, it is fundamental to acquire information of the characteristics of these populations and consequently it is necessary to perform physiological and anthropometric studies which might contribute in defining the communities and explaining the differences that might exist between them.

The Human Adaptability Section of the International Biological Programme recommends to perform research covering aspects of anthropometry, work capacity, body composition and physique in population groups with different work patterns and habitats.

In this paper the information obtained in a study of Chilean forestry workers has been summarized.

Material and methods

The study was performed in a sample of 165 forestry workers (age: 17 to 64 years), who carried out heavy manual operations of cutting, debranching and logging trees.

The anthropometric measurements were taken with instruments recommended by the IPB. Body composition was estimated using the technique proposed in 1974 by Durnin and Womersley, which has been validated for Chilean workers. In this study, the skinfolds were measured using a Holtain caliper.

The $\dot{V}O_2$ max was predicted from the results of a single load test lasting seven minutes. Cardiac frequency (fC) was monitored minute by minute using a telemetric system and the oxygen uptake ($\dot{V}O_2$) was measured, in the last two minutes of exercise, by means of the open circuit procedure. The values of fC and $\dot{V}O_2$ were interpolated in the Åstrand and Rhyming nomogram, which has been shown to be valid for Chilean populations. The values obtained from the nomogram were corrected for the age of the subjects using the correcting factors proposed by Åstrand.

Results and discussion

It is worth mentioning that the results of the anthropometric characteristics of 165 forestry workers - 5th, 50th and 95th percentiles in tables - were not analyzed by age groups because no significant differences were found when age was taken into consideration.

It is possible to state that forestry workers are the shortest group among Chileans and that their stature is below the values reported from other countries. This fact is very important since Chile, as most developing countries, is technologically dependent. Therefore, most of the mechanized equipment for forestry work is imported from abroad. This indicates the need for a more dynamic exchange of anthropometric data, if it is expected that ergonomics provides solutions to work design problems affecting different populations at international level.

The values of FFM were also remarkably similar to those found in other groups of Chilean workers.

The weight of FM increases up to the age of 30 years and then remains almost constant. These results are different from those of other groups of Chilean workers in which a tendency has been found to increase body fat with ageing. It is possible to state that in the other Chilean workers there is a trend to excess body fat. It is difficult to define the limit at which a subject becomes obese. If the 20 percent FM is taken as reference, then 74 percent of the foundry workers, 59 percent of the steel mill workers and only 17 percent of the forestry workers are over this limit.

There was a decline of $\dot{V}O_2$ max with age. The $\dot{V}O_2$ max (in liters per minute) was, on an average, 28.1 percent lower in the group of subjects over 50 years compared with the group aged less than 30 years. It has also to be mentioned that the VO_2 max of these forestry workers represents the highest value encountered up to now in Chilean workers.

The methods in this study don't allow any accurate interpretation of the similarity or difference in the $\dot{V}O_2$ max of Chileans as compared with other ethnic groups. It is difficult to establish, even with more accurate techniques, whether the differences between two populations are due to real genetic adaptive changes, or if they are the consequence of variations in physical activity, nutrition, environment or other factors.

The high $\dot{V}O_2$ max of the Chilean forestry

workers and the low FM content of their bodies, could be taken as indicators of good physical fitness. The most active group was represented by the forestry workers, the foundry workers carried out tasks from light to heavy and the students and academics were selected to represent a sedentary group. In these groups of subjects there was a significant relationship between FM and $\dot{V}O_2$ max, but the regression lines run parallel indicating that individuals engaged in heavy work can achieve higher $\dot{V}O_2$ max than those subjects, of similar FFM content, carrying out lighter work.

From the results of this study, the only conclusion that can be drawn is that physical work exerts some effect on the oxygen transport system which allow the trained individuals to attain higher $\dot{V}O_2$ max. At which level the adaptative changes occur is not yet well understood.

A multiple regression analysis was carried out to study any interrelations between age, as combined with some indices of body size and composition, and $\dot{V}O_2$ max. It is possible to state, that the combination of age with FFM or body weight yield highly significant relationships with $\dot{V}O_2$ max. The results for body weight might give rise to misinterpretation since this has not been a common finding in other Chilean workers. For example, in the foundry workers quoted before, body weight correlated poorly with $\dot{V}O_2$ max. It has already been mentioned that 74 percent of the foundry workers have more than 20 percent of their body weight as fat. Therefore, the high body weight of the foundry workers is not due to a higher FFM content of their bodies but to body fat. Considering that $\dot{V}O_2$ max is partly dependent on the structure and function of the working muscles, there is no reason to believe that the increase in body weight by the addition of fat should be related with higher $\dot{V}O_2$ max. If the FM content is low, as it was in the forestry workers, then body weight will be closer to the weight of FFM which might explain the good results encountered when $\dot{V}O_2$ max was predicted from age combined with body weight in these workers.

The results of the multiple regression analysis are encouraging. However, these findings need to be reviewed in the light of more direct methods since it would be most useful to develop simple anthropometric equations for screening work capacity of populations. It has to be considered that in developing societies, the lack of resources in many instances does not allow for choice of refinements. Therefore, it may be necessary to rely on simple methods, bearing in mind that there are more accurate existing alternatives.

(abridged version)

OPERATING A TWO-WHEELED TRACTOR UNDER TROPICAL CONDITIONS

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In tropical countries there is a need of developing mechanization programs.

In many cases it might be considered to introduce small powered pedestrian controlled cultivators, usually called two-wheeled tractors. European physiological studies demonstrate that operating a two-wheeled tractor involves a considerable physical strain, due to walking on rough surface whilst handling a rather heavy machine. Therefore, it seemed to be desirable to perform a series of physiological measurements during various soil tillage operations under tropical conditions.

The study was undertaken in Western Nigeria. Three Yoruba operators were measured during their work (ploughing and harrowing) with different types of machines under irrigated as well as upland conditions. The heart rate and the energy expenditure of the operators indicate that in most operations the physical strain exceeded the tolerance limits for continuous work considerably. It is clear that the work is too strenuous indeed, the more if a lower physical working capacity should be taken into account with the indigenous workers. From an ergonomic point of view most of the available machines did not seem to be very suitable for all these operations.

There are some factors that may influence the physical strain to some extent.

1) Soil condition. The more muddy or rough the soil, the higher the strain.
2) Working speed. This is a very important factor. It has to be recommended to work at a low speed. Therefore, the tractor must have sufficient gears for adjusting the speed adequately.
3) Steering system. Clutch steering has to be preferred, because it requires less effort than manual steering and break steering.

Furthermore, it seems that a greater stability of the machine makes it easier to work with. The weight of the tractor may be an influencing factor in case of an unfavourable steering system.

From these points it may be concluded that the work load depends on technical characteristics. Consequently, if there is no other choice than using such a machine, it is important to take the most suitable type. Nevertheless, the physical strain will probably exceed the tolerance limits. Adequate pauses will then be necessary. The study shows that rest allowances up to about 100% have to be recommended. This means that one tractor should be operated by two men, working and resting in turn.

The only ergonomic adequate solution seems to be using a light four-wheeled ride-on tractor for these tillage operations, because only in that way the operator will have an acceptable work load.

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(abridged version)

ERGONOMICS AND DEVELOPMENT IN BALI INDONESIA

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Introduction

Indonesia is facing the 3rd Five Year Development Plan, from April 1979 until March 1984, in relation to manpower matters, has some principle formulations as were stated within the Peoples Consultative Assembly Decree No. IV/MPR/1978.
They can be formulated as follows:

1. Human beings are considered the most prominent and main capital in the development (in which women are certainly included, as far as half the population consists of women).
   Therefore the optimal use of their capacity, ability and limitation should be conducted.
2. Development programmes should be planned and orientated in the opening of employment opportunities in which their protection and treatment efforts are already built.
3. In the application of science and technology, endeavours should be directed in using the appropriate technology, more labour intensive in character, maintaining and preserving ecology from destruction and prevention of wasting the natural resources.

Obviously from what is stated above, Ergonomics as a science and its application plays an important role among other factors and means in carrying out those formulations into practise. It is a fact that since its first introduction in Indonesia in 1969, Ergonomics in Bali has made some progress either as a science or in its application. The following might support this statement.

Education

The first lecture on Ergonomics started in 1969 for the 3rd year medical students as part of the physiological curriculum. Although it was in the form of an introductional lecture, it obviously became an attractive topic among the students. Then, as a part of Occupational Health it has been given to the 5th year medical students since 1970. And during the internship period on Occupational Health for two weeks, the 6th and 7th year medical students get acquainted with Ergonomics through discussion and study visits to industries. In short, practically since 1969, Ergonomics became a part of the curriculum of the Udayana Medical School.

In 1972, Ergonomics was taught for the first time at the Faculty of Technology, Civil Engineering and Architecture for one semester to the 3rd year students with the syllabi as follows:
history - anthropemetry, body size and work place - light and colour - noise and work, music - working environment, temperature, humidity - working time, fatique, rest pauses, nutrition - men machine system - improving working efficiency - organisation of work.
This was followed by another one semester for the 4th year students in 1973 with a syllabi as follows:
production process or flow of work - design and layout - identification of Ergonomic problems - check list and practical surveys-understanding of interaction between Ergonomics and non Ergonomic factors - study visit-exercise on problem solving - submitting paper.
In relation to the above mentioned activities a village full of various home industries and cottages was chosen as a pilot study area for the students doing field work on Ergonomics.

As part of the farming engineering curriculum at the School of Veterinary Science, since 1977 Ergonomics has been given to the 2nd year students; while endeavours in extending Ergonomics into other faculties were planned but due to some technical problems had to be cancelled.

In the form of short courses, Ergonomics is always considered as an important topic in conducting Occupational Health courses for physicians, para-medical staff, tripartite, managers, labourers, done in Bali.

Also a special course in Ergonomics was organized for planners and contractors, District Chiefs and other key persons from the Government Regency offices.
For planners and contractors, the curriculum consits among other of Ergonomics and Design, Ergonomics and Productivity and Ergonomics and development plan.
The curriculum for the key persons consist of;
history, definition, goal and objective, its development and future - anthropometry and work place - working environment - tools and working load - selection, health examination - working hours, rest pauses, fatigue, nutrition - population, family planning, transmigration - women workers - ecology and pollution - energy resources and their problems in the future - appropriate technology - ergonomics and design, productivity and development.

Evaluation to this course is strongly

positive and the 2nd course will be held again this year, and as the first one will be financed by the Regional Government.

In the form of awareness programmes, regular lectures and discussions are carried out to various organisations, to heads of Government offices in the region, to particular committees, to Members of Parliament, to the Regional Development Planning Board's members etc. In addition a monthly programm is organized on radio since 1969 and a two weekly regular programm on TV since 1978.

And in every student movement to the rural areas, whether it is in the form of volunteer action, community services, or within the formal curriculum, efforts in spreading the idea of Ergonomics are always carried out.

In short, in can be said that Ergonomics became already a part of the people's way of life, at least at the beginning level, and among the key persons of Bali. The Regional Deveolpment Planning Board has agreed to the use of ergonomic principles in the regional plan of Bali until the the year 2000, is evidence to this comment.

This very important decision will not be approved by most Parliament members without any proof in the form of data that Ergonomics is really useful and beneficial in bringing the people into a situation and condition of health, safety, efficiency and comfort. Therefore surveys and reseach are considered as the foundation of this achievement and with its application or implementation mostly in regard to improving efforts.

As far as research or survey is concerned some work done until now in various sectors might give some image of what has been done in Bali in the field of Ergonomics.

Transportation

In transportation, observation of how the drivers and passengers sit during the trip clearly shows that the buses are not adapted to anthropometric dimensions of the Indonesians, most of the drivers having to be propped up on pillows. A comparison between certain body dimensions of the Indonesian population and reach-distances to controls in buses confirm these observations. The passenger seats showed the same. Surveys of passengers during bus trips confirmed that travel by bus was indeed uncomfortable, which is more or less due to the incorrect design of seats for not taking into consideration the body dimensions of Indonesians. Due to these results, it has been proposed to the authorities that Indonesian Balinese dimensions have to be used as basis for the design of cars, whether they are imported or assembled in Indonesia.

Manpower is still being used to a great extent throughout the country in transporting goods, therefore it is important to determine the optimum weight and size of loads carried on the basis of anthropometric and physiological considerations. It was suggested that a unit load of 15 kg is an optimum weight for transporting a total weight of 180 kg and 300 kg in boxes over a distance of 12 m. In order to determine the optimum size of the boxes it was found that a size of 33.0 - 22.0 - 24.5 cm boxes could be considered as the most suitable for the time being. A recommendation to use 15 kg boxes has been submitted to factories dealing with rice wine, soap, soy sauce etc.

Other ergonomic studies have been performed in textile mills, hotels and a cigarette factory.

Bali, a small island of 5,770 km2 with a population of about 2,122,000 has chosen agriculture and tourism as the most prominent sectors to be developed which means that hard work on Ergonomics in these two sectors should be carried out as well.

Agricultural tools

The island of Bali is conical, therefore most of its rice fields are terraced. Beside that most of the farmers are so poor that it is impossible for them to purchase new devices or to mechanize their procedure. With these conditions, it is understandable that more or less traditional types of tools and methods of work will still have to be used in the coming years. Coinciding with the policy of the Indonesian Government to increase the production of rice, the application of Ergonomics to design tools and methods of work could be of additional help in the achievement of government goals. Efforts in this direction have already been undertaken.

Manuaba and Nala (1969) have carried out a small study of the most productive pacols (hoe) for Balinese farmers. That study showed that the "Schlieper" pacol with 1,535 m handle was the most efficient.
Beside pacols, in soil tilling many kinds of tools differing in size, weight and shape are currently being used and Ergonomics should be applied to discover the best "tambah", "lampit", "tengala" or plough, sickle, "tulud", "penampad" etc. New methods should be studied and developed to improve on the stooped body position of the worker during the planting of rice.

Due to its cheaper price, strength and comfort when worn while working in the sun, most Balinese farmers still use jute sacks as clothing with all its disadvantages. By comparing jute sack cloth and other materials currently produced by Balitex we came to the conclusion that further work should be done to find substitutes for jute sacking.

Tractors

In its efforts to increase the production of rice, the Indonesian Government has a

National Programme underway to introduce new varieties of rice (high-yieldingg varieties), and to increase the use of pesticides, fertilizers and mechanization throughout the Republic.

As a consequence of this action many advantages have been achieved, in fact it has also created some impacts that should be tackled, among others by Ergonomics in order so that Government goals will be successfully achieved.

In soil tilling it seems that the use of the tractor (hand-tractor) became more popular among farmers coming from the "have" groups and efforts in extending the use of tractors to the whole island is actively being done these last years. Since its first introduction, particularly in Bali, some disputes have occured among experts from several disciplines. As far as the use of tractors is concerned the same applies to transfering new technology to the farmers, several factors should be considered before making a desicion in using that new technology. Of course one factor which should be considered is the Ergonomic characteristic of the implement. In deciding whether tractors are acceptable or not in Bali it might be useful to note the following:

1. There are 4 types of tractors being used at present in Bali: Kubota (+ more than 250 kg in weight), Yanmar (287 kg), Iseki (273 kg) and Satoh (250 kg) which are difficult to use on terraced rice fields.
2. The price of an Iseki tractor is about US$ 3,520 each, while Satoh is about US$3,200, which in comparison to the average income of the Indonesian citizen is too high and especially for farmers owning 0.10 ha or for labour farmers (sharecroppers).
3. Tractors need fuel and Indonesia is now fighting for economical use of this foreign exchange resource, which means that either the operating cost will become higher in the near future and this may result in stopping the use of tractors completely.
4. Technically, according to the tractor owners, it is rather difficult to operate a tractor on a very dry or very soft wet soil.
5. Tractors have to be operated for a full day in order to achieve the minimum 50 are/day, which will have an impact on the operator as will the consequences of working alone for hours, vibration and physical stress due to heavy load, high temperature and possibly also the anthropometric difference between the operator and the designer of that tractor in the country where it was made.
6. Although it is true that a tractor will be able to work faster than the original plough pulled by oxen, it will create more unemployment if at the same time there is not going to be an effort made to create new jobs in the area. This opinion is based on the fact that most of the farmers are working only several days during the planting season and afterwards for 1 - 2 days during the harvesting time. In between they go to the rice fields twice for the purpose of cleaning, giving fertilizer and doing some spraying with pesticides.

These are some notes which should be considered as factors in deciding whether or not tractors should be used on Bali, as well as factors seen from various disciplines and needs.

Other agricultural problems

The use of pesticides means also the use of sprayers , differing in size, shape, weight and operation. Also here Ergonomics could be applied in seeking the most suitable sprayer for Indonesian farmers. In doing so Karna and Manuaba (1976) found no significant differences between various hand pump sprayers or between two machine pump sprayers. Increasing incidents of pesticide intoxication among farmers should also be taken into consideration. A survey in Bali in 1973-1974 revealed that about 42% of 479 farmers exposed to pesticides were mildly intoxicated and 3% were moderately or severely intoxicated. Another survey done in 1976 on insecticides showed that about 73.3% of the farmers are keeping the insecticides in their houses and 83.3% of them were doing that in an open space and 80% were using unlabelled bottles. This survey was done in the village Sangeh and 60 farmers were used as samples. Such a method in keeping a toxic agent should be improved upon and application of ergonomic principles will be useful.

With the new varieties of rice new ergonomic problems have arisen such as the stooped body position of the farmers in harvesting which did not occur with the traditional types of rice. It means an increase of energy demand during harvest work. And in doing so, another new implement, the sickle is currently being used as a substitute for the old "anai" or "anggapan". In fact with this kind of work more male farmers are doing this job.

Usually for transporting, rice is gathered in bundles each weighing about 20 kg. A relatively constant weight of a bundle of rice is achieved by using bamboo ropes of a fixed length which is defined by employing a part of the body as a standard. Female farmers carry one bundle of 20 kg on their head, while male farmers carry two bundles suspended at each end of a pole. Because it is difficult to form bundles with the new varieties of rice, the farmers have to thresh the rice first and place it in gunny sacks or baskets for transportation. In this case, hazards due to dust, extra energy consumption for beating rice and carrying gunny sacks or baskets (up to 100 kg) present new pro-

blems for the farmers, especially female farmers.

An increasing number of rice mills on Bali has recently led to new problems with regard to safety, health and working conditions (Manuaba 1974). Most of these mills are located in the middle of the housing area of a community and as a consequence , they have become a new source of enviromental pollution of dust, noise and vibration. As regard to the workers practically 100% did not use any ear protection devices, only 31% used masks and about 7% from the 28 rice mills visited had accident experiences. This is understandable as from 158 rice mills visited only 27 had some kind of safety devices. About 96% from 28 rice mills are using natural light for their illumination, about 78% are having windows with less than 1/6 of its floor width.

In short, due to incorrect design of the buildings, lighting, noise, vibration and safety are common problems in most rice mills. Some efforts in solving the problems have been made among others by making an appeal to the authorities to give more attention to the design of the building before deciding to give an operating license to those mills. Within this mechanisation, Ergonomics certainly will be highly beneficial.

The Balinese farmers

As regard to their health and hygiene status it can be said that due to their ignorance, poorness, low education etc. we still have a high mortality rate, a high birth rate, bad sanitation, infectious diseases and so on. But some efforts in the form of better and more comprehensive health care have been made by the establishment of Health Centres in each District with about 60,000 inhabitants to be taken care of.

Nutritional surveys showed that calorie intake is rather low as is also the protein, Hb, Vit.B and Fe in some of the workers.

In relation to anthropometrics, limited data could be collected from 140 farmers as follows:

stature	162.45 cm (146 - 174)
eye level	150.24 cm (137 - 164)
elbow height ...	101.38 cm (94 - 113)
shoulder height	131.92 cm (120 - 146)
The ages of the farmers	: 20 - 60 years
body weight	: 51.35kg (41-80)
location	: Batunggal Abiansemal

Conclusion

Finally in closing this paper perhaps the most important problem facing Bali at present is that of finding a policy which will balance the effots to preserve and enrich Balinese culture on the one hand and to carry out modernization on the other hand, for the exclusive benefit of Bali and the Balinese.

In achieving this an approach which is multi- and interdisciplinary in character should be conducted at the early stage at which decisions are made. In this context Ergonomics will be able to make its contribution optimally and maximally for the achievement of health, safety, comfort and efficiency of work.

Attention should be focused primarily to the designing stage of any process of development planning, whether it is related to foreign investments or internal ones. This will also be with regard to any kind of aid given by other countries, international bodies, bilaterally or multilaterally organized. It should be stressed that the help given should benifit the total population.

We have to remember that pollution and destruction of ecological systems usually begin within the industries themselves, therefore preventing the working condition from any pollution will also mean to prevent the community from any unwanted problems.

Bali with all her experiences untill now will try to do so. May this ideal be fulfilled.

(Abridged version)

SOME ERGONOMIC PROBLEMS AMONG (COCONUT) TODDY TAPPERS IN SRI LANKA

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Summary

This paper reveals some ergonomic problems in an agricultural task performed 100% manually, viz: coconut toddy tapping.

Back pain which was a common complaint among the toddy tappers was found more prevalent in de older experienced group of workers.

Exhaustive nature of the work may be a contributory cause for accidental falls among tappers.

Testing of coir rope used for walking, by competent persons and better accident recording methods are necessary.

A comprehensive survey including work load measurements of a tapper has to be carried out before any definite recommendations can be made.

Introduction

Significant contributions have been made towards the improvement in the ergonomic requirements of the factory and office worker. But it seems that the same degree of importance has not been given to ergonomics in agriculture. The area that is most neglected is agricultural tasks that are carried out 100% manually. Ergonomic considerations in work tasks however get the least priority in a developing country when working conditions are examined. The lack of knowledge and the lack of qualified personnel in these disciplines may be adduced as some reasons. Therefore the purpose of this paper is to show the problems in one of these areas that has not been investigated earlier.

Sri Lanka which is predominantly an agricultural country has a land area of 25,000 square miles, with a population of 15 million people. 56% of the working polulation of 3 million, is engaged in agriculture. The coconut palm grows in wet climatic conditions. The rich soil in the low lying areas and the hot sun are other requirements for the coconut palm. Large extent of coconut is therefore grown along the coast and inland which provide these ideal conditions. The coconut trees are planted in rows and 10 to 20 feet apart from each other. Out of the mulitude of uses obtained from the coconut tree, its flower when tapped issues sap, a semi-thick white juice, called toddy. Toddy is a refreshing sweet alcoholic drink when fresh. It could be fermented and distilled to give a strong alcoholic beverage called "arrack" which is similar to Scotch whisky. Treacle, jaggery and vinegar can also be obtained from toddy.

The Process

About 0.5% (i.e. 5,000 acres) of the total acreage of coconut land in Sri Lanka is tapped for toddy. At least 5,000 workers are engaged in toddy tapping. Toddy tapping is a 100% manual task. The tapper climbs up the trees of heights ranging 20 to 40 feet, with the aid of 3 foot span dry coconut husk supports tied along the tree trunks.The tapper has to carry with him the tools consisting of a cutting knife and an animal bone (for tapping), a total weight of about 7 lbs. He also takes with him a vessel (to collect toddy) weighing 6-7 lbs. He sits on a branch (leave stalk) on the tree, cuts the tip of an unopened flower, taps it for 2-5 mins., ties the flower and places a clay pot over the flower, before attending to the next flower. 3 to 4 flowers are tapped per tree. He also had to collect the toddy, pour into a clay pot en lower it to ground level.

A single tapper works on 35 to 75 trees a day by working continuously for 3 hours on the trees in the morning and 3 hours in the afternoon. The tapper then travels to the next tree, walking on coir ropes tied between trees. Therefore he need not climb every tree that needs tapping. The walking rope consists of 4 strands (untwisted) of 1 to 2 inch circumference rope and 2 strands (untwisted) of rope as hand support, tied on the coconut trunk about 4 feet apart. Walking ropes are not tested for either their breaking strengths (BS) or the safe working loads (SFL), but changed every 5 months. Ropes are seasoned by stretching manually and leaving them tied to trees for several days. Whilst the physical work load appears to be less while walking on ropes than on climbing, the risk factor of falls may be higher while rope walking. A tapper works bare foot, clad in a short cloth of a pair of shorts. On a belt he wears round the waist he carries the tapping tools and the toddy vessel.

Problems

The working hours of tappers are not defined. Rest pauses could be taken as and when required. A tapper who is on piece work seldom stops work after climbin a tree, unless he reaches a stage of exhaustion. When he is thirsty he can quench his thirst by drinking some toddy or the semi-sweet refreshing drink of a young

coconut. When he is tired he could rest on the coconut tree itself. However a continuous period of 3 to 4 hours has to be spent on the trees which are 20 to 40 feet above ground level. Therefore the risk of falling exists during this continuous period of work. The risk of falling by slipping while climbing, tapping or walking on ropes is more likely on rainy days.

The tapper is also exposed to extremes of climatic conditions such as the heat of the direct sun with temperatures ranging from 85-95°F, heavy monsoonal rains, extreme humid conditions (80-95%) and strong winds.

Climbing the tree itself is a strenuous experience which requires maximum flexion of the body joints. The working posture of a tapper is far from satisfactory. He has to sit or stand on the rough surface of the branches and balance himself to a steady, safe position before he starts tapping. This position changes from flower to flower. The aches and pains experienced by a trainee tapper all over his body could be partly due to his changing and uncomfortable work postures. Therefore a tapper is subjected to muscle fatique both dynamic and static. None of the ergonomic principles of seating or work postures could be applicable to a tappers situation.

On hot humid days a tapper could feel physiological strain after a short spell of work. He may need frequent rest pauses at ground level, which he is deprived of due to the nature of his work. There do not seem to be any record of work load measurements made in toddy tappers in Sri Lanka. Apart from falls by slipping another reason for the high incidence of accidental falls, may be exhaustion due to high energy expenditure without recovery periods.

This paper reports the findings of a preleminary study conducted to assess the problems enumerated above.

Method

The author is not aware of any surveys conducted to ascertain either the ergonomic problems or the causes of accidents among toddy tappers in Sri Lanka. This investigation was confined to a preliminary survey. The method adopted was a questionnaire. A Sample of 58 tappers were questioned and the anwers were noted. The 58 workers were selected at random from two main toddy tapping areas in Sri Lanka, from the North and South of Colombo. 22 out of 58 tappers were trainees of average age, 20 years, who had undergone 1½ months of training out of a total period of 4 months training. The balance, 36, were experienced labour. 17 with average age, 30 years, had 2 to 5 years experience and 19 with average age, 45 years, had 7-40 years experience.

The toddy tapping industry was predominantly manned by the Indian immigrant labour prior to 1964. With the introduction of training centres for toddy tappers by the Government and the repatriation of Indians, more and more Sri Lankans are joining this industry. The old Indian tappers still work in some estates. 12 out of the 19 subjects who had over 7 years experience were of Indian origin. All 22 trainees were Sri Lanka lads. The fact that Sri Lankans did not take to tapping prior to 1964 may be due to the stenuous and risky nature of the task.

The questionnaire survey covered two particular areas viz: fatique complaints and accidents. The fatique complaints were broken down into general physical fatique and work position or local fatique. The accidents as wel as the near misses experienced by the workers were noted. Subjects were further requested to recall any major accidents experienced by their fellow workers. There was no proper accident recording system in the toddy tapping extates. Therefore only a rough estimate of the fatal accidents and disabling injuries was obtained by this system of accident recall.

Results

Fatique and Pains

There has been a higher incidence of local aches among the trainees in their first week of training, with 77% showing limb pain and 23% back pain. This could be due to the high muscular activity and physical exercise experienced by the trainees who were not accustomed to this kind of activity. But these pains have almost disappeared in the 6th week. It is interesting to note that there is a very significant increas ($p<.01$) in back pain among the older workers with 12% of the 2-5 year group and 53% of the over 7 year group who complained of such pains. The increase in limb pain is due to the nature of the work or the old age has to be ascertained.

The general fatigue among tappers has shown a gradual increase from young trainees to the old experienced workers. The eye spasm and the vertigo feeling have averaged around 25% indicating that these effects do not change with the age or experience.

Callosities

Callosities are small hardish skin protuberances usually appearing on the palm or feet, on constant rubbing on rough surfaces. These can be very painful at times. 36% of the trainees said that they had callosities in their first week of work, and most of them disappeared after some time. 42% of the over 7 year group had these permanent hardened insensible lumps, showing that callosities persist more in older workers.

Accidents

There were no proper accident records maintained in the toddy tapping estates investi-

gated. It was assumed that the major potential hazard among toddy tappers was accidents from falling. The 22 trainees questioned could recollect only one near miss during the period of 1½ months training. A total of 7 falls and 10 near misses (which could have resulted in falls) have been experienced by the 2 older groups. Out of the 5 causes given, slipping from the tree or ropes on rainy days was the most common. There had been 5 occasions where the walking ropes have snapped. The possibility that any of these falls or a near miss could have resulted in a fatality or a permanent disability is a fact not to be forgotten. 3 accidents have been cuts from knives which are kept very sharp to cut flowers.

The fatal and disabling accidents as recalled by the subjects during their working period reveal, 11 such accidents. 8 accidents have been due to falls from slipping of the tree or ropes on rainy days. 4 have been fatal and death was instantaneous in 3 cases, according to the information provided by the subjects.

Discussion

Comparison of the fatigue complaints made by the young trainees and the older workers indicate that there are more complaints among older workers. However a significantly higher percentage (53%) ($p<.05$) of the older workers (>7 years group) show a back pain. The general fatique among the over 7 year group is also significant (79%) ($p<.05$). Could this be due to the age factor? A parallel survey on a control group (which could not be carried out owing to the limited time at the disposal of the author) would have elucidated this point. The higher percentage of local aches among the trainees in the first week of training can be expected due to the excess and unusual work performed by the muscles and jointes by an inexperienced worker. Complaints of limb pain, back pain and general fatigue made by the trainees in their 6th week (i.e. after 1½ months) when compared with the experienced labour showed significant differences (limb pain $p < .05$, back pain $p<.01$, general fatigue $p < .02$)

It was noted during the survey that more younger workers complained of pain from the callosities on their palms and feet than the older workers. Though 44% of the over 7 year group had these horny insensible lumps, these could be skin conditions where several layers of the epidermis are permantently dead. From the lower percentages of trainees (in their 6th week) and 2 to 5 year workers with callosities, indicate that the skin conditions improve after some time. As the blood circulation to these layers of the palm is not cut off in young workers, the callous skin could be painful. It is very probable that those skin protuberances that are caused by rough surfaces are results of climbing the tree. When climbing vertical surfaces the whole body is balanced on the feet and the palms or hands holds. In a study on the body movements in climbing a ladder, Dewar (1977) concludes that in climbing steeper ladder angles, the hand play a greater part in maintaining the the balance of the body. Since the coconut husk supports are at 3 foot spans on the tree it requires maximum flexion of knee and hip joints. The fairly high percentage of back pain (23%) among the trainees in their first week could be due to blimbing. The callositis on the feet can be caused by the rough surfaces of the dried coconut husk used as supports. It was revealed during the survey by the trainees that their palms peeled when they started working, which became painful and gradually resulted in callosities.

The results of the accidental falls as recalles by the toddy tappers do not seem to indicate the actual causes. But the fact remains that most falls occur on rainy days. It is seldom that a fall of over 30 feet does not result in a fatality or a permanent disability. The 36 subjects from 2 up to 40 years of service could recallect only 7 falls that did not result in a permanent injury.

The 4 fatalities and 7 permanent injuries experienced by the fellow workers as recalled by the 58 subjects give us only a vague idea of the actual number of accidental falls in this industry. Drunkenness, exhaustion and vertigo were not given as causes on the major accidents. But these could be hidden causes. Therefore the accidental falls need to be investigated in detail.

Conclusion

Toddy tapping appears to be a task that requires heavy physical work. The common physiological work measurement techniques such as, heart rate and oxygen consumption must be used to measure the physical work load. The higher percentage of physical fatigue and back pain in older workers need further investigation. Testing of ropes should be carried out prior to use and at regular intervals by competent persons. When testing ropes it may be necessary to know whether the ropes can withstand both dynamic and static pressures. This could be calculated according to Lefevre (1970). No conclusive evidence as to the causes of accidental falls can be drawn from this study. Accident recording systems in the toddy tapping industry should be improved.

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A SURVEY OF ERGONOMIC ASPECTS IN TANZANIAN FORESTRY

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Summary

In Tanzania, a wide range of people with different interests, skills and training are engaged in exploiting forests and other activities. Just as forests differ in many aspects, so do logging and transport methods, equipment and techniques.

As is the case in many areas, less consideration is given to men working in forests. This together with other reasons has resulted in high labour turnover and forestry getting an illiterate and unskilled labour force. In this paper, a survey on the present working conditions, workers' education and training background, nutrition and health condition of the forest workers in made.

Introduction

Forests in Tanzania differ in many aspects depending on the location, altitude and the extent of influence by man and animals. They experience different climates, ecological features and production capacities. There are three distinguishable forest types, closed forests (rainforests and plantations), woodland (miombo) forests and intermediate woodlands. About 57,000 hectares are man-made forests which is only about 0.13% of the total forest land. Mean annual wood production in man-made forests is estimated to be 20m^3/ha while in woodland forests only 3 m^3/ha.

Only 5% of wood harvested is industrial wood. Sawlogs form about 80% of industrial wood. Sawmills, pitsaws, chipboard, fibreboard and veneer factories are the main consumers of this industrial wood. Workers, especially loggers engaged in harvesting industrial wood, are the ones discussed at length in this paper as forest workers.

Harvesting methods, equipment and working conditions vary from one forest to another. Besides environmental factors like terrain, climate, soil, etc. the availability of capital, mill's size and technical know-how of the workers also determine the working methods, techniques and workers' efficiency in harvesting forest products.

Generally forest operations here are carried out manually or through a combination of manual labour and machinery. With the exception of a few mills the degree of mechanization is very low and the majority of the mills work below their rated capacities. The main reason is inadequate supply of logs caused by transport problems. Other reasons are frequent machinery breakdowns and unskilled workers.

In this paper, generalizations are going to be made on the working conditions, methods, workers' efficiency etc. on various mills. It should be borne in mind therefore that there are differences or exceptions to these generalizations.

Ergonomic aspects and the present working conditions

1. Workers in forestry.

Like elsewhere, less consideration has been given to men who do the work in forests. Forestry so far is facing difficulties in getting trained and skilled workers prepared to stay in the isolated remote forests for long periods. In addition to remoteness, forest work is unpopular because it demands high energy expenditure and in return, it is lowly paid. In many forests there is a high labour turnover partly because of poor working conditions and inadequate social facilities. Unfortunately because labour is easily available at low cost, there seems to be little concern over improving the working conditions so as to attract and reduce the number of workers running away.

Unlike in developed countries where human energy expenditure is decreasing due to mechanization, in Tanzania, human beings are still the main source of power in most of the forest activities. Many of the forest workers are old or illiterate people who have failed to secure jobs elsewhere. They are untrained for their jobs and those considered to be skilled have acquired that skill and experience through trial and error and through many years of working on the same job. Occasionally a few workers like logging foremen and chainsaw technicians undergo vocational or part time training courses.

2. Nutrition and workers' health.

There are three categories of forest workers. The first category is that working in man-made forests with permanent houses and small shambas (plots) for cultivating food crops. The second group works in natural forests and stay in temporary camps. This group cultivates no food crops and occasionally during sundays and public holidays they visit their families in towns. The third group either works in natural forests or in man-made forests but live with their families in the nearby villages where they cultivate food crops during their spare time.

Maize is the main food crop cultivated by these forest workers. From the maize flour, a thick poridge called 'ugali' is made. Ugali is considered to be the most popular and the cheapest dish which is taken together with either beans, fish, meat or vegetable soup. Since groups I and III cultivate their own maize, somehow they are self-sufficient or better-off than group II which buys everthing. Other food commodities are bought from the shops within the forests or nearby villages.

With the exception of a few cases where the mills provide their workers with porridge at lunch breaks, the majority of workers eat nothing while in the forest. This results to low work outputs and high delay times as midday approaches.

In developing countries where medical services are poor and forests are remote, diseases are a serious set back for work efficiency and cause great loss in work outputs. In Tanzania, there are normally small dispensaries near man-made forests which provide services to forest workers and the surrounding villages.

Normally dispensaries are located near the mill site whether in man-made forests or in natural forests. In case of accidents, patients (loggers) are transported on loaded trucks all the way to towns for treatment. In a few private sawmills the situation is even worse. Despite their mills being located within the logging areas, (far from civilization) it wouldn't be a big surprise if they don't have even first aid kits.

3. Working conditions, techniques and methods.

High temperatures accompanied by high humidity reduce workers physical working ability. High temperatures are experienced mostly in miombo forests where in the afternoons, temperatures sometimes go as high as 35°C and humidity over 85%. Sweating is high and workers feel more thirsty and tired than workers working in high altitude forests. In general, the working conditions in most of the forests are not conducive to high production. In miombo woodland forests for example, there is a problem of tsetse flies and mosquitoes and sometimes workers encounter snakes and wild animals in the forests.

Lack of training, the use of unproper tools, poor working techniques and methods are among the factors which make forest work hard and strenous. In Tanzania where loggers are poorly trained on the working techniques and methods, rarely are jobs performed in the proper manner.

A mention of few examples where in proper techniques and methods are applied will add more weight to the point. In felling, rarely are notches made to dictate the direction of fall. In some places cuts are made all around the three leaving no hinges while in some cases backcuts are made too high or too low in relation to the undercut which results to tree splitting and 'fibre pull'. Wedges meant to control the falling direction and to minimize the saw jamming are not used at all in some areas. Furthermore, while it is advocated not to bring down hangups by felling trees on which hang-ups are stuck, in many places due to lack of knowledge and means, this is the only way to release hangups.

In few plantations especially in thinning operations, hangups sulkies and skidding sulkies have been in use for the past few years. The skidding sulkies are manually operated and on average, they weigh about 25 kilogrammes. The wheels are either rubber tyred or made of iron and the average load size is about 0.25 m^3 The skidding distance can be up to 100 meters and skidding production per hour about 1 m^3.

Hang up sulkies are stronger and heavier (40 - 50 kg) than skidding sulkies. The wheels are made of steel and the sulky is so strong that almost any hangup in thinnings can be taken down. In short, the use of sulkies in plantations is being encouraged to reduce time and energy the workers spend on hangups and in forwarding logs manually to the landings. Where skidding sulkies are used, skidding costs have been found to be less than tractor skidding. In other words it means, the use of skidding sulkies especially in thinning operation not only would reduce costs, require less investments and foreign currency but, it would also create more employment.

The working tools and machinery lack proper maintenance and repair. Axe handles for example are not of the right dimension and quality. Some axes are too heavy to work with and most of them are blunt. Saw teeth are unproperly sharpened and set and this together with frequent saw jamming and saw bending make cutting one of the strenuous jobs in forest operations.

Besides faults in forest machines causing accidents and stress on the workers, they also lower production output due to low machine utilization. Non-availability of spares-parts to repair the machines on time is again one of the reasons why machines stay idle for long periods.

4. Accidents in the forest.

Many loggers are not trained in the safe use of tools and machinery and have little knowledge of the hazards and precautions necessary to prevent accidents and injuries. In addition, workers are not provided with safety devices like helmets, boots, ear protectors etc. Powersaws have no chain brake and tractors lack protective cabins. All these factors lead to a high number of accidents and injuries in many of the forest operations.

There are several causes of accidents. In cutting operation alone, some of the factors which contribute to accidents include the use of improperly maintained and faulty tools

and machinery, poor working techniques and methods, improper use of tools and machinery and stress on the workers. Also, lack of concentration on the work, faults on trees, i.o. leaning too much, hangups and improper site clearance are among other factors too.

In skidding operations, drivers are hit by slashes, branches and shrubs due to lack of protective cabins. Where communication or sight viewing between the driver and the chokerman and the chaser (unchokerman) is poor, the latter two are often hit by logs or their fingers caught in the skidding line.

Lack of vehicles to transport loggers to and from the forest force loggers to climb on top of logs on their way home. Loggers are hit by overhanging branches and nearby trees and incase of accident, loggers are smashed by these logs.

Discussion on the improvement of the present situation

1. Training of forest workers.

Forest workers need training on the correct working techniques, basic tool maintenance and efficient handling of tools. Just as it is useless to supply tools to untrained workers, training of loggers is of no use if tools are not available once training is over. In other words, training and tool supply should go hand in hand.

Since the majority of the forest workers are illiterate, even among the long service workers, to get people worth taking for further training is not easy. It has been a general trend for many mills to employ illiterate and unskilled workers rather than trained and skilled ones bacause the former demand less pay and previllages. However, with the introduction of machinery to replace manual labour, and with bigger and more sophisicated mills coming into operation, things are changing since the situation is demanding more trained and skilled manpower.

Despite the fact that it would pay to train workers, most of the mills are sceptical of training young workers. From experience, after training, many of them run away into towns to work in big industries where there are better social facilities and more pay. To curb this problem, the management ought to improve the working conditions, pay more and render more social services and incentives to its workers.

The present sawmilling and logging courses given by the Forest Industrial Training Institute (FITI) to foremen should be intensified and the institute expanded to accomodate more students. In 1973 and 1974, the International Labour Organization (ILO) organized short courses on the use of sulky in felling and skidding, tool maintenance and chainsaw operation.

2. Food intake by forest workers.

Work output in forests is influenced by many factors mainly related to the working environment and the worker himself. Evironmental factors include stand or forest condition, terrain, climate etc. while human factors are workers' working power, skill and traditional background. Workers' power depends on the body weight, health condition and how well the workers are fed. It has been found that the working capacities of labourers in developing countries are lower than in developed countries because of their lower body weights and poor nutrition. Poor nutrition causes loss of working days due to frequent illness and low resistance against infections leading to poor health. Workers with poor health always complain, show poor general life satisfaction and are more susceptible to accidents. By feeding the workers or encouraging them to produce low cost food of high nutritional values, working power and consequently work output will increase. Where there are no shops around (as is the case in many areas), the management should make sure that essential commodities are provided to workers by taking the responsibility of buying them in big stocks.

However, some sawmillers argue that even without providing the workers with meals, the task or piece work is fulfilled. True it is, but so long as the task or piece work is wrongly set or unsoundly based, the argument is nullified by the fact that in some areas the tasks demand too much from the workers while in some places tasks are too light. In other words, research on work studies ought to be done concomitantly with ergonomic research so as to fix fair and reasonable tasks.

3. Health improvement.

As much as possible, medical facilities should be available near the logging areas where most of operations are taking place. Small cases should be treated promptly on spot instead of taking patients all the way to towns. Again life could have been easier if logging foremen were taught first aid principles and walk around in the forest with first aid kits to treat minor cases which later with time may develop into serious cases.

In areas with mosquitoes and tsetse flies, precautions should be taken by providing workers with anti-malaria tablets regularly. Also by keeping the premises around the camping sites clean, pit latrines and showers well separated from cooking places, many of the diseases could be eliminated.

All domestic water used by forest workers is collected from ground water holes, streams or nearby rivers. In dry season, there are problems of water and this force workers to

walk long distances searching for water. With rivers and streams passing through different areas and ground water being filled with all sorts of rubbish especially during the rainy season, it increases the chances of water being contaminated with water borne diseases like stomach troubles, diarrhea and serious ones like cholera and typhoid.

Thus, forest managements should see to it that water is treated, boiled and made clean by adding 'alum' (a coagulant which settles mud at the bottom).

4. Possibilities of reducing accidents.

Causes of accidents are many but a good number of them could have been reduced if certain measures or improvements were taken. Among these include:
Improvement of safety consciousness among workers; Cooperation between individuals and fellow workers; Educating the workers on the causes of accidents and the risks involved in various work operations; Introduction of good working tools and training of forest workers on the proper use and maintenance of these tools and work organization; Improvement of health and nutrition of workers; Increase of workers' pay.

Increase of pay will hopefully make them think less of their domestic problems and enable them to eat more and better food. By doing so, they will be able to produce more which will in the end lead to the breaking of the present vicious cycle.

(abridged version)

THE FOREST WORKER'S TOOL AND SAFETY IN SIERRA LEONE

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Back ground to forestry in Sierra Leone

The Forestry Division which is part of the Ministry of Agriculture and Forestry was formed in 1911 to stop the unrestricted exploitation of the forest resources of Sierra Leone. By that time most of the forest on the coast had been exploited for mahogany and cam wood Baphia nitida and shifting cultivation was playing havoc in the hinterland. The Forestry Act was passed in 1912 and forest reservation started. The hills of the Western Area near Freetown, the capital of Sierra Leone, were acquired and the remnant high forests of the then Protectorate which had escaped shifting cultivation were also constituted Forest Reserves. To date about 1,179.55 sq. miles which is 4.42% of the total area of the country has been constituted Forest Reserves.

Exploitation is carried on by one state owned corporation and two private companies. One of these organisations exports logs. All timber produced, mainly planks, is for domestic consumption.

Two types of regeneration were practised in the past. Natural regeneration - The Tropical Shelter Wood System - TSS and artificial regeneration using fast growing native species.

The TSS has been stopped in favour of artificial regeneration. The planting target of 1,000 acres of 404.7 hectares per annum which has not been keeping pace with the annual rate of exploitation has been reduced to allow for the tending of already established plantation.

Types of forest workers in Sierra Leone

Two basic types of Agri-Silviculture have been described by Olawoye (1975). These are "own your own crop" - "traditional taungya" and "farming for pay" - "direct or departmental taungya".

In Sierra Leone the "own your own crop" - "traditional taungya" - has been practised since plantation forestry was started in 1922. There are however slight modifications in details. For example at the moment rice is the only crop permitted and farmers are allowed to stay for only one crop year.

There are therefore two types of workers engaged on Agri-Silviculture in Sierra Leone. The paid worker who plants and tends the forest trees and the "own your own crop" farmer. (It is possible that both types of workers can be the same person. In cases where the forest worker is a bona fide land owner he can be allowed to cultivate land in the area where he is working after official hours).

The number of paid forestry workers is very small. There are about 2.000 paid forest workers in the whole country. Since the country is a purely an agricultural country about 75% of the population is engaged on some form of agricultural activity. But almost all farmers will cultivate rice for their subsistence either in swamps or on upland areas. The upland farmers are the ones that are used in the "own your own crop" agri-Silviculture. The number of such farmers will greatly increase in Sierra Leone as more forest land is exploited and made available for regeneration and forest vegetation outside forest reserves is reduced to infertile scrub land.

The forest workers tools

The tools used in silvicultural operations in Sierra Leone are the same as those used in traditional Argiculture. These include the cutlass, axe and hoe. These simple implements have changed very little over the years. The axe, for example, is still the same shape as the stone axe used in the stone age. The stone age implement before you was found by me in the Gola Forest in 1975. The size and shape of these tools vary from one ethnic group to the other and for the type work the user is engaged one. These tools are made from discarded light vehicle springs in most cases and sometimes from imported cutlasses which are converted by black smiths to suit the worker. These could be the slim cutlass of the bush trail cleaner to the heavy wood cutters cutlass.

The cutlass is an indispensable tool of the forest worker. He will always carry one regardless of what operation he may be engaged upon. The cutlass is not only used as a tool but also as a defensive weapon when he is working in the tropical forest or when he moves from one village to the other on foot. The cutlass is used to brush in farming and silvicultural operations, i.e. for cutting shrubs, climbers and all woody stems from 7-8 cm diameter; for larger trees, the axe is used.

Hoes are normally used in nurseries for weeding and ploughing rice fields.

Pick axes, shovels and spades are introduced tools and are used mostly in nursery work.

The effect of all these tools on the Forest Worker's health has not been fully investigated in Sierra Leone. The first visible effects appear on the palm of the worker. Blisters form at the base of his fingers and the thump. In other cases, depending on the nature of the work, the skin on the palm develops corns as a result of the constant pressure on the skin. There have been instances when infections have been caused when splinters from the handle of the tool enter the skin of the palm causing cellulitis. The fingers also become cramped and permanently curved according to the size and shape of the handle of the tool the work is using, in many cases the worker will complain of pains in the shoulder and the wrist if he is engaged continuously on operation using the cutlass or the axe. In some cases back pains may be experienced. Serious cases of arthritis have been recorded during old age in the shoulder and elbow of agro-forestry workers.

Safety and Safety Regulations

The incidence of injuries at work is very low indeed. When injuries occur, they may be caused by:

1 Wounds from cutlasses and axes;
2 Snake bites;
3 Other minor cuts and bruises caused by the very nature of the tropical forest (thorny climbers and noxious weeds).

Because of the low rate of injuries at work and the simple nature of the tools used in agro-forestry on specific safety laws have been enacted for this sector of the economy in Sierra Leone.

General Laws have been enacted, which are applicable to all working conditions including agro-forestry for example the provision of:

1 Basic first aid at work;
2 Medical aid, conveyance of injuried person to hospital etc. (Cap 218 Sections 71-73 Laws of Sierra Leone).

The forest worker in Sierra Leone needs to have his own safety laws like those for his counterparts in other industries. The provision of pretective clothing at work will reduce the incidence of wounds, bruises, snake bites and the formations of corns on the palm. The use of mobile radios will help locate seriously injured and sick workers in the forest. Snake serum should also be part of the forest workers every day kit. It should also be mandatory to have a fully trained first aider in every gang of forest workers. Most important is Senior Forestry Officers should be equiped with light transports which will enable them to bring help to workers in need of such help or to move injured workers without delay to hospital.

Until such provisions are made the forestry worker in Sierra Leone will have to depend on his natural will to survive in the tropical forest. "

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ERGONOMICAL RESEARCH AND TEACHING IN COLOMBIA

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Introduction

The development of Ergonomics in Colombia is closely related to the development of Industrial Engineering.
The concept of Industrial Engineering as such was introduced at the Colombian universities during the late fifties. It was based upon the classical Taylorism of the USA, the scientific management. In many aspects, the studies that are now carried out in Colombia still conserve many of the characteristics of the Taylorism.

At an early stage, however, certain critisism was raised against the Tayloristic approach. from a group of teachers and other intelectuals, as well as from workers and trade unions. From then on there has been a strong contradistinction between"the Taylorists" and those who fight for humanizing work and protecting the workers' safety and health.

Ergonomics joined this fight with an open mind. The word Ergonomics (Ergonomia) was introduced in Colombia for the first time around 1962. It started at the University of the Americas in Bogota in the context of a program to introduce MTM (Methods - Time Measurement), the classical and most questioned technique of scientific management.

This event was the starting point for a discussion -somewhat superfial may be- on Ergonomics at various Colombian universities. It might be added that during the years 1967 and 1968, a bicycle ergometer was imported as one of the activities of a UNESCO-project at the University of Industrial Engineering of Santander in Bucaramanga. Using this instrument, a series of experiments were carried out, although without much practical applicability. If one does not consider the technical support of theoretical lectures as a practical application.

More or less at the same time some ergonomical research and teaching activities were carried out, which have had a great influence in Colombia. They were performed by the Swedish ergonomist, Mr. Elgstrand, within the frame of a technical assistance programme at the University of Cauca in Popayan. The research activities, although having inevitable limitations, of Mr. Elgstrand have served as a reference point for the development in Colombia but also in other Latin American countries.

During the first years of 1970 no special ergonomical research activities were carried out in Colombia. In 1976 a new promising attempt was made to establish research in Ergonomics in Colombia.

Recent Ergonomical activities in Colombia

In 1976 I returned to the National University of Colombia in Medellin, where I had been active during the 1960-ies. I then proposed to the University authorities to establish the subject Ergonomics as part of the studies for Industrial Engineering. My proposal was accepted and in the same year, for the first time in Colombia, the subject Ergonomics was offered as an integrated, elective part of the curriculum.

The new subject raised a lot of interest among the students who were to finish their engineering studies. Intense debates took place about the classical concepts of production in relation to the future needs of the country. The multiplicatory effects of the teaching soon gave birth to practical activities and research, some of them in the form of thesis works. Numérous proffessional associations asked for lectures and conferences on Ergonomics and three or four refreshment courses for graduates were arranged. Also the private industries showed their interest, culminating in the creation of an Ergonomics Commitee in the largest textile industry of the country. At this very moment the commitee is not so very active, but it might be expected to increase their activities in the near future. In 1978 the subject Ergonomics was established as a compulsory subject within the curriculum of Industrial Engineering. Since 1976 about 100 students have finished this course with satisfactory results.
Other Colombian universities have followed the example to establish Ergonomics as a teaching subject: The Industrial University of Santander, the Technology University of Pereira and the University of Antioquia.
It is also likely that other universities will follow along the same road.
In 1977 the association of Industrial Engineering from the University of Antioquia published my paper "Curso de Ergonomia" with the principle objective that it should serve as a base for the actual teaching. The edition was restricted to 500 copies, but with the idea that it should be the first step to a revised and extended edition. However, an unexpected interest caused the edition to be finished sooner. Because of the demands another edition with the same amount of copies, unfortenately not revised and extended, will be printed. The second edition is nearly finished which means that about one thousend copies will be circulating. Considering the limited industrialised sector of the country, this might be regarded as rather a large number.

The contents of the teaching of Ergonomics at the National University of Colombia in Medellin

The contents of the teaching of Ergonomics is corresponding to the context of the above mentioned textbook.
It is divided in four parts:

a Historical introduction and actual debate concerning the nature and organisation of work, with special reference to Colombian circumstances.

b Work physiology. Nutrition. Energy expenditure in manual tasks. Design of work, considering physical work demands. Rest allowances planning. This is one of our most important concerns due to its importance in productive systems in Colombia and therefore it has been applied in local industries.

c Design of work places, machines, tools and products. Probably this is one of the areas of Ergonomics which will have to be extensively developed at an international level. However it is analysed very superfiacially within the text. There are various reasons which justify this such as the lack of anthropometric data and technological dependance.

d Enviromental factors. Due to the short time available they are reduced to lighting noise and beat. The idea is to include other aspects in the future, especially those related to the respiratory system.

Some research was carried out in Medellin

a Ergonomical study of heat load.

b Hygiene and bealth of forestry workers.

c Ergonomical study of different jobs.

d Study of lighting, noise and beat in a mechanical industry.

e Ergonomical study in the building industry.

f Anthropometric survey of workers from Medellin.

Final Remarks and future prospects

As has been mentioned before, during the last years there has been an increasing interest in Colombia in developing teaching, research and extension of Ergonomics, particularly in Medellin which is one of the most important industrial ares in the country.
However to this positive fact we have to add something negative: the activities in the field have not been coordinated and the work that was carried out was done without any mechanism or organisation regulating the activities within a clear programme. There are a number of people working on their own without any information of what other people are doing in the same field. There is a lack of knowledge about equipment and existing resourses within other organisations and furthermore there is an insufficient theoretical base and there is a lack of basic research data and statistics.

The teachers and researchers interested in Ergonomics and Occupational Health very recently have organised themselves. They have not taken any specific name nor have we defined any specific goals. At this preliminary stage we are meeting every fortnight simply to exchange information. The participants comment on their experiences, studies or research work including the problems they have encounterd and the resourses available to them etc.
We hope that after some time and once we have defined our resources and needs, we will be able to develop a multidisciplinary approach designing comprehensive research programmes.
At present, the organisation included in the group who are working in the field are:

- The school of Public Health of the University of Antioquia
- The local Bureau of the Ministry of Health
- Department of Occupational Health of the Institute of Social Security
- Faculty of Anthropology of the University of Antioquia
- Faculty of Industrial Engineering of the University of Antioquia
- Faculty of Industrial Engineering of the Universidad Nacional de Colombia
- Faculty of Forest Engineering of the Universidad Nacional de Colombia
- Colombian Sports Medicine Organisation (cooperation programme with Federal Republic of Germany)
- Local authorities of Medellin
- Executives and personel of large enterprises interested in applying ergonomical concepts.

Personally I have hopes for the future achievements of this team of recently organised members. They are aware of the human problems and their faith in Ergonomics should result in a growing of this field in Colombia.

A LOOK AT THE PROBLEM OF RESEARCH AND EDUCATION IN ERGONOMICS IN TROPICAL COUNTRIES

By Toru Adachihara

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The introduction of machinery in all phases of agriculture and forestry has led to an incresing dependence on this mode of production for improving efficiency and it has resulted in liberating man from the more severe work associated with manual labor. But mechanization of labor has also created new mental and physical problems for the worker and led to an increase of occupational accidents. This situation, which is agravated in proportion to the advancement of mechanization, is unfavourable. It is a problem common to all the socalled "developed countries"; called "developed" or "under-developed" on the basis of their "degree of mechanization". It is under these circumstances that the study and education of ergonomics developed. Looking at the situation more closely in which the study and education of ergonomics developed, the following can be noted. It is this mechanization which appears in all aspects of human life and also evolves toward the industrialization that enables it to exist and grow that formed the "basis" on which the discipline of ergonomics was born and developed.

The reason for restating this already known fact is to reconfirm the following point. That is, that ergonomics grew out of the "problem awareness" of people living in a industrialized society and that it has been fostered under such circumstances. Looking at the basis of ergonomics from another angle, it can be said that in societies where industrialization is not advanced. (It goes without saying that lack of mechanization does in any way diminish the quality or the happiness of life), there exists no"basis" on which ergonomics can emerge and develop.

Since the study and education of ergonomics deals with human labor, and this labor is supporting the social life of man living in society, ergonomics can never be brought about nor it can provide a meaningful study or source of education for the people of the society, if the social circumstances that from the basis or background of human labor are neglected. If the study and education of human labor are carried out "independently without control" with no regard to what the society or the people in the society are striving for, the results will be dead data, merely satisfying the interests and concerns of people outside the society. Or, it will be used by outsiders as a means of human management, to rule over people in society and control them as workers.

It is simply stating in a "different way" that mechanization and industrialization in tropical countries are not as advanced as in the "developed" countries. Mechanization and industrialization have both their advantages and disadvantages. People in the developing countries do not receive the benefits of material wealth or the conveniences associated with industrialization, nor do they have to face the problems caused by vibration, noise, exhaust gas, fume, dust and other noxious substances. For people in industrialized societies, liberation from these anxieties seems desirable, often it is even a target of envy. However, as mentioned previously, it is quite natural that in the developing nations, people's "problem awareness". which forms the basis and background leading to the emergence and development of ergonomics, is either absent or either very weak. For those who are continuously confronted with the disadvantages of mechanization and industrialisation, living conditions where the problems of ergonomics do not arise seem more favorable. Nevertheless, the trend in thought in modern civilization has moved toward evaluating mechanization and industrialization as being "favourable", thus leaving those delayed in the course of mechanical process to feel insecure and left behind. And this can be said as being a matter of "economic problem awareness" rather than a "ergonomic problem awareness".

Considering these aspects, one of the principal questions becomes how to evaluate and foster the study and education of ergonomics in tropical countries. Even when we look at the field of labor in agriculture and forestry, the basic problem is to decide whether the principles and methods of ergonomics derived from the problem awareness experienced in industrialized countries can be applied to the "work problem" in tropical countries. And even if they were applied, what significance they bear. This leads to a fundamental question touching upon the principles of ergonomics.

All research begins by recognizing certain phenomena. Research in ergonomics tries first to grasp the work situations of the people. By recognizing the phenomena, observing them and "measuring" them or "counting" them using the appropriate methods, some kind of numerical value can be obtained. Yet, such results will remain numerical figures as long as there exists no philosophy behind them that enables interpretation of the measured values and

attributes meaning to them. If ergonomics study and education in tropical countries were to be regarded as one measure of the "old" policy, to be applied by those in the industrially-advanced countries in coming to work in tropical countries, or if it were to be considered as necessary in the future in the sense that people in these countries will eventually become aware of problems of ergonomics with the development of industrialization, there is no room for further discussion. Still, there remains the question of, "shouldn't there be some other approach?", thus leading to the main theme of this discussion.

In order to enhance the study and education of ergonomics, ergonomics should free itself from the trend of "modern thought" where happiness in human life and social wealth are pursued and evaluated in terms of conveniences of mechanization or degree of industrialization. Ergonomics should work for striving toward forms of labour where man is independent. Hence, efforts should be made to develop new methods in the study and education of ergonomics and at the same time, keep in mind the fundamental question of what is more favorable work for people in a better society. It is essential that efforts need to be taken in the search for a philosophy of work for people in the society.

(abridged version)

THE ROLE OF ERGONOMICS IN TROPICAL AGRICULTURE IN DEVELOPING COUNTRIES

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Probably the most energy consuming task in tropical agriculture is primary cultivation; relatively little fundamental work has been done on this problem.

Before looking at what should be done, it is relevant to consider what would happen if someone came up with a miracle tool or system that made life significantly easier for the cultivator. The immediate question is how would you get that sort of information across to the type of farmer who is still doing his primary cultivation by hand. Added to this you have the problem that a new implement or technique that is worked in a substantially different way from the existing method may require a complete new set of skills and muscular coordination to operate it. These will take time to acquire, and the chances are that the first day a man tries out a new tool he will not achieve as much as he did with his old, although basically inefficient, tool and at the end of the day he will probably be more tired. It may require considerable determination to persist to the point when the new tool or technique is more efficient than the old one.

Before starting on a project to design the ergonomically perfect implement for primary cultivation, one must accept that designing the implement is likely to be the easiest part of the job. Testing and evaluation under a wide range of conditions will be difficult, and getting it accepted almost impossible unless the breakthrough is dramatic, and the new techniques can be learnt with the minimum of training and disruption. Perhaps the best illustration of this problem is the European scythe. On paper it appears to be one of the most effective ways of cutting green forage crops and, used with a cradle, harvesting grain. Many attempts have been made to introduce them into Africa and other countries but most have failed, primarily because I think the man who has tried to introduce them has not got the skill of the traditional farm worker. He may be able to make a few cuts, but he is not able (or prepared) to spend all day showing how much work can be done in a day. Because a man lacks skill he also finds it very difficult to instruct complete novices.

Given that the soil condition required for growing a crop can be defined, the soil mechanics should then establish the optimum shape of the tool, and the method of application that will require the minimum of power to achieve the required break-up of the soil. At this stage there would be a need for an ergonomist to ensure that the tool could in fact be operated by a man efficiently. A certain amount of lateral thinking would be an advantage at this point, and it could well be that the new implement for primary cultivation bears no resemblence to any existing tool or mode of operation. This may be an advantage in getting a new technique accepted. Altering the angle of an existing hoe by 5 to 10° and telling a man to use it with his hands in a different place may give a reduction in energy required, but if the change is too small it may be very difficult to demonstrate the difference or ensure a permanent change af habit.

The problem of getting improved tools and techniques through to the small farmer is one of scale - dealing with vast numbers of individuals. In theory there should be much less trouble in introducing new techniques on large labour intensive projects where big gangs of labourers are performing repetitive work, be it road making, canal building or clearing bush.

Unfortunately there are many cases of labour intensive work where the management, for purely selfish reasons, has been most reluctant to bring in work study. Most of these cases occur in the public works field where the Government or large company will let out particular jobs to contractors on a tender basis. The Government concerned will assume that by going to tender it will get the job done in the most efficient and cheapest way, but this is not always true. Even if not in league with each other, the contractors have a vested interest in keeping the cost high, and they are particularly worried that once a study team got down to analysing the work done and the methods used, the Government concerned would have a much better idea of what the real costs could be and hold the contractors down to that price. You often see this type of problem from the side-lines as mechanization advisers: contracts have gone to capital intensive systems because they gave the lowest tender, but it was obvious that properly organised hand labour with the right tools would be considerably cheaper; however, no one had been in a position to organize labour gangs with the same efficiency that was applied to capital intensive mechanization.

A good example of this recently was the large sugar plantation in Africa that decided it would have to mechanize its can-handling in the field due to a shortage of cutters even though a relatively small private farm feeding the same factory had no problems in this respect.

The reason for the problems, was so obvious once it had been identified. Cutters on both the estates had to cut and pile the cane into heaps of about 1 ton for automatic loading on to special self-loading trailers. These trailers require two chains each weighing about 50 kg to be passed around the bundle before loading. On the estate the cutters were expected to carry these chains up to 500m into the cane from the road head before starting cutting, whereas on the smaller farm the chains were carried on the loading trailers and threaded under the heaps by the loading gang. It was hardly surprising that the cutters on the big estate were reluctant to turn out for work when their first task was to carry a very heavy chain up 500m through what could be extremely difficult walking. Another problem with the same two extates was that although the cutters had to collect the cane to a heap from the same area, on the big plantation the bulk of the carrying was across the ridges on which the sugar was planted, whereas on the small farm the carrying was along the road. This again gave a significant difference in the work-load and hence the rate of work. In a study carried out on sisal cutters, it was found that the cutters - who had to carry the 10 - 15 kg bundles down the road to the transport roads - varied the speed of carrying according to the distance carried; the curve of carrying time v. distance was distinctly 'S' shaped. Up to 20m the end effects dominated and the carry time was almost constant. From 20 to 100m the time increased linearly with the distance, ie the speed was constant; avobe 100m there was a dramatic steepening of the curve. ie the speed of walking dropped significantly. It appeared that most estates had fixed on 200m as the spacing for their haul roads and this was ergonomically satisfactory. Unfortunately, there were no occasions where very long carries could be checked to see how the curve went after its initial steepening.

Another point that came out in these studies was that most cutters started soon after dawn (6 am) and finished by 11 am. Those that carried on after 12 continued to work at substantially the same rate as before for their unit tasks such as cutting, bundling or carrying, but organized their time so badly that their output dropped to about half. Thus instead of cutting steadily for an hour or more and then bundling, etc., they would cut for 5 minutes, then make up 2 or 3 bundles, and carry 2 to the end of the row before going back to cutting etc.

These cutters had obviously adjusted their work-loads to suit themselves. The reasons why must remain a matter for conjecture. However, one may hypothesise that the cutters were behaving so as to reduce their level of fatique, which would have been increasing throughout the day. An analysis of the heart-rates of the cutters would have been desirable with particular attention paid to the recovery (ie decrease in heart-rate) during the least strenuous activity. Since work should continue only so long that it does not unduly prolong recovery, the cutters were probably acting to either reduce their average levels of heart-rate in order to achieve a significant recovery in a relatively short time, or, spending longer on less strenuous activity to allow a greater time for recovery. Under these circumstances, an analysis of heart-rate would have been more informative than an analysis of oxygen uptake.

As a matter of interest these studies were made in response to a request to develop a machine for cutting sisal as hand cutting was becoming expensive and labour difficult to come by. The result of the studies was that the so-called cutter spent about 20% of his time actually cutting, 30% carrying, and 40% making up the leaves into bundles for carrying. Half the bundling time was spent counting 25 leaves per bundle as the man paid on the basis of 100 x 25 leaf bundles per day. The only estates that paid on the volume of leaf cut had a 20% higher output per man hour as timed. The answer to the cutting machine was to propose either a modification of the method of payment or preferably a completely new system of transporting.

Animal draught equipment does not appear (on the surface) to present as many problems as hand or engine operated implements. The reactions of the animals themselves seem to be able to demonstrate fairly effectively if an implement has been well designed from their point of view. The operators, too, will normally ensure that the implement is hitched correctly so that it requires the minimum of effort on their part to control. Whether to use one or two handles on a plough depends to a certain extent on the type of hitch to the animals and also the work done by the implemant; if a man can walk directly behind the implement two handles are suitable. If the surface left by the implement is rough, the operator may walk to one side fo the implement and a single handle is adequate. (The two handles of animal drawn implements do not control the implement like a bicycle. Steering is achieved by tilting the implement to left or right. Two handles may be required to manhandle a machine into line at the end of a row however.)

Two-handle implements do have an advantage in hard conditions as the operator can lean on the handles to add weight to the plough. The converse should never apply - if an implement goes too deep it should be raised on the hitch and not by the operator carrying part of the weight. With the two-handle type of implement, handle height is critical and it is often difficult to compromise between the correct height in work and also for manoeuvring out of work at the end of the row where most of the effort is required. Many ploughs are simply

thrown on their sides for transport or turning at the end of the row; under these circumstances, the two-handle plough has the advantage as at least one handle is always sticking up in the air. These ploughs often have special wearing pads on the handles to ensure that the handgrips are not worn sharp.

Transport of ox equipment can be a problem particularly in mountainous areas and in flooded paddy. Under these circumstances where the operator frequently has to carry the plough to and from work on his shoulders, a light implement is an advantage; also a thick wooden beam is easier on the shoulder than a narrow steel section.

Normally in work the implement should not require any special effort to steer, and the walking speed of most oxen (horses and mules can be much faster) is such that the speed is unlikely to be excessive. Some implements have been designed where the operator has to do extra work such as the tie scoop used to make tied ridges behind a ridging plough. This is not normally very satisfactory as it soon becomes apparent that the operator has very little energy to spare for this type of ancillary operation. Where special concentration is required, it may be necessary to allow the operator to ride on the machine. Fortunalety most operations that require this are relatively light, so the ride-on operator does not overtax the animal.

Animal drawn toolbars have attracted a lot of attention form engineers in developed countries who are trying to say how the less developed farmers should mechanize. So far the toolbars, mainly for economic reasons, have been accepted only where promoted and heavily subsidised by Governments. Many of the designs have been exceedingly poor from the ergonomic point of view, with awkward levers going the wrong way, and in some cases even dangerous. A very interesting design was produced by some students of design in Mexico which claims to be based on ergonomic rather than agricultural principles.

It is with the introduction of small powered cultivators that the main problems of ergonomics arise. These machines have only been successful under fairly limited conditions. In Europe and America, for market gardens used on restricted areas where the soils are easily worked, and in Japan again on easy soils for flooded rice. In all cases the operator is usually only part-time on the machine and he is very often the owner.
When these machines have been introduced to other parts of the world the main problem has been operator fatique. A labourer will find that he will in fact expend far less energy digging by hand than controlling a power tiller, particularly a large one in hard ground conditions. While an owner may be prepared to put up with the hard work on the basis that it is only 2 to 3 days and he is achieving far more than he would by hand, the hired operator does not have these incentives. The chances are that the owner hiring operators will try to recover the maximum on his investment and expect the machine to work continually on contract cultivation for 2 to 3 weeks. In one country where these tillers were tried, a typical reaction by operators, once they realised their fate, was to drive the tiller into a tree. This ensured them at least a few days rest while the tiller was being repaired.

The alternative of having 2 or 3 operators to a machine does not work either. Dividing responsibilities for the care and maintenance of a machine is one problem, the other is that most people like to work steadily at their own rate, and alternating bouts of very heavy exertion with equal rest periods does not appeal. Perhaps there is an ergonomic solution to this problem.Whether the reasons for operator fatique can be overcome is antoher question. The main problem is one of cost. The cheaper units do not have the clutch assisted steering of the bigger machines, and this can make a considerable difference when turning at the end of a run. The next problem is speed. To have an advantage over animals the motorised cultivator must be faster, and again from the mechanical point of view where weight is restricted the only way to absorb the power available is to have a higher forward speed. This usually means the operator has to walk very quickly over uneven ground and this in itself requires considerable effort. The heavy machines would normally be easier to control in work but very much more difficult to manoeuvre at the ends and also into another field, particularly where access involves crossing a drainage or irrigation ditch. Handle height becomes more critical with motorised cultivators, partly because of the increased depth at which they work, causing a greater difference between the in and out of work height, and partly because, even if set properly, they require more control than an ox implement. The steering of tillers is effected by moving the handles to the left or right; the exertion of large forces by the arms in sideways directions is physically very demanding.

The cheapest and simplest motorised cultivators replace the driving wheels by a rotary cultivator for weeding or seedbed preparation. The depth of work being controlled by braking the forward movement with a single tine. This type of implement requires continuous attention, and while effective is exhausting. Continual pressure on the handles means that all the vibrations from the engine and cultivator are carried trough to the operator.

The small ride-on tractors like the animal drawn toolbars are frequently very badly designed from the ergonomic point of view, with awkward hand lift and poor visibility. At least one machine has got what is cynically

described as an eye-level crank for starting the diesel engine.

Inevitably, small, cheap tractors rely on single or at best twin cylinder engines with the associated noise and vibration problems. In an effort to keep the cost down there is no provision for special silencing or insulation.

Small engine-driven threshers, raspadors, etc present a number of ergonomics and safety problems. The threshers usually require feeding at the top with the product being removed from the bottom. This is basically the wrong way round, and the design of the feed can have very significant effects on the output of the machine. In most of these machines a uniform feed is essential to obtain maximum output from the size and power available, with the quality of work for threshing efficiency usually being adversely affected by uneven feeding. However, on many machines no consideration is given to how operators will work. Inevitably, threshing is dusty and noisy and it would be interesting to know how this affects the output/safety of the operators.

In one comparative trial of sisal raspadors (a simple machine for extracting the fibre from sisal leaves) the smallest and cheapest machine was found to have a significantly higher output than the other machines even when operators were changed between different machines. The reason was that the manufacturers of that particular machine provided a table at waist height (the height of the feed table) so that the operator did not have to bent down to pick up the leaves from the floor. This machine was also more popular with the operators as it did not snatch the leaves as much nor send a spray of extremely unpleasant juice back on the operator. The only complaint was that it was comparatively narrow for a 2-man machine and worked best if you could find left and right handed operators.

The manufacturers' and some of the owners' (as opposed to operators) attitude to easing the work load was interesting, as they considered that with labour as cheap as it was there was no point in paying extra (2 tables) to increase the output. What they did not realise was that their main cost was owning and running the machine, and that if the output per machine hour could be increased the saving there would more than justify the extra expense.

The same attitude is common when it comes to operators for the big machines: tractors, earthmoving machines, etc. There is an attitude that if you can get a man for £5 a week to operate a machine, why waste £1000 on an air-conditioned cab for him? This may be true but the justification for quiet cabs improved environment in developed countries is not simply that the operators will not work without these benefits, but also that their productivity, accuracy or reliability is increased with the improved environment. It may be true that low-paid poorly trained operators never reach the level of efficiency where they might be affected by the poor conditions, but when you consider just how bad the dust and heat can be working in some tropical areas this seems unlikely. It would be interesting if figures were available to quantify the effects of dust, noise and heat on the operators' performance at this level. On the mechanical side there is no doubt that the modern engine and transmission are very much more sensitive to dust, but the design and filtering systems have been improved to the point, on most machines, that the engine is protected against the environment. This is not so when the machine breaks down and should be brought back to a proper workshop before opening up any of the oily parts. I am convinced that many of the problems associated with field repairs of machinery are due to the very poor environment for the mechanic particularly where he is expected to work unprotected in the sun. Not only do you have the temperature problem but also a visibility problem: once the eyes have adjusted to the glare of the sun, it is almost impossible to inspect any shaded part of the engine.

Vibration is another problem. Primary cultivation of hard dry soils can leave a surface that is both hard and rough making secondary cultivations very unpleasant. Even so, there is a school of thought that sophisticated suspension seats should not be used under these conditions since many operators will operate a machine to the limit of their tolerance. There is no point in isolating the operator from the bumps if the machine cannot stand up to the rough treatment.

Fully enclosed quiet cabs are often regarded as an essential in cold weather, but a liability in the summer when the operator wants to be exposed to every cooling breeze. Air conditioning is expensive and presents extra servicing problems and also isolates the operator almost completely from the machine about him. It was interesting, therefore, to find a tractor working in the North of Nigeria where the temperature was 46°C in the shade, fitted with a fully enclosed quiet cab and no air conditioning. In fact the cab had two heavy duty heater fans which could be used without the heater to keep the air circulating. The air was very dry and so gave considerable evaporative cooling. As the wind speed was such that in one direction the tractor moved along in its own cloud of dust and smoke, the driver was much happier in the shade of his cab with the dust-free breeze blowing over him than he would have been if exposed to the elements. He certainly appreciated the benefits of the cab although it was not obvious if its extra cost was matched by an increase in performance or reliability.

Nearly all these anecdotes illustrate that ergonomics must extend far beyond the basic interaction between man and his machine or piece of equipment. Ergonomics must consider the larger system in which man-equipment interaction is only one component part. Probably one of the greatest problems facing an ergonomist, particularly in a developing country, is deciding on the boundaries of his system, and, having decided, obtaining the necessary data. In addition to man's capacity for physical and/or mental work and the efficiency with which it may be applied the influence of his environment, attitudes, motivation, rewards, socio-economic and political circumstances all contribute to his overall performance. The study of the influence of equipment design on man's performance at work is valid only if these other factors are relatively unimportant and will not confound the results should they be applied elsewhere. If there is any likelihood that performance may be affected by anything other than equipment design, or indeed any of the main variables under scrutiny whatever their nature, the context of the study must be clearly stated.

(abridged version)

IMPROVED MICROCLIMATIC ENVIRONMENT FOR OPERATORS OF TRACTORS AND SELF-PROPELLED AGRICULTURAL MACHINES IN THE SUB-TROPICAL AND TROPICAL CLIMATIC ZONES

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The microclimate is the factor of the physical environment of the tractor operator which is most affected by the sub-tropical and tropical climatic conditions. Besides the obvious influence of high ambient temperatures and of the high relative moisture content of the air, an important role in determining the microclimate is played by the high level of thermal radiation. This may be still increased by the poor dissipation of the engine heat, particularly on tractors originally designed for operation in the temperate climatic zone.

The possibility of application of the full climatization of the cab, depends on the amount of capital available to the given agricultural or forestry enterprise. In most cases, partial, cheap solutions will have to be considered.

Let us assume that tractors in the tropics will not be deprived of such a well justified safety feature as the roll-over protective structure. The structure, even in its simplest version, may form the frame of a sun and rain protecting canopy, or a relatively cheap cab. Heat radiation protection, air circulation and dust protection, noise and - not the least important - safety are the features of this simple cab which should be evaluated from the point of view of ergonomics

The protection of the driver from heat radiating surfaces of the engine and other mechanical components of the tractor largely depends on its initial design, or successful modification, which would take into account the tropical conditions in which the machine is operated The "tropical" design should include:

- An operator's platform independent from the gear box cover;
- An effective screening of the operator's legs from the engine;
- An appropriate location of the exhaust manifold and pipe.

Several aspects of free air circulation should be considered:

- The convection of the heat from the engine. Of cours an airflow around the engine, designed in such a way that the heated air is forced by the fan or by the tractor's movement into the operator's workspace is not permissible. Air cooled engines might prove to be a considerable problem in this connection. Deflectors on one, or both sides of the engine body may improve the situation.
- Turbulent air movement inside the partly enclosed work space may cause dust concentration and sedimentation which are particularely undesirable in the upper part of the cab in the vicinity of the operator's breathing zone.

The simple, cheap cab should be designed in such a way that it does not amplify the tractor noise at the operator's ear. The amplification may be the result of the acoustic properties of the cab's roof, causing resonance with the engine, or of the poor quality of the craftsmanship, resulting in the early ageing of the fixtures and other components, with annoying acoustic effects.

Even the simplest canopy or cab arrangements for the climatic protection of the driver, are connected with the driver's safety in an overturning accident. The risk of the driver's getting caught between the roof plate and the two-post safety frame was detected in the early days of roll-over protection studies. Designs unsafe from this point of view should be eliminated. Considering the risk from objects falling on the tractor's roof, particularly in forestry work, a four post protective frame with a roof plate tested to withstand the typical impact of falling objects is more desirable. The advantage of this type of frame is that it is also better suited to form a skeleton for a climatic protection cab.

Taking into account the modern tendency of the world agriculture to use more sophisticated and capital consuming methods of production, the chance is improving for more effective climatic protection of the agricultural machine operator in the tropics. The ergonomic approach to this problem may be technical or physiological. At present the technical approach seems to be the simpler of the two.

Many manufacturers of expensive, heavy tractors have in the recent years acquired considerable experience in the design and application of heat relieving systems for tractor cabs. The cab suited for this type of climatization is, of course, a totally enclosed structure, protecting the driver from mechanical hazards and usually ensuring a noise level at the operator's ear lower than the ambient one outside

The simplest "technical" approach to the cooling unit of a climatization system of this kind is the requirement of it being capable of:

- Cooling in less than one hour the interior of the cab subjected to the ambient temperature and solar and engine radiation usual in the tropical and sub-tropical climate to a temperature ranging between, let us say, 18° and 22°C,
- Maintaining during the working day a temperature level chosen by the operator,
- Maintaining a temperature gradient inside the cab not greater than 5°C between the operator's feet and head level /feet warmer/,
- No increasing the noise at the operator's ear above 80 - 85 dBA.

Thus the adaptation of the system to tropical conditions may be relatively simple, involving, for instance, an increase of the power of the cooling unit or of the proportion of the air recirculated.

The second one of these requirements may be more difficult to comply with, as several factors may upset the equilibrium of the cab's microclimate. The heavy solar radiation may be one of them. Since it will abviously cause a great deal of discomfort to the operator, features diminishing the radiation load such as tinted or reflective glass, shutters etc. will have to be added to the cab. The advantage of these features, particularly of an anti-radiation film on the glass surface, has been shown in the recent Swedish research results.

The temperature gradient depends on the location of the air outlets /louvers/ of the climatization unit and on the air velocity inside the cab. This gradient will tend to be influenced by changes in thermal radiation, as well as by any adjustment of the system made by the operator. The air conditioning unit must be able to equalize these differences, so that they do not surpass the accepted limits.

There is good reason to believe that the tractor cab climatization unit is able to provide subjectively comfortable conditions for tractor drivers in the tropics. There are, however, several problems of physiological nature, particularly with regard to the design criteria and erfonomics testing of climatization systems, which remain to be solved.

First of all, the generally recognized and widely used criteria for the operator's comfort are based on the climatic conditions prevailing in the temprate zone. The validity of the well known ASHRAE Chart in tractor cab climatic comfort research was confirmed by research in the U.S.A. on the strength of experiments carried out under laboratory and field-laboratory conditions differing from those encountered in the tropics. It seems likely that the comfort zone for the subtropical and tropical tractor operator lies outside the actual ASHRAE comfort zone, but this has to be proved experimentally. The probable reasons for this difference in comfort zones for the operators of tractors and farm machines in the temperate and tropical climate are:

- The different range of adjustment of the physiological thermo-regulation system of the tropical worker. In the same way as the subjective comfort temperatures in summer differ from those in winter in the temperate climate, the tropical driver's subjective optimum probabely lies above that of the temperate climate one.
- The fact that the ASHRAE comfort prediction is based on the assumption of equal dry bulb and mean radiant temperatures. This is unlikely to be the case for the interior of a tractor cab under sub-tropical and tropical conditions. Higher radiant temperatures should be expected in these climated.
- The low insulation properties of the tropical dress /ca 0,4 clo as opposed to 0,6 - 0,8 clo of the ASHRAE research/.
- The character of the operators task.

The necessity of leaving the cab, sometimes as often as several times per hour in connection with the task performed. This will not affect the subjective teperature optimum measured in a closed cab under actual or simulated tropical conditions; however, the maximum allowable temperature gradient of 5° - 6°C between the cool cab interior and its warm surrounding remains valid. The subjective response to greater differences and their possible influence on the health of the operator are not sufficiently well defined. In technical terms this may mean that the reliable i.e. providing stable temperature conditions, range of adjustment of the climatization unit will have to be increased for the time being. The fact that a given climatization unit is capable of cooling the interior of the cab of a tractor /exposed during several hours to the combined influence of the tropical ambient temperature and solar radiation/ to, let us say, 15°C within half an hour is of little ergonomical consequence, compared with its provision with a simple adjustment system capable of maintaining the operator's subjective thermal comfort at any desired level during the working day. This is a rather complex requirement of which the capacity of the cooling unit is only one part.

The dust protection of the cab interior is closely connected with the operation of an air conditioning unit of an enclosed tractor cab. Dust concentrations around the cab during tillage, earth moving and certain fertilizer distributing and harvesting operations in hot climate are likely to surpass those found in the course of recent European research. The latter are high enough to justify the pressurization of the cab, the most effective measure against dust pollution of the interior used so far.

(abridged version)

THE IMPROVEMENT OF FELLING TECHNIQUE IN JAVA

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Summary

The population density of the island of Java is very high at approximately 643 people per km2. The majority of the people around the forests make their living in various forestry activities, and so the manual exploitation of forests in Java is not an uncommen scene.
Nevertheless, these exploitation activities which comprise felling, skidding and loading and unloading still need to be increased.

In the logging process, primarily it is the actual felling of the trees and the care of the saws that need to be improved upon. For this a training programm for the forest workers has been set up which will hopefully increase their working efficiency. The evidence reveals that the performance of those workers who have received special training has risen by 15%.

Introduction

The majority of the inhabitants of Indonesia, approximately 85 million people or 62 percent of the nation's total population, live on the 132,187 km2 that make up the island of Java. Most residents make a living from farming, including forestry.

In the field of forestry, the most important activity is the actual exploitation of the forest. Most of the work is still done by hand, especially the felling, skidding and loading and unloading. This is because of the relative ease with which manual labour can beobtained in and around the forest areas. In addition the use of manual labour in the forest activities helps to prevent the appearence of wider social and economic problems which are a sure consequence of mechanization.

In manual felling the efficiency with which the saw is used in felling and bucking still needs to be improved. It is not only improvement needed in the felling techniques, but also in the saw maintenance.

In connection with the above-mentioned, a training programm for forest workers has been set up in order to improve their efficiency.

A conventional working method

Most of the forest stands on Java consist of the species Tectona grandis, which are intensively managed by the State Forestry Enterprise. This enterprise is responsible for timber production as well as for the social-economic welfare of the people in and around the forests. Because of this which techniques and the equipement have to be used, cannot be based merely upon the balance of technical and economic factors .

There is evidence that teak trees can be felled most economically in the 80th year of their cycle, when the average diameter is between 40 and 60 cm and the felling, skidding and loading and unloading can be done manually.

Before being felled, the above-mentioned trees are girdled, that is, cut all around the trunk in a single line at a height of 50 - 60 cm from the ground level, with a depth of 3 - 5 cm, with an axe. The purpose of this kind of cut is to kill the tree slowly. In this way, the trunk will not split or break, as drying occurs naterally and the weight of the wood will decrease.
The moisture content decreases from 95 - 98 percent to 40 - 45 percent. Two years later the felling is done by a team of loggers, each team consisting of two men using two axes and one handsaw.

Trees are felled by making an undercut with an axe on the girdling. Two men standing facing each other take turns wielding the axe. A handsaw is used to make the backcut on the opposite side of the trunk. A wedge (a piece of wood used to prevent the handsaw from sticking in the cut) is used if the saw becomes pinched or squeezed. Wedges are merely pieces of wood picked up and used on the spot. When these wedges are struck they often break.

The saw is drawn back and forth between the men at breast level. To stop the saw movement it takes a consious and physical effort. During bucking, a similar movement is used, with the men either sitting on the ground or standing.

The direction in which the tree is felled is up to the loggers. However, because the loggers did not follow the correct felling technique, the felling direction cannot be precisely managed. When this happens other standing trees are struck, and cracks in the tree truncks cannot be avoided

Beside this there is a common practice among loggers to remove some of the teeth of the handsaw, so that from a total of 90 teeth appoximately 60 remain over a length of 1.60 meters. The width of each tooth is changed

from 12 mm to 5 or 6 mm and its height from 16 mm to 7 mm. The reason they give for this is that with these changes in the number and size of teeth, the movement of the saw is more facilitated.

The average output of a pair of loggers is 2 - 4 m3 per day, from 7 to 11 AM. Afternoons in the Teak forest are too hot for the workers.

The improved working method

The undercut is made as close to the ground level as possible. First the verticle butress roots are cut clear from the main trunk. Then the direction of the fall is determined with attention given to the crown of the tree and the spot considered safest for the fall. The depth of undercut is approximately one third of the trunk, while the corresponding back-cut is made sligthly above it and about 0.6th of the diameter of the tree. To make the direction of the fall more accurate 1 - 3 large wedges are used in the back-cut.

The sawing is done in a squatting position with a back and forth motion drawing the saw to and away from the body. In this manner, the cutter can benefit from the motion already contained in the saw from pulling and there is no need for a serious exertion in the push component of the movement. By this movement the entire length of the blade is used. The addition is between 25 - 35 cm long.

Saw teeth setting having the same size (0.4mm) evidently influence the pulling power and make it easier, whereas saws having uneven teeth height in the felling process are considered not efficient.

Because of this a check on the setting of the teeth with a special apparatus can often be done.

With the improvement of the felling technique the efficiency of the loggers increases appoximately by 15%. In addition a young logger absorbs new techniques much faster than an older one. According to the young trainees the new method is much better than the conventional method, because the maintenance and the filing angle of 38 degrees in the new method results in a good cutting line.

The equipment used by each pair of loggers are a saw with "Dud" or "Drd" teeth, two axes with approximately 60 - 70 cm axe helve long, 2 - 3 large metal wedges for felling, 3 - 5 small metal wedges for bucking, and two helmets.

Conclusion

As a result of this training, the following has been observed:

1. The felling of trees has been done sufficiently close to the ground.
2. The techniques for felling and bucking could still be improved upon so that yields could be increased.
3. The care of handsaws should be given more attention in order to maintain their efficiency.

MAGERSAREN, A FOREST VILLAGE SYSTEM IN TEAK FOREST OF JAVA

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Java is the most populous island of about 13,000 islands comprising Indonesia. Its size is about 13 million hectare with an estimated population at present of about 83 million people. It means that Java has a population density of about 640 people per sq km. The majority of the people live from the agrarian sector.

Approximately 3 million hectare of forests are reported to exist in Java. This makes a forest coverage of 23%. All forests are owned by the Government.

Most forests in Java are man made forests and consist of 2 million hectare production forest, 750 thousand hectare protection forest and 250 thousand hectare nature reserve. Of the production forests, 1 million hectare is teak forest, 550 thousand hectare is pine forest, 450 thousand hectare other species and natural forest.

Management of forest in a such dense populated area is not an easy task. The state owned forest enterprise Perum Perhutani is responsable for all forest related activities in Java, including forest establishment, regulation, harvesting, timber manufacturing and sales. Perhutani was formed after enactment of Government Regulation no. 19 year 1960 as P.N. Perhutani, and takes the new form of Perum Perhutani (Forest State Corporation) in the year 1973. Since 1973 Perhutani took charge of all forestry activities in Central and East Java replacing the Indonesian Forest Service and since 1978 forest of West Java were included under Perhutani's management. At present, Perhutani employs 16,700 salaried employees plus about 270 thousand part-time workers in planting, logging and manufacturing. Planting and logging activities are scattered throughout Java.

It was at the end of the 19th century that an attempt was made to bring the teak forest under scientific management. The fellings were regularized on a predetermined area basis and clear cutting with artificial regeneration by direct sowing became the silvicultural system. Artificial regeneration is done by the so called tumpangsari system a form of an agro silvicultural system, that allows planting workers to cultivate food crops alternately between the main species row. Practically all the present teak forest of Java was established by this system. Felling is still done manly and hauling is done by animals (cows).

At first workers were recruited from the nearby village. Since felling and planting area were mostly located in the midst of the forest and far from the villages, the workers made their own temporarely bivouac and these bivouacs formed a community called "Magersaren". Those were constructed manually from sources available in the forest and were very primitive. The walls were made from teak barks and the roof from teak leaves; a very poor and unhealthy accomodation indeed.

When the newly formed Perum Perhutani was established in 1973, the first program in this direction was better living condition for the forest labourers replacing the old magersaren.

The new magersaren consists of Units of 12 houses for worker families, one for the foreman, one school and meeting room and a small mosque. There are now 80 magersarens of this type built by Perhutani, giving healthy houses to 1,000 workers and their family. This program is still expanding. The size of each house is 6 x 5 m, that of foreman 8 x 5 m, and is provided with well or water pump for water supply.

The purpose of these magersarens is, beside improving the living conditions of the labourers, also coordinating the labourers in their work and in their further education. They are given, training to improve their efficiency in planting, tending, exploitation of the teak forest and also in agriculture, animal husbandry, home industry and handycraft. One of their jobs is reforestation of clear cutting area by means of tumpangsari. As mentioned before they are allowed to plant food crops, mostly dryland paddy and maize, between the teak rows. Perhutani is introducing and assisting modern technology in cultivating the food crops by providing superior seed, fertilizers, insecticides, and guidance in better cultivating method. This program is called intensified intercropping system. Production of paddy with this program increases from 0.7 ton to 3 ton a hectare, on increase of more than 400%.

General health and family planning are tought to their wives. Periodical medical assistance is also given in cooperation with the Sub-district's Public Health Service. Outbreak of diseases is now absent. Malaria, eye diseases, and influenza are common, the first one is decreasing in occurrence.

Perhutani assists also in the education of their children by providing classes and teachers. Detailed description of these magersaren was reported by Soekiman (1977).

Evaluation done by Perhutani Training Centre Students (1978) gave the following conclusions.

The magersaren project comes out beneficial for the workers as well as for Perum Perhutani. The workers get improved houses and surrounding, health condition and social life were also improved. Production of their food crops increases. These factors and the nearer location of the magersaren to the job site, so that they get more effective working hours, increases their income.
Socially the magersaren is succesful. It forms a good community and its members cooperate in the maintenance of magersaren.

Perhutani on the other hand get a more stable labour force for its activities. Their productivity is now substantially improved.

Application for placement in magersaren are numerous. Perhutani plans to improve the construction and design of the houses in order to provide more workers with better living conditions at a faster rate.

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