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INTERNATIONAL POSTGRADUATE COURSE IN ECOLOGICAL APPROACHES TO RESOURCES DEVELOPMENT, LAND MANAGEMENT AND IMPACT ASSESSMENT IN DEVELOPING COUNTRIES (EMA)

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Subject IV: Animal husbandry

STUDY MATERIAL
elaborated by a team of authors under G. Fenske

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Introduction
IV.1. Range management

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Volume Three

IV.3. Processing and marketing

IV.3.1. Processing and Marketing of Meat and Meat Products

IV.3.1.1. Introduction

The climatic conditions of the subtropics and tropics are globally characterized by high temperatures and relatively low humidity or high temperatures and relatively high humidity respectively. The difference in temperatures between day and night may amount to = 30 °K. The climatical and geographical conditions exercise an influence not merely onthe character of the plant and animal production but also the specifications for the construction of projects for the food industry, including the meat processing industry, the operation of such a plant, and the distribution of products.

In the first part of this paper - processing and marketing - generally accepted recommendations relate to the construction and operation of slaughter- and meat processing plants as well as the distribution and marketing of meat and meat products, taking into account ecological and environmental aspects. Antemortem and postmortem effects on the meat as well as biochemical processes occurring in the meat after the killing are also described. Furthermorde, hints are given on the conditions for transport and cooling of meat, on hygienics and potential impairments of the health of consumers by harmful materials of different origins as well as on the possibilities for the preservation of meat products.

IV.3.1.2. Meat as food - a potential threat to health?

Livestock-keeping is fundamental to providing people with meat, fat, and milk. A part from these nutrients, meat contains water, small quantities of glycogen (carbohydrates), and vitamins as well as minerals and flavours. Meat is of high nutritive value. However, it is not only a valuable and nutritive food but also an expensive one.

The world meat production has increased from 83.6 x 10^6 tonnes in 1961/65 to 142.2 x 10^6 metric tonnes 1980 (Fig. IV.3.1., cit. in Fritzsche, 1980).

The growth rate in developing countries is considerable and mainly results from continual increase of both the sheep and goat stocks (Table IV.3.1. and IV.3.2., cit. in Fritzsche, 1980). For different reasons per-capita consumption in the developing countries with the exception of some countries in Latin America is significantly lower than in industrial countries. Meat is a biological material which is steadily subject to metabolism or changes in state. Besides endogenic (genetic) factors exogenic (environmental) factors are of special significance thereby. That is mainly a matter of chemical/biochemical and microbial/enzymatic processes that depend upon temperature and time and is being influenced by the parameter "relative air humidity".

A consideration of postmortem change in muscle may be subdivided into three general areas:

- the influence of antemortem con itions on postmortem change
- the actual postmortem change
- the impact of postmortem change on the use of muscle as food (Cassens, 1966).

Here, problems of stress on the animals during transport and right before killing, of starving as well as resting play a role. These single factors are well investigated with cattle

Table IV.3.1.: Development of the meat production in several regions of the world.

	Total meat production						Annual rate of increas from 1975 - 1979
	1961-1965		1975		1979		
	1,000 t	%	1,000 t	%	1,000 t	%	%
World total	83,626	70.3	118,927	100.0	138,143	116.2	4.1
Developing countries total	15,727	72.9	21,587	100.0	25,780	119.4	4.9
Africa	2,803	80.5	3,480	100.0	4,349	125.0	6.3
Latin America	8,395	72.5	11,572	100.0	13,292	114.9	3.7
Middle East	1,768	66.8	2,672	100.0	3,331	124.7	6.2
Far East	2,701	71.0	3,806	100.0	4,743	124.6	6.2
Argentina	2,726	86.1	3,165	100.0	3,851	121.7	5.4
Mexico	876	63.7	1,375	100.0	1,505	109.5	2.4
Egypt	283	71.6	395	100.0	474	120.0	5.0
Irak	99	79.2	125	100.0	145	116.0	4.0
Ethiopia	421	107.4	392	100.0	509	129.8	7.5
Afghanistan	139	79.4	175	100.0	216	123.4	5.9
Countries of the CMEA	13,939	56.0	24,903	100.0	26,329	105.7	1.4

Table IV.3.2.: Development of the share of sheep in livestocks in developing countries

Share of the developing countries in per cent

	World population	Sheep stock of the world
1961 - 65	45.6	38.4
1975	48.9	40.8
1979	49.7	42.3

and pigs. The study of stress on pigs is advance because they are relativly susceptible to stress and show stronger reaction to external impact than other meat animals. Stress is regarded as the main cause for differences in the quality of meat. With respect to pigs, transport to the slaughter-house is regarded as one of the most frequent causes for stress resultings in differend meat qualities. A combination of very different stress situations, such as climatical conditions, physical movement, starving, and psychic agitation, acting independently or in combinations, lead to increased body termperature. Generally one can say that the temperature determines the reaction velocity of the processes proceeding in the muscles not only in vivo but also postmortem. The decay of the energy carriers adenosine triphosphate (ATP) and glycogen (carbohydrates) can proceed fairly quickly. Therefore, special attention is due to transport conditions, taking care that the load density is appropriate and ventilation in the vehicles is sufficient. Transportation during hot seasons should be carried out at night or in early morning. This also applies to driving cattles over a long distance. The environmental factor "stress" can become a special problem in two respects: Stressed animals can become ill due to increased virulence of potentially present viruses and finally die. They can also infect other animals or people and cause dangerous diseases.

Furthermore, stall-keeping of animals can prove disadvantageous because of the possibility that animals infect each other especially by pathogenic germs. This phenomenon is well known and an explanation is the encounter of animals from different original stocks.

The micro-organisms which are taken up orally may pass in case of low - resistant animals from the gut into the bloodstream, may accumulate in the muscular fibres and infect the consumer if the meat has not been sufficiently heated prior consumption.

Stunning can be the cause for fractures of the bones with cattles and pigs, and with the latter also for hemorrhages in the muscles. Kosher butchering, i.e. slaughtering without previous stunning does not cause this problem and the blood is better removed from the tissue.

After slaughtering several metabolic processes come to a stop for there is no more oxygen input. In the anerobic state glycogen is transformed into lactic acid. The pH-value declines from 7.4 to 5.4, sometimes even lower. The decay of ATP is more intense than its re-synthesis and paralysation of the muscles results. The processes occuring after circulation of the blood has stopped are shown in Fig. IV.3.2. (Lawrie, 1970).

Of special interest is the postmortem curing process. The process called meat curing or autolysis is a physico-chemical and enzymatic one. It leads to the desired maturity after the stiffness of the muscles has ceased (Rigor mortis) and brings about the specific flavour aroma for instance by the production of lactic acid as mentioned above. In case of insufficient cooling the undesired "overheated" meat curing can occur. This phenomenon also plays a special role in curing meat of big game. Obvious changes in the meat become visible in the change of its colour.

Table IV.3.3. shows that the curing time for beef at temperatures around 37 °C is 4 to 5 hours. Similar time is needed for mutton; for poultry and pork the curing time is only 1 to 2 hours.

The possibilities for curing meat under cooling shown in table IV.3.3. are usually not relevant for the subtropics and tropics. There the meat is generally immediately marketed and consumed.

Meat maturation is always accompanied by the action of microorganisms. It can be assumed that the muscular tissue of living animals is free from germs with the above mentioned exception of animals subjected to heavy stress before killing. After the slaughtering when the carcasses are ent-up and the meat is

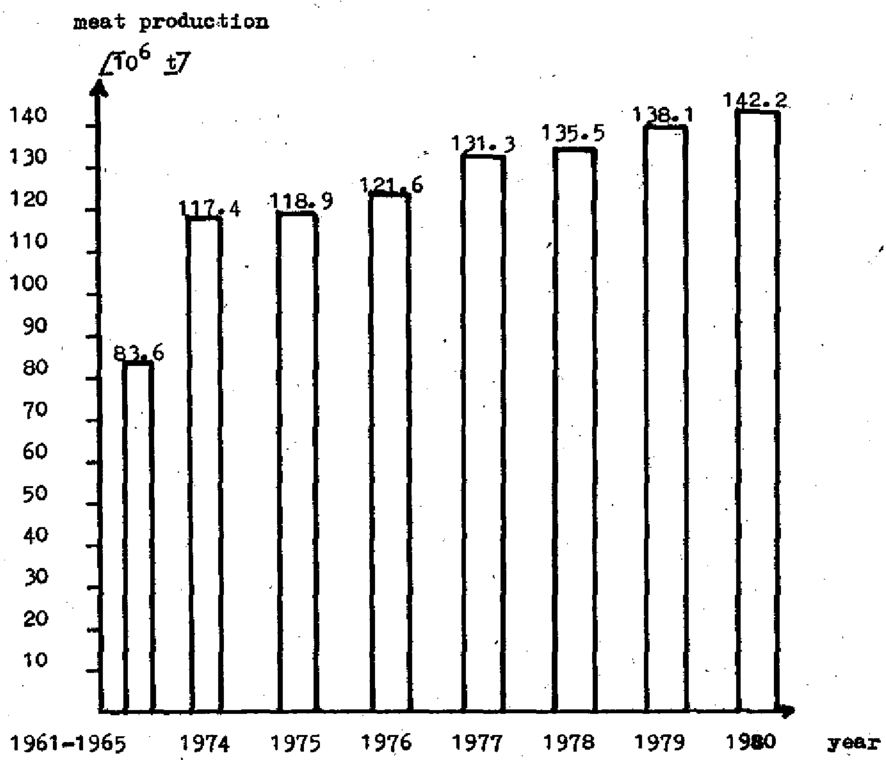
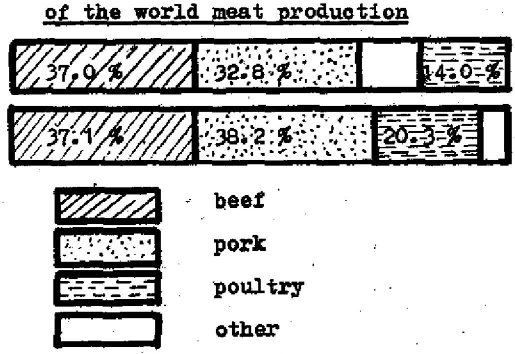


Fig. IV.3.1.: <u>Percentage of beef, pork and poultry production of the world meat production</u>



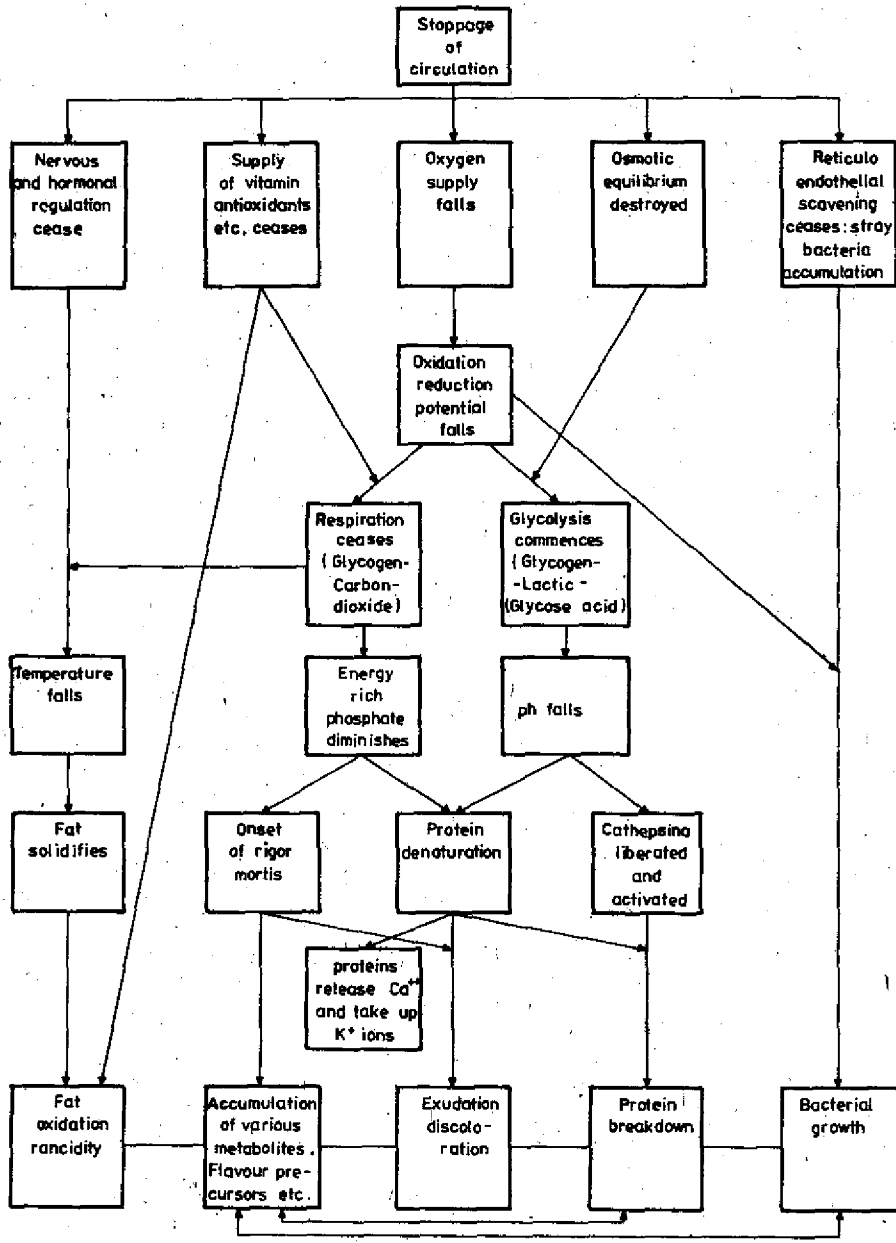


Fig. IV.3.2: The consequences of stoppage of the circulation in muscular tissue.

Table IV.3.3.: <u>Duration of curing beef at different temperatures</u>

	Temperature (^{o}C)	Duration
1	37	approx. 4 to 5 hours
2	29	34 hours
3	20	2 days
4	15	3 days
5	10	10 days
6	4	20 days
7	0/+2	2 to 3 weeks

processed infestation by germs will occur which can be kept low but cannot be prevented completely. The germ content on the surface of the meat after slaughtering may number 10^2 to $10^4 \cdot g^{-1}$. The proliferation of germs continues also under cooling; at a temperature of + 4 °C the expected number of germs will be 10^3 to $10^5 \cdot g^{-1}$ after three to eight days. Whereas on carcasse cut in halfs or quaters the germs are mainly confined to the surface the germ counts quoted can be found everywhere in the meat when it is further cut-up.

With higher temperatures decomposition of meat can occur within a few days. Here it is of advantage if only the innards are taken out and the bodies of the killed animals are no further cut-up. A favorable situation with respect to stability of the meat is an environment of low humidity. If the surface of the carcasses dries quickly the activity of micro-organisms is hampered. Nevertheless it is necessary to mention the possibilities for the propagation of apathogenic and pathogenic germs and thus the potential danger for the consumer if the contaminated but not yet decaying meat is to be consumed without being sufficiently heated or even raw.

Another potential danger to the consumer comes from harmful substances that can be present in bodies of killed domestic animals and game, especially in industrial countries. This relates to the contamination of the meat, especially the innards, with toxic heavy metals like lead, cadmium, arsenic, and mercury. Moreover, analyses proved the presence of chemotherapeutical agents, thyreostatics, estrogenic substances, transquilizers, and anthelminthics (Bert and Frese, 1983) in meat and innards. Furthermore, the uncontrolled application of antibiotics be mentioned that can lead to the well-known resistance of bacteria and problems of therapy in medicine.

IV.3.1.3. Requirements for the design of a slaughter and processing plant

Technological desing is a complex process of technology - related anticipation and projection of factories or unite to be built or

reconstructed. It is creative work that is best carried through as teamwork of specialists under consideration of earlier experience from special literature and similar projects (Rockstroh, 1977).
The tasks can be derived from the following requirements:

- to supply people with meat according to their needs
- to avoid the propagation of diseases from the meat to human beings. This may be ensured by regular meat inspections what will be feasible in less developed countries mainly in larger slaughter-houses.
- to preserve the full nutritive value of the meat
- to slaughter and process the meat in a way that does not annoy or endanger the public and as humanely and painless by as possible
- to organise the production economically to keep the processing costs and thus the meat price low.

Slaughtering and meat processing should be considered in the first line from the point of view of hygienics and supply and not primarily which from an economic point of view has not of profitability. One has to make sure that the design of new facilities is based on the latest scientific and technological knowledge and guarantee high operational efficiency.
In the preparatory stafe design tasks are the following ones:

- Studies, investigations and comparisons of variants to prepare preliminary investment decisions
- Choosing the site of the plant on the basis of economic and societal requirements and determination of the production capacity on the basis of quantitative and structural demand under consideration of development trends
- Choosing the site of the basis of factory-related factors:
  - supply of raw material and auxiliary materials
  - securing sales of the final and byproducts (considering the socio-economic problems and infrastructure)
  - supply and waste treatment (water, waste water)
  - solving the traffic problems and recruiting necessary labour

- working-out concepts for a rational energy consumption by choosing energy-saving processes in consideration of domestic energy resources. Assessment of energy costs, specified by electric and thermal energy as well as utilization of waste energy (recycling condensate, waste heat from cooling processes).

Further demands regard solutions for complete systems on the highest technical standard in the world:

- experiences and knowledge resulting from own research and development, for example projecting and designing buildings and traffic lines (quality of material) under consideration of climatic conditions inclusive protection against insects and vermins.
- observation of prescribed standards and regulations
- demands resulting from economical material utilization alining at the ideal solution of a non-waste technology. The amount of waste produced by packing material with an increasing share of plastics must be taken into account, whereby an optimum and multiple use of packing material might offer an alternative. Apart from full utilization of all parts of carcasses suitable for human consumption the utilization of byproducts is also important, for example skins for leather and glands for the production of hormones and enzymes, as far as there is a domestic processing industry. Export possibilities should be examined, also for sausage skins that are high in demand on the world market.
- good working and living conditions that meet the requirements for occupational health and safety as well as hygienics (contamination with pathogenic agents).
- A crucial point for the management of the production is the employment of staff who have both theoretical knowledge and practical experiences. For that reason education and training of people in the fields of theory, hygienics, and practice is of vital importance for successful work. Additionally, studies on the scientific organization of production and guidance of people are as important as the continual education of people in the special field.

Building and extension of production plants require attention to a proper location with respect to traffic connections and road nets. Soil, water, and electricity supply conditions have to meet the needs of a new plant. To avoid wrong investment decisions one has to consider carefully the aim of the construction activities and how to utilize the plant to capacity.

The location of the production facility has to allow continous production. Shortest transport distances and avoiding any overlappings in the production flow by a proper arrangement of the machines should guarantee a rational and controlable production.

IV.3.1.4. The operation of slaughter and processing facilities considering the problems of environmental protection

The construction and operation of slaughter-houses and processing plants are usually regulated by detailed occupational health and safety legislation in the various countries, for example setting standards for handling of animals and meat the stunning of animals as well as environmental issues to avoid nuisance to the neighbours.

Environmental laws contain expecially regulations for avoiding odours and noise nuisance. Furthermore, regulations are necessary for cleaning and disinfection, insect control, and waste water treatment

Nuisance by bad odours may occur during storage, transport, and processing, for example of residues and bones, in the process of producing meat- and bone-dust, or lard. By applying the principles of non-waste production, closed production systems or appropriate cooling these problems can largely be limited. In some countries deodorizing is employed. Technical solutions are offered that provide for air ducts in all production halls. The air is exchanged at certain intervals, whereby the odourized waste air is discharged through a deodorizing unit. The removal of noncondensable gases from the condensors may be done by a afterburning unit.

In the food industry a great number of processes either utilize micro-organisms or are threatened by impairments caused by them. That necessitates a design of machines and equipment that guarantees optimum conditions for the operation of the plant in a manner poor or free of undesired germs and allows easy and complete cleaning and disinfection. The demands for an antiseptic operational regime can be summarized as follows:

- All equipment must be designed in a way that allows to empty them completely
- Cleaning and disinfection must be possible at all parts of the equipment
- All surfaces contaminated with germ-containing products or such that can serve as substratum for aerobic or anaerobic micro-organisms must be accessible to cleaning and disinfection
- Machines and technical equipment must be designed, planned, and organized in a way that permits to neutralize possible contaminations after every charge in a discontinual process or in intervals in a continous process respectively.

In sophisticated plants cleaning and disinfection is carried out mechanically or automatically by the CIP process (cleaning in place).

Because waste water from slaughter-houses and processing plants is polluted by organic substances of different sorts, especially by micro-organisms and parasites, it may not be discharged into rivers or lakes without proper treatment.

The purification of the waste water should be attained with minimum expenditure. The choice of a specific process depends on the analyses of all factors such as the degree of purification demanded (threshold value for effluents), kind, volume and concentration of the waste water (Busch and others, 1983). For the purification of waste water in abattoirs and so-called sanitary slaughter-houses sewage treatment plants are suitable. For waste water containing large quantities of pathogenic micro-organisms (sanitary slaughter-houses) disinfection (chemical or thermal treatment) should be compulsory. After that the waste water can be discharged into rivers or lakes or used as a water and nutrient source in agriculture (sewage farming).

Finally, two processes relevant to meat processing shall be mentioned which have been applied for centuries, but from a today's sanitary point of view have to be reexamined carefully: the curing process using nitrate or nitrite and the smoking process for meat products. In both cases there is the possibility of the formation of carcinogenic substances. These nitrosamines and polycyclic aromatic hydrocarbons (benzopyrene), should be present in food only in limited quantities. Appropriate regulations have to be implemented or the utilization of the process should not be permitted at all.

It has been proved that with increasing size of the plant and thus normally increasing degree of mechanization and automation the specific energy consumption goes up as well. Manifold ideas are needed to save energy. One must recall older energy-saving processes, enrich them with new scientific-technological knowledge and finally also try new ways. It is estimated that less than 5 % of costs in the meat processing industry are energy costs. To improve energy efficiency in the meat processing industry is no short-term but a long-term task, as both earlier and recent publications showed. Energy problems are very stratified. In the following the rational use of energy and problems of an optimum use of energy mainly in heat treatment processes for the preservation of meat and meat products are considered.

Rational use of energy

In the meat processing industry home and abroad both electrical and thermal energy consumption has been growing steadily during the last years. Exact, comparable data on energy consumption in the meat processing industry are, however, only rarely available, among others from KOEVEL (1977) and MARECEK (1975). The latter author gives data on electrical energy consumption in the meat processing industry of Czechoslovakia, amounting to 149.4 kWh/t product in 1970 and 189.4 kWh/t product in 1972. For several production departments the following data on energy consumption are given:

Fast cooling, pig	35 45
Slaughter line for mutton production	7 10
Smoking plants	12 20
Fat melting for lard production	20 25
Curing rooms for raw hard sausages production	250 350

(All data in kWh/t product)

The increased energy consumption is caused by enlarging cooling and freezing capacities, increased mechanization of processes, air conditioning of rooms, e.g. curing rooms for raw hard sausages production.

Special attention shall be given to possibilities for energy-saving processes for the preservation of meat and meat products. Preservation here mainly consists in delaying or possibly preventing microbial deterioration and undesirable enzymatic effects. That means above all to impede or kill germs. For micro-organisms there have to be certain ecological minima (temperature, food supply, water content, pH) in every environment. With respect to pH, for example, they have different ecological potencies in which they are able to propagate or survive. Leistner (1980) in this connection speaks of hurdles. He developed the so-called hurdle-concept according to which an energy-saving preservation of food from a microbial point of view is possible. This concept is schematically shown in Fig. IV.3.3. in a modified and extended version (Sielaff and Thiemig, 1982). The concept of hurdles is based on the following ideas: in every micro-biologically stable food there are hurdles that can not be "overcome" by micro-organisms. The germs are caught so to speak, and the product is stable. The hurdles can be sterilization (F-value), pasteurization (P-value) and the connected cook value (C-value), cold-treatment (K/G), water-activity (a_w-value)[1], concentration of hydrogen ions (pH), or the redox potential (E_h).

For the production of high-quality tinned food, the temperature-time-regime and the conservation of energy can be influenced by mathematical pre-calculation or measurement of the actual temperature (Sielaff and Schleusener, 1981, and Sielaff and co-workers, 1982).

Pasteurization is applied to the production of less durable tinned food. The resistance to micro-organisms is mainly determined by the parameters of the hurdle concept shown right of pasteurization.

Whether meat and meat products are cold-treated or frozen depends upon the intended purpose. While still during the last century the bodies of killed animals or meat products could be preserved without cooling because of their quick distribution, today structural changes (killing, processing, and distribution are separated) which necessitate the cold-treatment. It should be kept in mind, however, that if a quick sale is assured cooling can be unnecessary. The necessity of freezing meat for short-term storage, for example in highly populated areas, has to be reconsidered, too. Meat can be made durable for a short time by using a spray containing edible acids (citric, lactic, acetic, tartaric, ascorbic acid) and salt, combined with following surface drying. The temporary protection against activities of micro-organisms is accomplished by the action of the acids or by lowering the a_w-value on the meat surface. It is recommended to use a solution containing 0.75 ..... 1 % lactic acid. This application results in a decrease of pH on the surface of the meat and in connection with cooling in a significant decline of the number of aerobic grampositive and gramnegative germs (Snijders and co-workers, 1979).

It has long been known that vegetative bacteria, yeasts, and mildews are killed already at a temperature that is merely 10 ... 20 ^oK higher than their optimum temperature at a pH of

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[1] The water activity is the steam pressure of the water in the food (P_s) divided by the saturation pressure of pure water (P_d) at the same temperature: $a_w = \frac{P_s}{P_d}$

lower than 4.5. Spurs of bacilli and clostrides are heat resistant. Using Clostridium botulinum as an example one can show that germs are far more heat resistant in a lightly acid or neutral medium than in one with a pH of 3.5 or 4.5 (see Fig. IV.3.4.). The figure points out the practical significance of the influence of the acid content for the killing or inactivation of micro-organisms by heat-treatment.

In the interest of increasing the preservation effect more use should be made of the possibility to lower the pH-value, for example by marinading meat. There is no doubt that there are further energy-saving possibilities to preserve food, among others seasoning meat or the production of dry meat products under respective climatical conditions like the subtropics or tropics where the natural environment can be utilized for that purpose.

Nevertheless, in the interest of stockpiling food one will not be able to do without tinned foods or storing meat in freezing rooms, so respective capacities have to be made available on the short or long run. It is a task of the participants in the course to work out concepts how the following problems can be solved under the respective conditions of their countries:

1. Are there in the territory possibilities for the construction of slaughter-houses based on existing or projected units for animal husbandry?
2. What natural environmental conditions can be harnessed or utilized more effectively for the preservation of meat?
3. Should on the basis of the consumption habitas of people processing plants for the production of conventional products or even new products (for example tinned food, raw hard sausages etc.) be errected?
4. What pre-conditions have to be created to operate such food processing plants with respect to environmental protection, supply of energy and water, traffic connections and - especially important - securing qualified labour?

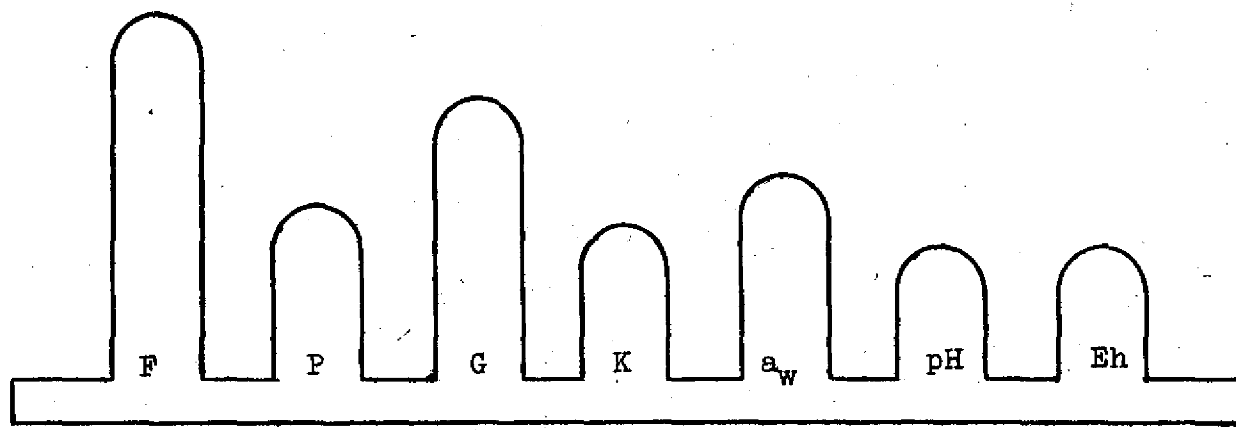

Fig. IV. 3.-3. Scheme of the "hurdle" concept

(F - sterilization value, P - pasteurization value, G - freezing, K - cooling, a_w - water activity, pH - concentration of hydrogen ions, Eh - redox potential)

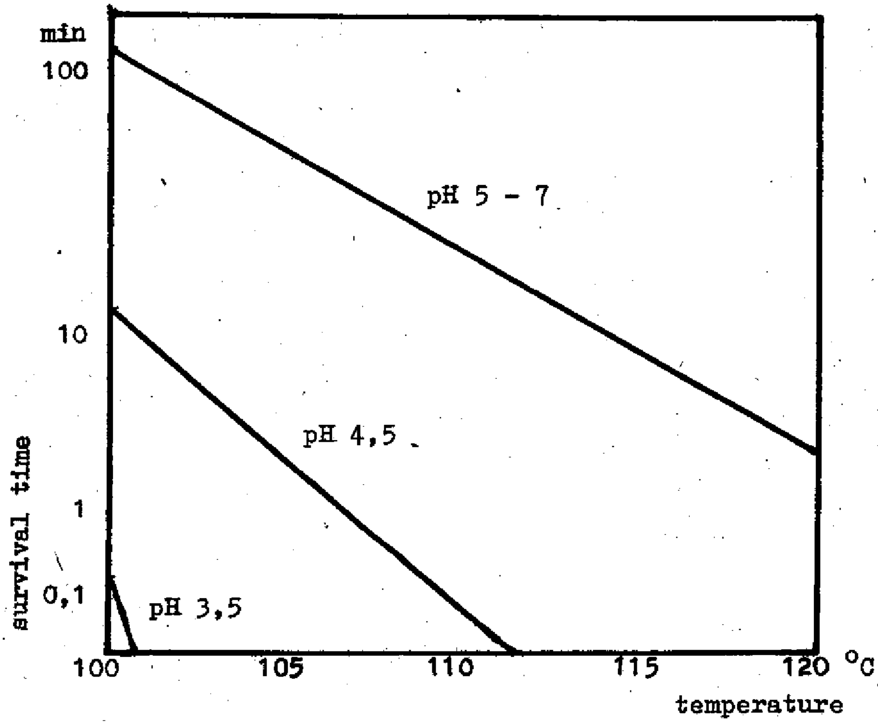

Fig. IV.3.4.: Influence of pH on the resistance against heat of spores of Cl. botulinum (according to N.W. DESROSIER, 1959)

5. How can the requirements for hygienics, transport, storage and distribution of meat and meat products be met?
6. Which processes/methods for the production of meat and meat products involve risks from a hygienic/health point of view?

In answering the questions 1 to 6, the respective overall structure of the country (for instance state of development of the livestock farming and food industry) has to be considered. Also, step-by-step plans for the construction of plants, processing, storage, transport, cooling, and distribution to the consumer should be worked out considering economic and social aspects as well. They have to be based on the needs of the respective country.

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IV.3.2. Processing and marketing of milk

IV.3.2.1. The importance of milk in human nutrition

Milk holds a special place among the animal and vegetable foodstuff. During the first period of life it is the only food for animals and human beings. Therefore milk contains all nutrients the growin organism needs. But also in all other phases of life milk and dairy products play an outstanding role for the following reasons:

- Milk contains all three main nutrients (protein, fat, carbo-hydrates)
- Milk provides water- and fat-soluble vitamins
- As milk contains essential amino-acids it can increase the value of other food, particularly of vegetable one
- Milk is able to provide mineral salts, particularly calcium and phosphorus
- The nutrients contained in the milk are well dispersed and easily resorbable.

Milk supposedly contains special protective and growth factors that protect the new-born against infections and promote growth. But this thesis is scientifically not assured. The situation in the field of nutrition in many countries of the world is marked by a shortage in animal proteins. In developing countries an estimated per cent 25 to 30 of inhabitants suffer from protein shortage in their diet (RENNER, 1974).

One kilogramme of milk contains approximately 35 grammes of valuable protein with a high nutritional effect. Therefore milk is very well suited to make-up or minimize this shortage. Still another aspect underlines the importance of milk.

Milk is gained from ruminants (cows, sheep, goat, buffalo). Because of their specific digestive system these animals are able to eat fodder that is not directly suitable for human nutrition but can be made usable for humans indirectly through the stomach of the ruminants. One has also to attach importance to the fact that intensification of milk production results also in an increase of meat supply. The preponderant part of the milk production in the world is cow's milk. This share is growing. Also of major importance is milk from buffalos, goats, and sheeps; buffalo's milk above all in subtropical and tropical areas, sheep's milk in mountainous areas. The different kinds of milk have different contents of the main nutrients. (table IV.3.4.).

Table IV.3.4.: <u>Composition of milk of different species of animals (in per cent, according to SCHULZ, 1965)</u>

No.	Species	Water	Dry-mass	Fat	Lactose	Protein	Ash
1	Cow	87.6	12.4	3.5	4.7	3.5	0.7
2	Buffalo	82.2	18.0	8.0	4.8	4.8	0.8
3	Goat	85.5	14.3	4.8	4.0	5.0	0.7
4	Sheep	83.0	17.0	5.3	4.6	6.3	0.8

Depending upon the state of breeding and feeding essential regional differences occur particularly with respect to fat and protein.

IV.3.2.2. Properties of the raw material "milk" that are decisive for its utilization

With respect to its production and properties milk shows a number of special characteristics which are of great importance for its utilization:

- Because of its high content of water, nutrients, and inevitably of micro-organisms, milk is a perishable good;
- During the lactation period of the animals milk is produced twice a day as a rule;
- Milk can be infected with pathogenic micro-organisms from ill animals or from the environment;
- Because of its high water content (1,000 litres of cow's milk contain approximately 870 litres of water) and its perishable nature milk can be stored and transported only at high expenses;
- The degree of concentration of milk production is generally low; the production of milk is a typical large-area production. This factor is especially important in countries with an extensive agriculture. Thereby it must be considered that increased concentration of milk production coincides with increased transportation expenditures for fodder and utilization of wastes (dung, manure).

IV.3.2.3. Characteristic types of milk supply

There are three types of milk supply:

1. Self supply in the farmer's household
2. Sale of milk directly to the consumer by the producer.
3. Collection of milk by an processing plant and sale of the products by a trading system.

There are no clear boundaries between these three types. In developing countries the first two types prevail. Here, it is necessary to inform producers and consumers about possible risks to health if untreated or spoilt milk is consumed. The demand can be formulated as follows:

In any case milk must be boiled before being consumed; it is to be used as fresh as possible; between boiling and consuming, milk has to be kept cool and protected against exterior influencess; cleanness is a basic principle in handling milk. The subject of further considerations, however, shall not be these types of milk utilization but industrial processing for its importance grows with increasing urbanization, and may give rise to new problems.

IV.3.2.4. <u>Collection and transport of raw milk</u>

Collection and transport is the connecting link between production and processing of milk. Their organization exercises great influence on the taste and hygienic quality of dairy products and the arising costs. Today one reckons with a share of 30 ... 40 per cent of the operational costs for transport, distribution, and storage. A considerable share of it is needed for the transport of raw milk. The problem grows with declining concentration of milk production (larger distances), increasing air temperatures (rapid decay of the raw milk), and less developed infrastructure (insufficient traffic connections).

The most rational form of collecting and processing milk can be characterized as follows:

- hygienic production of milk in large-size units
- cooling the milk down to 6 ... 8 °C at the producers
- transport of the milk in tank lorries that are isolated and can be cooled if necessary.

In areas with scattered dairy cattle husbandry the establishment of a network of collection and cooling stations that can be reached easily via traffic routes is indispensable.

In some African countries the preservation of milk by adding hydrogen peroxide is allowed. With respect to its practical application and hygienic implications this process is discussed controversialy.

IV.3.2.5. The processing of milk in the dairy

The processing of milk in the dairy serves the following aims:

- Excluding any hygienic risk that may arise from spreading pathogenic micro-organisms;
- Extension of the stability of the milk;
- Standardization of milk (particularly of the fat content) for the use as certified milk or for further processing into other dairy products.

In the German Democratic Republic the following processing steps are made compulsory:

1. Purification of the milk; it is carried out in separators by utilizing centrifugal force.
2. Standardization of the fat content; it is carried out in separators as well.
3. Heating up the milk to 72 ... 74 °C for a time of 40 seconds or to 85 °C to kill all pathogenic germs and largely reduce all other micro-organisms.
4. Cooling the milk down to 4 to 6 °C.

For liquid dairy products with longer durability additional homogenization is carried out to avoid creaming. These procedures are basically the same in all countries with industrial dairy. They are followed by the technologies for the production of the different dairy products.

IV.3.2.6. Production and distribution of certified milk

The distribution of fresh certified milk is from the overall economic as well as the management point of view the most rational way to supply large groups of people with the valuable substances contained in the milk. First of all, all valuable substances of the raw milk undergo only little change by processing, and secondly, the costs are relatively low compared to the production of other dairy products.

Therefore, this type of milk utilization should be given priority. Besides the advantages mentioned, certified milk has got two disadvantages that can have an effect especially in developing countries. Even after treatment the stability is limited. Milk is also very susceptible to recontamination with micro-organisms. Milk has to be kept, therefore, at temperatures below 10 °C until consumption. Depending on the temperature milk is then stable up to several days. That is a goal that can not be reached without cooling during transport, distribution, and with the consumer. Milk can be protected against recontamination and other influences by suitable forms of packing.

Internationally, glass bottles as re-usable packings and plastic bags as one-way packings are used. Which is choosen depends on the materials available and overall economic conditions in the respective country. In both cases the supply radius is small and limited to highly populated areas because of the low stability of the products.

IV.3.2.7. <u>Milk supply in remote and less developed areas</u>

In isolated or less developed areas without self-supply it is possible to substitute fresh milk by milk powder.

Milk powder is manufactured by dehydrating milk. The content of dry mass in the powder amounts to 94 ... 96 % and, with proper packing, it is stable up to several months without cooling. Because the milk powder is highly hygroscopic the packing must safely avoid the access of humidity.

The consumer can revert milk powder to potable milk without technical means by simply adding water. But highest attention must be aid to the hygienic quality of the water used for solving the milk powder. In any case it has to be boiled before use.

Experiences from the past show that otherwise heavy damages in the nutrition on a large scale can be the result.

IV.3.2.8. General principles for the construction of an industrial milk processing plant

The main questions that need to be answered before constructing such a plant are:

1. What quantity and quality of milk is produced at which several site?
2. How can the milk be transported to the dairy and what is the expenditure?
3. What forms of organization are necessary?
4. What group of population is to be supplied where and with what products?
5. How shall the trading of the products be, considering hygienic and economic factors?

In choosing the micro-site of the plant one has above all to consider the following aspects:

1. Is there enough water of high hygienic quality?
2. Are the traffic connections good (roads or railways)?
3. How can the supply with electricity and steam be guaranteed?
4. Dairies are basically factories with little impact on the environment. That means there is no emission of harmful substances or wastes. Nevertheless, a certain distance from living areas should be assured.

The international dairy equipment producing industry, also the engineering industry of the German Democratic Republic supplies plants and facilities that fit every specific need. More detailed questions are explained in case study IV.B.1.

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IV.4. Unconventional Sources of Protein Game Management (Management of reserve areas and other game habitats)

IV.4.1. Introduction

Wild animals provide an important renewable natural resource that can be utilized for feeding the continually increasing population in tropical countries. Most of the African peoples and nomadic tribes in South-east Asia supplement their dominant agricultural activities by utilizing wild life and thus achieve an optimal use of resources. Certain tribes like the Bushmen live as hunters and gatherers exclusively from the use of wild animals. The legal culling of game in Botswana in 1975 provided the subsistence hunter with an average of 217 kg of meat per hunter. In many regions of Africa wild animals meat is the only source of protein for the majority of the rural population. In Botswana, for example, 60 % of the rural population cover their protein requirements from wild animals (Von Richter, 1969). In rural areas of Ghana up to 70 % of the total consumption of meat may be provided by wild animals (Asibey, 1974). More game meat is consumed by the rural population of the northern province of Ivory Coast than meat from domestic animals (de Vos and Kaittany, 1972). In the case of the People's Republic of Congo, the percentages of meat consumption are as follows: Game meat 50 %, imported beef 42 %, and meat from domestic livestock 8 % (Hill, 1967). In the Amazon region of Peru (Loreto), 85 % of the animal protein consumed by the local population is from fish and wildlife. The intensive utilization of wildlife in tropical regions of Brazil is through the "Caboclos". It extends from large and small mammals, birds, amphibians, fish and molluscs to insects and their larvae (Santos, 1966). In fact, insect larvae are prized as a special delicacy on account of their high protein and energy contents. The game population provides an important source of protein for tribal people of Asia and Latin America who practise shifting cultivation in forests. The increase in legal and illegal sales of wild animals meat is observed even in urbanized centres of these countries. Thus utilization of game provides an unvonventional source of protein to rural populations of the tropical regions. However, the game utilization and management as an aspect of landuse remains practically ignored in regional or national research programmes and development planning despite its considerable economic significance for the people of these countries.

Aims of Game management

Game management aims at increasing food protein, creating more jobs and strengthening the balance of payments. Since game populations live under different environmental conditions, they can utilize the habitat in a better way than domestic stock and thus the size of game animals (live weight) exceeds that of domestic animals. The annual production of game per hectare is therefore higher than for domestic animals. Game animals are far more capable of migrating long distances than are domestic animals. As a result, they can move considerably forther away from watering places and follow much longer migration trails to make up for seasonal variations in food. Similarly, game animals preserve productive pasture areas far better than do cattle so that overgrazing and subsequent erosion can be controlled and the production of food protein is increased. A more intensive integration of game management in to African savanna is desirable for pasture economy. Game animals do not require fencing and watering facilities or human supervision and thus farmers in Zimbabwe and Namibia have already converted their farmlands into game management areas. In certain areas of the humid tropics, cattle raising is not possible because of tsetse fly infestation and, therefore, meat production in such areas is only possible with game.

IV.4.2. Measures of Game management

Game management is planned in three steps: (1) more meat from the same game population; (2) increased game population with the same pasture areas; and (3) increased food base for game. In order to get more meat from the same population, traditional hunting should be replaced by selective hunting. The traditional hunters pursue game with bow and arrow, snares, pitfalls etc, and thus the animals die a slow, painful death and are lost to human nutrition. The wounded animals even help increase the predatory animal population. In selective hunting usually old bulls are bagged, young fertile bulls and femal animals being spared. It attempts to maintain a constant stock of game in accordance with the biological balance. The animals to be shot are those which would otherwise be eliminated by natural enemies, diseases and lack of food. The game quota is kept within a safe limit. Increased meat yield from the same game population can be made possible if transport and preservation facilities are provided. In wet savannas, meat of big game like elephant or Kafir buffalo can be transported in dried form over long distances. Thus a make-shift drying oven is set up to dry the meat which has been cut in strips. This dried meat (biltong) is then packed in sacks and loaded on a lorry.

The game population can be increased in the same pasture areas by manipulating the composition of game species. Vultures and hyaenas which live on dead game or butchering wastes are useful as "policemen" and maintain the biological balance. But carnivores like lion or tigers which do not provide animal protein to man can take away enormous amounts of man's food. Therefore, the control of cats of prey is necessary. Similarly the composition of game species is also an important aspect of game mangament. For example, the white-tailed gnu (Connochaetes gnu) which provides a good yield of meat, always remains in common herds with zebra (Equus burchelli). This symbiotic association is to protect each other from natural enemies like cat and therefore it places an additional burden on gnu production in terms of food management, because zebra meat is not in demand.

The other aspect of game management is to increase the food base. This can be done by several ways during the pinch period which occurs in the dry season. The herds of game animals take up long migration in search of food during this period and are interrupted by roads, new settlements and artificial lakes. Therefore, natural hay should be placed on suitable sites for feeding these animals. The food base for game is also increased when most of the shooting is done in the first half of the dry season. The game population is smaller in the season with the least food than in the season with an abundant food supply. Therefore, it is possible to utilize food reserves in seasons with abundant food which would otherwise be wasted.

IV.4.2. New technologies for the utilization of agricultural and food processing by-products and waste materials

One of the most acute problems in the world today is that of human nutrition. Considerable progress must be made in the field of food production to irradicate hunger and malnutrition among the underpriviliged classes in the developing countries and to establish a nutritional basis which will be able to sustain a world population anticipated to reach 6 - 6.5 milliards by the turn of the century. It is not only vital to satisfy the demands for energy-giving foods but also nutritional requirements, particularly adequate supplies of protein. Protein is an essential component of the diet, without which human beings suffer both in physical and mental health.

Efforts to produce more food from traditional sources have been made in many directions: plant genetics, animal husbandry, development of marine and inland water fisheries, etc.
Undoubtedly, intensification of agriculture will remain the basis for improving food supplies in the foreseeable future. At the same time, demographic growth on the one hand, limited land and fresh water resources , rising costs for energy and other intensification factors on the other, will require increased efforts to make additional sources accessible for direct human consumption or a growing number of productive livestock.

Assuming that in the coming decades the demand for animal products and consequently also animal feeds will increase, the discovery of alternative protein sources could considerably or even entirely reduce the use of wheat, soya, etc. as fodder and thereby make valuable primary products from plants directly available for human consumption.

That is why it is not only necessary to improve agriculture and food production technologies currently being applied, but also to look for new, unconventional methods which are suitable for the production of protein and nutrients and which will be adequate to meet the growing global and regional demands.

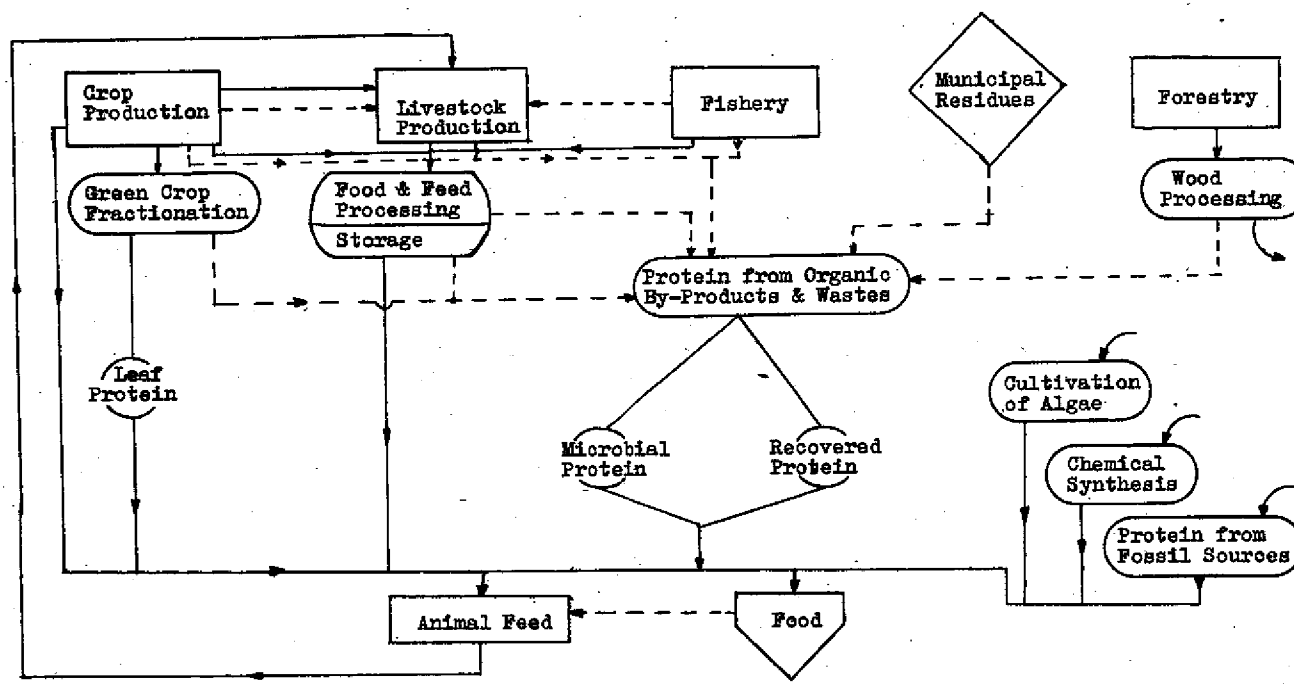

Fig. IV.4. 1. Production of Edible Proteins from Agricultural and other Sources

-------- Flow of Organic By-Products and Waste Management

The main directions in the probable development of animal feeds and human food from traditional and novel sources are indicated in Figure IV.4.1.

As far as the availability of resources in a given region are concerned, different substances have been proposed for increasing protein supply: petroleum and natural gas, green crops, agricultural and food processing residues, wastes from the paper industries, municipal residues , etc. (Table IV.4.1.). In order to use these and other substances as raw materials for obtaining proteins, a number of different technologies are feasible or are even being applied on different production scales, for example:

- production of single cell protein (SCP) from fossil fuel sources
- conversion of biomass to microbial protein
- biological synthesis of protein (algea)
- extraction of proteins from crop plants (LPC)
- recovery of protein from agricultural, industrial, or municipal wastes
- improving the nutritional value of protein from plant sources
- use of cellulosic substrates for growing mushrooms

Source	Type	Examples
	Oilseeds	Soyabeans, peanuts, rapeseed, cotton seed, sesame seed, sunflower seed
Agricultural or equivalent	Legumes (other than oilseed)	Broad bean (vicia faba)
	Leaf protein	Various types of leaves
	Protein from farm animals	Meat, milk, eggs
Fishery and Aquaculture	Protein from aquatic animals	Various types of fish and crustacean
	Algae	Spirulina, Chlorella and other types of algae
Biosynthesis	Carbohydrates (residues from agriculture, food, industry, and wood processing, municipal wastes, etc.)	Microproteins (bacteria or fungi)

Table IV.4.1. Conventional and Novel Sources of Nutrients with a High Protein Content

Although the chemical synthesis of nutrients for food or feed is also scientifically feasible, the amount of energy consumed by presently known processes still requires further investigation for the elaboration of economically efficient technologies for large scale production. On the other hand, production of SCP from petroleum and natural gas is under way in many countries (USSR, Japan, England, etc.). Large scale synthesis of SCP on a hydrocarbon base has already reached a high technological niveau.

In this respect the use of natural gas has proved to be particularly efficient. But there are, however, competing demands for the fossil fuels and it is well known that supplies are not unlimited. Therefore, research into other prospective raw materials for the production of microbial protein has been intensified over the last years.

One of the most promising ways of reducing protein deficiency is by means of microbial conversion of by-products or wastes from agriculture, forestry, agro-industries and fisheries to protein concentrates. Bio-resources of this type exist in every country and are constantly being renewed in plants by photosynthesis. As an indication of the quantity of these secondary products, it is estimated that agricultural residues constitute approximately two-thirds of total crop production. Estimated quantities of some agricultural, forestry and food or feed processing residues are given in Table IV.4.2.

Type of Residue	Quantity of carbohydrate (x 10^3 ton)
Wheat straw	286.580
Wheat bran	57.320
Maize stover	120.040
Maize cobs	30.070
Sugar cane bagasse	83.000
Molasses	9.300

Table IV.4. 2. Annual World Production of some Agricultural and Processing Residues

Source: J.T. WORGAN, In: Proteins in Human Nutrition (J.W.G. PORTER and B.A. ROLLS, eds) London, 1973.

Some secondary products are recycled into the food production system as livestock feed and only a very small quantity are directly incorporated into food products. A considerable proportion, however, of these secondary products is unsuitable as livestock feed, or has a low nutritional value. Furthermore, some waste materials, particularly those which occur as factory effluents, create a pollution problem. Apart from these, there are some other advantages which emphazise the increasing significance of microbial conversion processes as alternative technologies for protein production:

- The protein content of the products of microbial conversion is significantly higher than that of traditional food or feed (Table IV.4.3.)
- The extremely high rate of microbial synthesis enables some micro-organisms to reproduce in a very short time. Microbes can double their cell mass in 20 minutes to 6 hours. Yeast can double their cell mass in about 2 hours.
- Próduction is exceptionally independent of climate, weather conditions and the ravages of pests and diseases which may reduce or completely destroy yields of agricultural crops.
- Microbial conversion processes do not compete with agriculture for arable land.

Type	%	Type	%
Cassava	1-2	Beef	18.0
Potatoes	2.1	Chicken	19.0
Milk (liquid)	3.3	Roasted Peanuts	28.0
Wheat flour	11.0	Skimmed milk powder	36.0
Eggs	12.0	Soyflour	50.0
White fish	16-20	SCP	50.0

Table IV.4.3. Average Protein Contents of Raw Foods

Sources: D. CRABBE, S. LAWSON. The World Food Book, London and New York, 1981. P. DAVIDS (ed.) Single Cell Protein, London 1974.

Increasing attention is being given to the addition of algae in human nutrition or as protein animal feed in livestock production. There are more than 100.000 species of these plants, and most of them have yet to be explored for possible uses. Already a few of them are eaten in various parts of the world or processed to high protein food commodities sold in health food stores. Favorable natural conditions in tropical and subtropical regions open up new prospects for cultivating some types of algae which can be used as substitutes for conventional nitrogen fertilizer.

Because micro-organisms are capable of a wide variety of metabolic reactions they can adapt to many sources of nutrients. This adaptability makes them suitable not only for industrial but also for small scale fermentations. The last method mentioned already applied thousands of years ago for processing and preserving foods, beverages or animal feed is still important for improving the food supply in tropical and subtropical regions. At the same time industrial biosynthesis is developing feasible technological alternatives to bridge the enrgy/protein gap in food deficient countries as well as for reducing the dependence of some developed countries with a highly intensive livestock sector on imports of cereals as well as of soyabeans and other protein concentrates for animal feed.

Whereas highly developed industrial technologies are known for and used for obtaining protein concentrates from fossil fuel sources, most of the technologies considered for microbial conversion of residues from agriculture, processing industries or equivalent sources are still at the laboratory stage or applied at a pilot plant level (T.IV.4.4) A number of varied and complex scientific, technical, economic, medical and even social problems must be solved to make the broader use of the promising properties of microbial conversion of biomass feasible as an economically significant alternative to traditional technologies.

Technology \ Raw material source	urban sewage	municipal wastes	animal wastes	crop residues	wood residues	processing residues	crops	livestock products	fishery products	algae	fossil fuels
Cultivation/ Reproduction							3	3	1–3	1–2	
Fractionation of Protein from Plant Biomass				1			3			0	
Protein Recovery	0–1	0–1	1–2	1–2		3	1–2	2	3		
Microproteins from carbohydrate sources		1–2		1–2	2	2	1			0	
Microproteins from hydrocarbons											2

Table IV.4.4. Status of Bioprotein Technologies

0 – Latent: little known work but process believed to be possible
1 – Under research (laboratory stage, pilot plant)
2 – Applied in a few units of production or on a regional scale
3 – Extensively produced or applied

Source: J. HIRS, S. MUENCH (eds). New Technologies for the Utilization of Biologically Based Raw Materials for Feed and Food Production. CP-82-70, October 1982, IIASA, Laxenburg, Austria

On the basis of technological solutions hitherto known or in the foreseeable future to be expected and under consideration of of the presently unsettled or only partial solved problems the following conclusions may be drawn considering the significance of non-conventional technologies for protein production and improvement of the global and regional nutrition situation:

- Although it may be feasible to produce quantities of microproteins in the immediate future marketable for human consumption, the most extensive use will probably be the production of protein concentrates for livestock feed.
- In nearly all countries of the world sufficient raw materials are available for the introduction or expansion of non-conventional processes of protein extraction.
- Decisive for the speed of implementation of these new technologies will be:
  - the assimilability, palatability and social acceptance of the final product for human consumption or animal feed
  - the continous availability of raw materials for large scale production
  - the development or introduction of technologies which facilitate the production of standardized microbial protein which can be produced cheaper than comparable traditional products
  - the development of technically and economically acceptable modes of transport of large quantities of bulky raw materials (straw, sewage wastes, etc.)
- Some of the technologies for obtaining microbial protein or improving the nutritional values of foods for human consumption or animal feeds are especially well suited for small scale operational units with a flexible operational scale. Their further development could effectively support the endeavours of the food deficit countries to improve their energy/protein balance.

From an economical point of view, a comparative analysis of conventional and novel (microbial) technologies has to be considered and the advantages resulting from the application of non-conventional technologies evaluated in respect of saving agricultural land, positive implications for the environment, etc.

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IV.4.3. Utilization of game animals

IV.4.3.1. Game Cropping

Wildlife management signifies a manipulative intervention in the ecosystem to enable man to use the animals better and optimally. This is practised in many national parks of South and East Africa and also in South America and is restricted to the culling of animals when they interfere with the interest of crop farming. The scientifically directed cropping action of elephant and hippopotamus herds in the overstocked Murchison Falls National Parks in Uganda is the best example, where animal populations were reduced in order to prevent further destruction of vegetation and soil erosion. In 1965, 2,000 of the 15,000 elephants and 3,000 of the total 13,000 hippopotamus were shot to feed the inhabitants (Graham, 1973) without altering the population structure of the remaining herds, and without disturbing the parks, intensive tourism etc. Similarly, game cropping campaign in tsetse-infested areas of former Rhodesia in 1959 recorded 700,000 game animals shot by official hunters (Dasmann, 1964).

IV.4.3.2. Game ranching

In East Africa, many projects are carried out where freely living populations of game animals are managed to provide meat and skins. The landowners in Zimbabwe, South-West and South Africa are managing game either by itself or in combination with domestic animals, and the culling is regulated on the basis of annual estimates of numbers. This type of utilization is called "game ranching". It is practiced usually on fenced areas and represents the most intensive form of game management by which a sustained production, yield and marketing of wild animals and their by-products is sought after. Such game farms are already run in South and East Africa, Argentina, and Venezuela, and others are now being established in Paraguay and West Africa. The game meat harvested is often carried by refrigeration trucks to the next port to be exported. The meat production yields per unit area exceed those achieved by cattle rearing.

A wildlife management project in the Masai area of Kenya which formed an integral part of a land utilization project also showed unequivocally that wildlife utilization yields a higher financial return than keeping cattle for meat (F.A.O., 1975).

IV.4.3.3. Game farming

Game farming is the most intensive form of game management. An attempt is made to tame game animals as a precondition for many ways of manipulating the species under this form. The ostrich (Struthio camelus australis) is the only single African species which is domesticated for this purpose. Guinea fowl (Numida meleagria galeata) have been domesticated for centuries and efforts are being made to domesticate bushfowl (Francolinus bicalcaratus) in Nigeria. Ajayi (1975) reported successful domestication of the giant pouched rat (Cricetomys gambianus) in West Africa, where it is used as delicacy. The other species for intensive rearing and breeding purposes are the eland antelope (Taurotragus oryx), springbok (Antidorcas marsupialis), blesbok (Damaliscus dorcas) and Oryx (Oryx beisa), (King and Heath, 1975). The axis deer, wild boar, nilgai and black buck are species which can be used for domestication and intensive breeding in game farms in Asia (Belsare, 1983). In tropical South America, successful attempts are being made at intensive rearing of the world's largest rodent, the capybara (Hydrochoerus capybara), of the tapir, the Amazon manatee, the vicuna and different species of caiman.

Ideal game farm and its management

Game management in tropical rain forest has a wide scope because there is no real dry season and, therefore, food is always made available to the game. However, hunting is difficult in these dense forests. Similarly, the transport of bagged game through the impassable terrain is so difficult that the big game must be dried to avoid its decay. Wet and dry savannas are disadvantageous to game management, although attempts are made to domesticate the reed rat in Ghana and the African giant rat in Nigeria, good results being in such farms. Thorny savanna is not good either for keeping game because of water supply problems and little food being available. Small herds of eland antelopes and Thomson gazelles are kept in the Hopcraft Farm near Nairobi under scientific control and ranchlike conditions in such a biotope (Crawford, 1970). Since game are much more mobile, semi-desert and desert conditions can also be suitable for game farming. The game species to be used are eland antelope, oryx antelope and black buck, which can survive dry periods without any access to surface water and can tolerate temperatures of 45 °C without any stress.

Area of farm

The area required for a particular population depends upon food and water availability, terrain, breeding and loafing grounds and the disturbances caused by different agencies, both natural and artificial ones. Under natural conditions, a range of one animal per hectare is considered as a well stocked area which includes all components of habitat requirement of the animals. In farming, however, three animals per hectare can be maintained. It takes into account the disturbances likely to be caused by culling and other farm practices and its effect on the animals reproduction.

The breakup of 500 ha of farm area can be as follows: Breeding areas of 50 ha; loafing ground, 8 to 10 patches of 20 - 25 ha each; grass and fodder area of 200 ha. The breeding area should be fire-protected and be kept free from artificial structures. Under no circumstances anybody should be allowed to enter this breeding area. The salt licks and water holes should be kept at the periphery of the breeding area so that they can be inspected from time to time without disturbances. The loafing ground is required for ruminating and loafing during the hot hours of the day. Each path of loafing ground should be provided with salt licks and water holes. The grass and fooder area should be ploughed, irrigated and maintained for intensive grass and fodder production. In this area water holes, salt licks and roads should be constructed.

Farm enclosure

The shape of the farm should be circular so that animals have escape routes all round. Fencing for different animals is of different specification, e. g. fencing for deer and for wild boar will be of different type. Similarly, there should be four gates into the farm from all the four directions and be opened on rotational basis one at a time. This will spread the traffic nuisance over the whole area and will have a uniform effect on the area's animal use pattern.

Preparation of farm

After surveying the area of the farm it is necessary to carry out initial treatment of the farm before stocking the animals. For this purpose weeding and uprooting of unpalatable species will be carried out in breeding and loafing areas during July and August for two consecutive years. The weeds should be uprooted manually and destroyed. The unwanted brushwood should also be cut. Fodder and fruit bearing trees should be planted. The farm should be ploughed and irrigated for developing fodder and grass. Similarly, a portable enclosure to cover at least 25 ha at a time should be provided to give rest to some areas under rotational grazing systems. Such enclosures can be made of bamboo poles tied vertically 3 m apart with the help of strings on either side of the enclosures. All these bamboo poles are held by a nylon string at the top from which an open thin plastic sheet will be stretched along the enclosures to exclude animals.

Method of stocking

Capturing the animals from high-density areas

The animals can be captured from high-density areas of sanctuaries and national parks and can be transported to the farm under tranquilised condition.

Procuring captured animals and releasing

The animals can be taken from the zoo and animal orphanages. Excess animals in the zoo can be purchased and released inside the farm.

Population breakup (deer)

The age and sex structure of the population has to be maintained at appropriate proportions so as to induce the maximum production of animals with the available stock. As the animals are continously harvested from the adult and subadult class, the following age and sex structure is proposed.

1.	Breeding hinds	500
2.	Subadult hinds	225
3.	Yearling and fawn (female)	225
4.	Adult stag	100
5.	Subadult stag	225
6.	Yearling and fawn (male)	225
	Total	1,500

The average litter size is taken as 1 fawn per breeding hind per year. A high survival rate of the fawn is expected since there will not be any predators. However, considering some natural calamities, 10 % fawn mortality is envisaged to arrive at a safe litter size of 0.9 fawn per breeding hind per year. Thus 500 breeding hinds in the population are expected to produce 450 young annually. Since the sex ratio of fawn is taken as 50 : 50, out of 450 fawn, there will be 225 males and 225 females out of 450 fawns born.

All the deer are polygamous in nature. An adult stag is expected to cover 20-30 females during the rutting season. But in the farm area, a ratio of 1 : 5 can be kept so that more stags are made available for culling.

The age must be assessed before harvesting. It is also important to count the number of animals accurately and assess the age and sex structure as it forms the very basis of management. As the population will keep on fluctuating round the year, monthly temporal counts are necessary. Under these circumstances, direct counting or visual counting supplemented by back counting is prescribed so that number and age structure of animals are known as accurately as possible.

For direct counting, the whole farm can be divided into convenient geographical sectors which can be visually covered from a machan hide at a suitable point. The enumerators will sit in such hides in all the sectors at a time when the animals come out for grazing. All the enumerators will have a binocular and a portable small tape recorder. The time of enumeration can be fixed for an hour or so, each enumerator will stop counting at a fixed hour and record the data directly, by tape recorder. Each invidiual animal will be called once describing its age and sex so that it is properly recorded, e. g. adult male fawn, subadult female, adult female etc. Later on this informtion can be transferred to paper and computed for the whole farm. The counting should be done at the beginning of each month so that the change from one age class to another is recorded properly.

For track counting, a 6 m wide strip along the radius is prepared at convenient place so that all the animals are made to cross it once at a time. A silent drive can be arranged for this. In this way every individual animal will leave its hoof marks on the strip. The stride of animals of different age classes is measured and the reading of at least 100 such strides measuring the distrance between outer edge of hoof at the maximum spread of the same animals is made. The average stride for all these readings is calculated. Two or three lines are drawn on the sandy strip at the distance of mean stride, and all the hoof marks present between such lines are counted all along the strip. More than half of the hoof marks inside the line can be treated as one and less than half can be ignored. The number of hoof marks are divided by four and thus will give the number of animals having crossed the strip.

Cropping of animals

Animal cropping depends upon food availability, seasonal variation in animals weight and coat, rutting and breeding season, and age class turnover. The percentage of culling should be 20 % in adult hinds , 75 % in adult stags, 55 % in subadult hinds, and 66 % in subadult stags.

4.4. Methods of cropping

Learning is very much developed in large mammals. They soon get used to the presence of harmless objects. But once they start associating danger with something, they get scared of it and change their behaviour pattern to save themselves. The flight distance of animals in different areas is directly proportional to the amount of danger they associate with humans or vehicles. Thus for cropping the animal success will be in concealing the killing mechanism from the animals. The best possible method of cropping the wild animals is to shoot them at night under search light with thehelp of telescopic silenced rifles. Cropping can also be done very effectively by bow and arrow at night under search light.

Disposal of the animal

As soon as the quarry is procured, it is taken to the laboratory where its measurement of weight and size are recorded. The animal is skinned and the venison is preserved in deep freezer. The skin and the antlers are suitably treated and preserved.

Next morning the venison is taken to fair price shop where it is sold at the fixed rates. Offal, bones, skin and antlers, can be disposed of as per current utilization pattern. Offal is also used for human consumption in some places, and by manufacturers of animal feed. Skins would be preserved for tanning and antlers are already much in demand by industry.

4.5. Expected turnover of protein

The protein from the edible portion of "bushmeat" is calculated by Asibey and Eyeson (1975) as follows:

1. Bushbruck (Tragelaphus scriptus)	21.6
2. Crown ducker (Sylvicapra grimmia)	20.8
3. African elephant (Loxodonta africana)	30.9
4. Grass cutter (Tryonomys swinderianus)	22.7
5. Green monkey (Cercopitheous aethiops)	17.6
6. Hartebeest (Alcelaphus buselaphus)	23.3
7. Kob (Adenota kob)	24.1
8. Royal Antelope (Neotrgus pygmaeus)	23.4
9. Warthog (Phacochoerus aethipicus)	20.7
10. Waterbuck (Kobus defassa)	21.6

If 40 kg edibte bushmeat is obtained per animal, the average protein from it will be 8 to 10 kg which is much more as compared to protein from the domestic meat.

IV.4.4. Economics of game ranching and game farming in African countries

According to Hopcraft (1975) game ranching and farming are means of large-scale land reclamation utilizing evolutionary results and exploiting indigenous herbivores within their own tropical ecosystems. His controlled experiments in Kenya gave evidence that indigenous gazelles were nearly 50 % more efficient in meat production and 83 % more efficient in lean meat production than were cattle kept under optimum conditions. Similarly, the weight gained is protein and not fat. If game is properly managed, more revenue can be obtained by selling meat and giving hunting licences to tourists. The export of game from developing countries in the tropics will not be of much importance to obtain foreign currency, but more money can be obtained by allowing tourists to hunt. The native hunters shot 17,000 animals in the Okawango Delta and gave a revenue of 15,000 marks to the government, but tourists gave 585,000 marks for the same number of animals. In 1972, Kenya in this way obtained 60 million marks of foreign currency from tourists (Stein and Schulze, 1976).

IV.4.6. Conclusions

Game animals provide high-value animal protein for the rural population in the tropics, without demanding problematical modifications of traditional land use methods. Their management provides numerous jobs in the rural areas, requiring little or no training and thus preventing exoudus of people to the cities. Game ranching and farming provide additional income to the farmers and also supply animal protein to the local population. These farms also serve as examples of rational land use in developing countries.

The major research efforts should be directed to intensive utilization and breeding of prospective game animals of the tropical fauna and the productive potential of such land use forms in the direction of economic management. Unfortunately the forms of wildlife utilization predominantly practiced thus far are uncontrolled taking no account of wildlife stocks. They are confronted with the serious threat to their future survival and to their utility for the local population to which they represent so important a renewable natural resource. The ban on hunting and trade in wildlife products is no solution and results in increased activities of well organized commercial poachers which can not be controlled by the Governmental forces.

The ultimate objective of wildlife management is to provide food and to improve living conditions of the rural population. It must, therefore, be inserted into the overall planning of an integrated rural development.

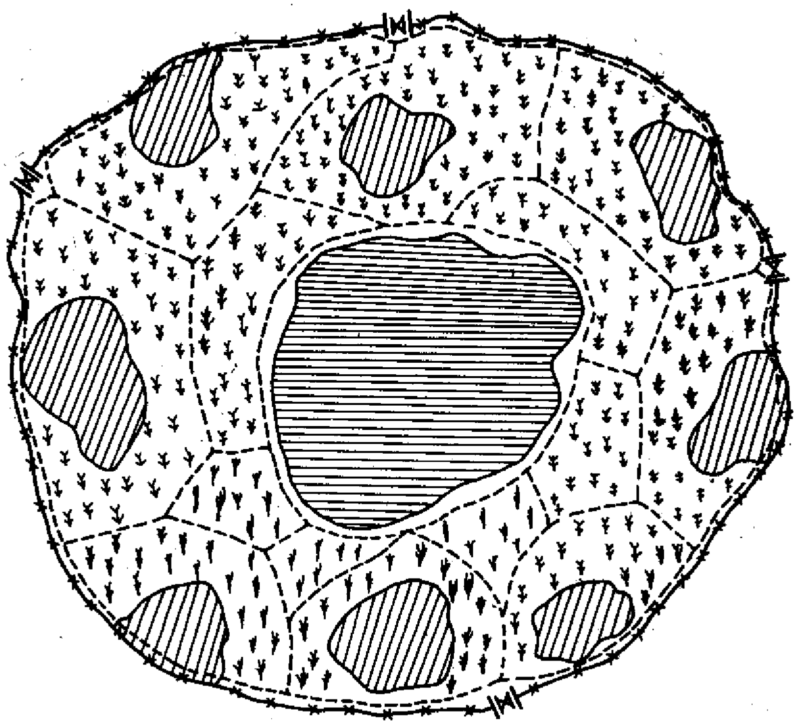

Fig.IV .4.1. MODEL FARM

BREEDING AREA

LOAFING GROUND

GATE

JEEP TRACK

ENCLOSURE

GRASS & FODDER AREA

R e f e r e n c e s

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Subject IV.5. Environmental impact of animal husbandry

IV.5.1. Overgrazing, soil erosion and desertification

IV.5.1.1. Fundamentals

By desertification we understand the extension of desert-like conditions or the "aridisation of soil and vegetation" in originally more productive dry zones of the globe. The results are:

- Reduction of the biological potential, of the biological productivity of these arid and semiarid ecosystems and by that reduction of plant biomass.
- Reduction of the performance of livestock farming and of the possibilities and preconditions for the living of the population in these areas.

As the results of UNCOD (United Nations Conference on Desertification, August 29 - September 9 1977, Nairobi) show a decisive reason is the insufficient consideration of production limits in agricultural use set by the ecological conditions of dry zones. To these ecological conditions belong:

1) Dry climates are characterized not only by little rainfall or low ratio of rainfall/potential evaporation, but also by:
   a) Occurrence of short or longer lasting (several years) droughts (i.e. Sahel drought).
   b) The amount of rainfall underlies extreme annual variation and is distributed irregularely to sporadically within one year. In Jodhpur/Rajasthian the average rainfall is 355 mm/a; the smallest annual rainfall was just some 25 mm, the highest was 1,185 mm.
2) Arid land ecosystems are very "sensitive" notably to any changes in the natural balance under the influence of land-use:

Due to little amounts of water the formation of organic substances (plants and animals) is low, the plant cover is relatively scarce, its protective effect on soil surface is low. Accordingly, the soils contain less organic substances and have less stability in structure. Plant cover, soil properties and prevalence of physical weathering and sharply marked forms of surface (relief) as well as favoure large scale displacement of soil material by water and wind (water and wind erosion). Each destruction of the natural plant cover (agricultural use, road construction, mining, etc.) may lead to extreme soil destruction.

3) Depending on the relief, the ecological conditions (micro climate, soil, water supply, density and kind of vegetation) differ very much on a relatively small area.

Any use not considering the production limits given by climate, ecologically fragile balance and spatial differentiation of ecological conditions, is wrong and leads to desertification.

As shown in Table IV.5.1. pasture farming is the predominant form of agricultural land use in dry zones (3.6 thousand million ha) and the destruction of natural vegetation and soil structure leads to an annually increase of desertificated area of 3.2 million ha (Table IV.5.1.), if pasture farming does not correspond to the ecological conditions. Accordingly, the greatest share of desertificated area and continuing desertification is due to overgrazing.

IV.5.1.2. Processes and factors

Desertification usually starts with overgrazing during the dry season and in years with little rainfall, when the number of animals per unit of area exceeds the amount of crops on this area.

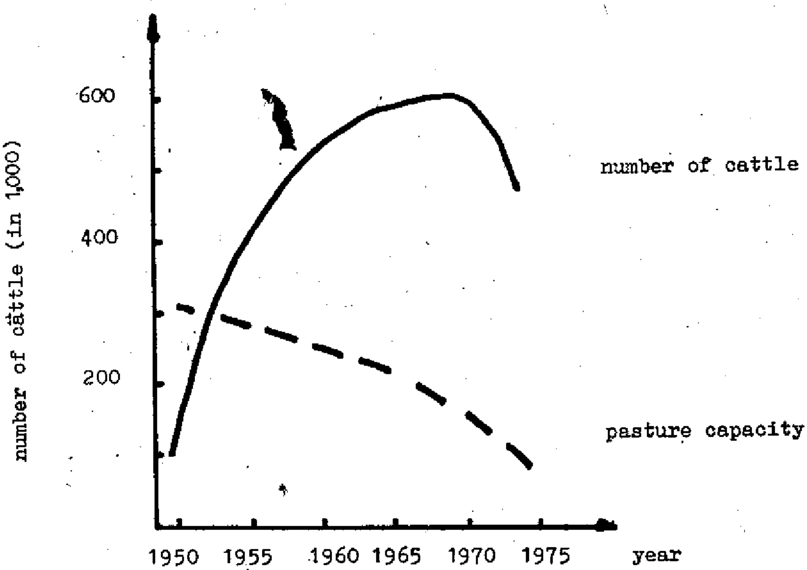


Fig. IV.5.1. Change of the number of livestock and of pasture capacity in the Dafur-Region of Sudan (according to WIDSTRAND, 1975)

	pasture farming	rain agricul-ture	irrigation	total
arid and semiarid zones (mio. ha)	3,600	250	250	4,100
desertificated and jeopardized areas (mio. ha)	3,200	250	45	3,495
percentual share	89	100	18	87
annual rate of deserti-fication (mio. ha)	3.2	2.5	0.125	5.8
in per cent	0.1	1.5	0.05	0.15

Table IV.5.1.: Desertificated and jeopardized areas and annual rate of desertification, ordered by main directions of land-use in arid and semiarid zones (without extreme deserts and subhumid zones)
(partly according to UNCOD overview, 1977)

The results are a partial or total destruction of vegetation, an increase of bare soil surface, a destruction of soil structure through the direct influence of the atmosphere on the soil surface and through movements of animals as well as a stronger surface run-off and wind and water erosion. Thus, the natural regeneration of the plant cover is interrupted, the quality and quantity of fodder is reduced and the productivity of the fields (carrying capacity, pasture capacity) decreases (see Figure IV.5.1.), and finally it results in soil erosion and a change of the land into areas that are not suitable for pasturing any longer. An especially high danger of desertification arises in areas with an erosion-prone relief (stup slopes and watershed for water erosion, large plains for wind erosion) on soils having aninstable structure and at places with extremely high density of animals (watering places, migration and drifting ways, etc.). The traditional nomadic and semi-nomadic pasturalism corresponds well with ecological conditions, if the number of animals is not too great, because of its flexibility (animals migrate to the fodder places).

Improved veterinary service, establishing of additional watering places (not considering available fodder quantities) lead to an increasing number of animals (Figure IV.5.1.), The following factors favour this: (see also Figure IV.5.2.)

a) The most important "insurance" against frequent dry seasons and periods of drought for the stock-holder (nomads and semi-nomads) is a possibly great number of animals.
b) The livestock is a property, the "riches", there are nearly no other possibilities of "accumulation of capital".
c) That is why not the performance of animals (meat, milk, etc.) but the number of animals is essential for the social and economic situation of nomads.
d) With a partly integration into marketing, "reserve" of livestock seems to be the best security against price fluctuations.

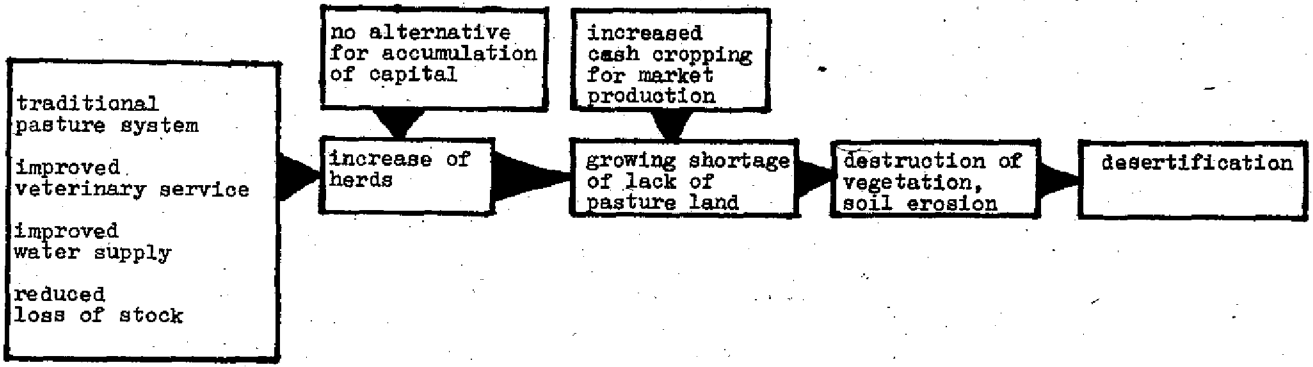


Fig. IV. 5.2. Influence of non-climatic factors on desertification under traditional pasturing (according to WIDSTRAND, 1975)

That, is whyrecently the number of animals exceeds the pasture capacity in many regions. This is shown in Figure IV.5.1. for the Darfur-Region/Sudan, but it is true for many other countries too (e.g. Iraq, Syria, Jordan, Algeria, India). As a result of increasing population (need for foodstuff), and of rising prices for raw materials of food and plants (market economy) the expansion of cultivated areas in pasture regions leads to a reduction of pasture land (Figure IV.5.2.). In the period from 1951 to 1961 the available pasture land in Rajstan/India decreased from 13 million ha to 11 million ha. At the same time the number of goats, sheep and cattle increased from 9.4 million to 14.4 million; i.e. the pasture land available per animal decreased by 31 per cent. This results in a destruction of vegetation and soil and leads to desertification.(Figure IV.5.2.). Most pasture lands lost their productivity by 85 - 90 per cent in the Luni-block, a typical zone of Rajasthan. In 1958 some 25 per cent of the total area of this zone was oversanded (sometimes even formation of dunes); in 1976 this share made-up 33 per cent.

In traditional pasturalism it is also to be considered, that the herds are privatly owned but the pasture land is of common property. Therefore the private livestock-holder has little interest in adapting the number of his livestock to the pasture capacity (what often means a reduction of the number of animals) because he would be economically inferiour to other stock-holders. These processes are of course all subject to the varying annual rainfall, periods of droughts, i.e. to climatic influences, so that the amount of fodder and by that the number of animals in herds increases during humid periods or in years of above-average rainfall; the following dry period is characterized by excessive destruction of vegetation, exhaustion of water resources and intensified desertification. The common practice of burning the natural vegetation with its detrimental effects that further promote desertification shall only be mentioned here. Livestock numbers and densities exceeding the carrying capacity of pastures and seasonal variation causes desertification not only under the traditional system but also in case of pasture utilization for market production.

That is for instance true for several areas of Australia and the USA. In 1975, out of 64 million ha of pasture land in the USA some 33 per cent (20 million ha) were classified as "poor" and "bad". These eroded soils that have lost part of their productivity are above all a consequence of overgrazing. Large parts of North Arizona and New Mexico are already desertificated.

IV.5.1.3. Measures for prevention and control

The above mentioned Conference on Desertification (UNCOD) discussed and adopted a Plan of action to combat desertification based on broad experience and information on causes, processes, distribution and results of desertification that contains numerous recommendations for the proper use of pasture land in dry areas. The main problem in desertification control by appropriate pasture techniques is the adjustment of livestock numbers and number of watering places to the availability of fodder. Numerous research finding and experiences show that under certain circumstances a reduction in the number of animals may lead to an increased production of meat,milk, etc. Proved measures to improve and mostly intensify the pasture use are:

- splitting the available pasture land into lots as a precondition for rotational grazing, for temporary protection of vegetation and better growth and for storing fodder for dry seasons
- protection or planting of suitable shrubs and bushes as fodder for dry seasons, as fuel wood and as shelter against wind
- implementation of measures for soil and water preservation, establishment of a sufficient number of watering places to reduce the drifting ways of livestock (from fodder to watering places and back) and thus to increase an effective production of animals as well as to avoid extreme densities of animals in the vincinity of watering places. Additional possibilities are the diversification of pasture farming by combining it with crop farming (with and without irrigation) and by improved utilization of game. Most of these measures presuppose central planning, legal regulation of the ownership of water, soil and livestock as well as

the change from nomadic pasture farming to stationary pasture farming. The last point may be solved sucessfully only when nomads are integrated into the general development of these areas, when they have a share in economic progress and when these measures are aimed at improving their social and economic conditions and achieve this.

Furthermore, this necessitates establishment of facilities for transport and marketing, fixed and controlled prices etc. Under subarid conditions of the West-Kilimandjaro Region (Tanzania) for instance, it was possible to reduce the fattening time of cattle without additional fodder from 4-5 years to 2 1/2 years only by fencing and establishing of watering places. Another form of intensification of pasture farming is irrigation, fertilization, seeding of suitable grasses and leguminous plants to the original grass cover, conservation of fodder (hay, silage) in the rainy season and additional feeding in the dry season if necessary and on a certain degree also the application of herbicides to reduce an excessive growth of bushes ("bushification") and thus to avoid the burning down. These measures may be implemented at the local level only.

Altogether, all measures taken should be an integrated part of complex, long-term plans for the economic development of the national economy of the country, aiming at social progress and improvement of living conditions of the population.

IV.5.2. Livestock epidemics in the tropics and subtropics from an ecological point of view

IV.5.2.1. Significance of infectiuos diseases for animal husbandry in tropical and subtropical countries

The tropical and subtropical areas of the earth are still characterized by special wide spreading of dangerous infectious diseases. They include three groups of diseases:

1. Tropical livestock epidemics proper which are as diseases in characteristic manner epizootiologically associated with certain higher or lower organisms hosting or transmitting pathogens. These organisms depend in their living on climate or are related in another way with environmental conditions of the tropics. To tropical livestock epidemics of this genesis belong first of all the great etiologically related groups of Trypanosomoses and Piroplasmoses, and besides these also several virus infections such as African horse sickness, Blue tongue, and Rift valley fever. Most of the tropical livestock epidemics do not exclusively depend on tropical climate but extent also into subtropics and temperate climates.

2. Beside these environment related livestock epidemics nowadays infectious diseases occur wide spread in the tropics and partly even in the subtropics, the genesis of which is first of all not influenced by climatic-geographical factors. In the last two centuries these diseases were reduced in countries with a developed agriculture and veterinary medical service. To these diseases belong cattle plague, dourine, contagious bovine pleuropneumonia, and other.

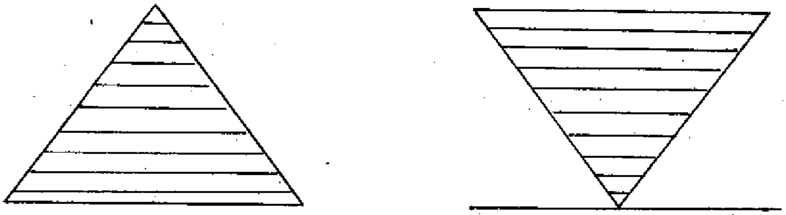
3. Besides, tropical and subtropical countries have numerous infectious diseases which are also found in other areas, for instance foot and mouth disease, malleus, rabies, anthrax swine fever and others

Since the term of tropical livestock epidemics is not clearly definable, because of these relations, today they are described as "exotic epidemics". These are epidemics which are not indigenious in the respective countries, e.g. they have not occured for a long time or never. Animals there have no resistance against it. This term was coined. in Europe. But also the tropical and subtropical countries know exotic epidemics, such as the M. paratuberculosis-infection (John's disease) which had its natural spreading area in Europe and was transferred into numerous tropical countries by the export of ewes for breeding and cattle.

The occurence of infectious diseases in domestic livestock is decisively influenced by the following factors:

1. conditions of production (races, fodder production, technology and other)
2. ecosystem
3. efficiency of veterinary service and agriculture

There are direct interactions between the spread of certain infectious diseases and these three factors. In countries with highly developed agriculture and an efficient veterinary service the percentage of livestock losses caused by infectious diseases is declining and lies far below 50 %. In comparison with that in most tropical and subtropical countries the infectious diseases with a percentage of 90 % of all livestock losses represent the most important interfering factor in the development of animal husbandry. Figure IV.5.3. shows these relations schematically.



Developmental level of animal production, veterinary service, conditions of "ecosystem"

Share of infectious diseases in animal loss

Fig. IV.5.3. Scheme of relations

A present-day example for the outstanding significance of infectious diseases is shown in the spectrum of causes of death of 97 commercial cattle in Tanzania in 1976 (Fig. IV.5.4.). Here, a systematic PM-analysis of all animals died on transit ways or in Holding grounds in the Tabora region of Tanzania during 3 months is shown.

In this place it should be pointed out that in several tropical and subtropical countries check-ups were insufficient realized. The establishment of diagnostic units and a permanent check-up of losses of livestock are a decisive precondition for effective control of infectious diseases and livestock epidemics.

Infectious diseases are an important hinderance factor in the international trade with livestock and animal products. This affects most severely tropical and subtropical countries exporting agricultural products. The danger of spreading livestock epidemics and the losses caused by them increases through the trade with animals, animal products as well as other mediators, through the extension of international commercial relations, the speed of modern means of communication,

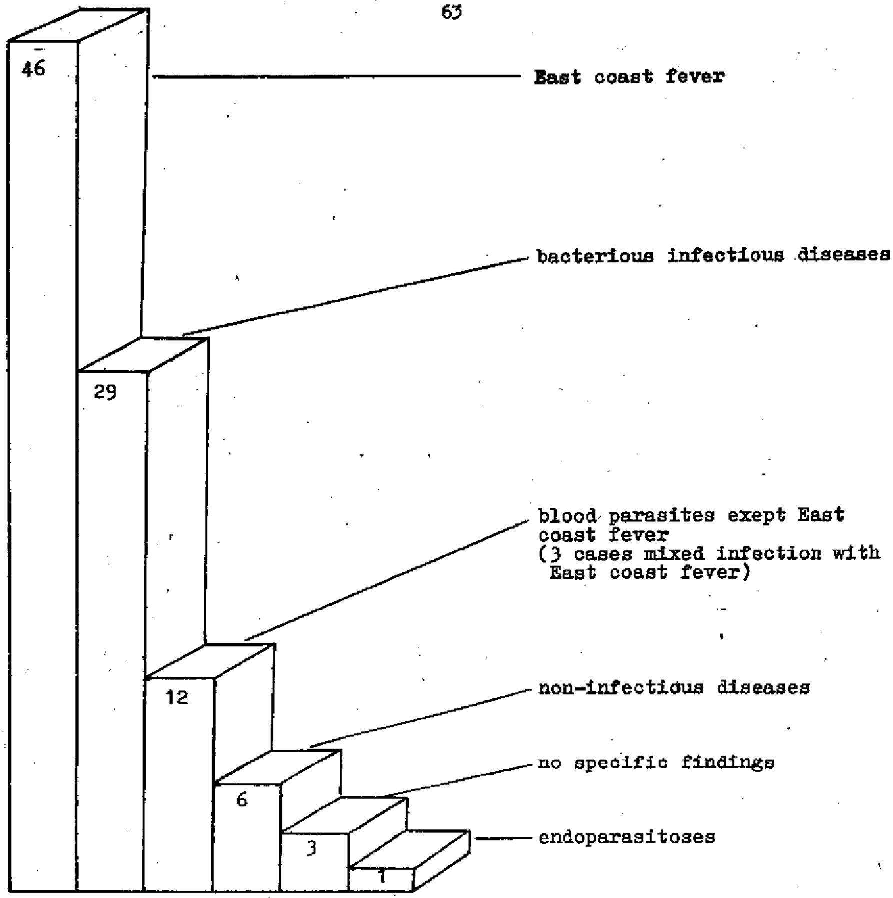


Fig. IV.5.4. Spectrum of causes of death of commercial cattle the increasing concentration of animal husbandry and the extreme sensitivity of animal races to exotic epidemics. That is why each country should pay increasing attention to the check-up and control of infectious diseases on its own territory. International organizations like the OIE ("Office International of Epizootics"), the WHO (World Health Organization) and the FAO (Food and Agriculture Organization) developed zoosanitary rules, models and recommendations for epidemic control. Unfortunately, the worldwide application of uniform control mechanisms in the individual countries is limited by different structures of production, ecological conditions and epidemical situation. Veterinary hygienic parameters are an essential part of international commercial relations with animals and their products and should be carefully selected by the partners and checked-up by certificates. Bilateral contracts, time-limited agreements and regional orders serve the gradual improvement of the present situation.

Principally, the veterinary service controls the outbreak and spread of livestock epidemics within a national territory by three control systems:

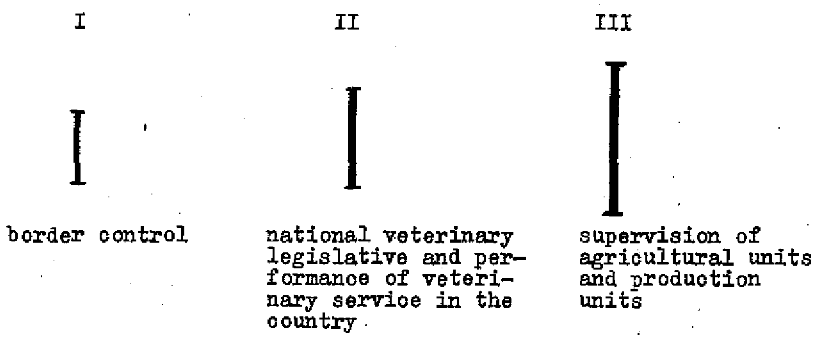


Fig. IV.5.5.: Veterinary control system

Except for the control of certificates the border control is the most insecure control system. Its effectivity depends decisively on the level of development of the veterinary service. The border control is an effective barrier against the invasion of infectious diseases only in countries with a highly developed veterinary service and a complete border supervision. The invasion of severe epidemics into highly developed countries, as the spread of Blue tongue into the USA, the African swine fever into France or Cuba, and many other examples give proof that the border control is not an absolutely secure protection against epidemics. In many tropical and subtropical countries border control is insufficient, unless it is favoured by geographical conditions. The border control respective the prevention from invasion of epidemics is strengthened by a number of measures:

- quarantine
- vaccinations of commercial animals
- information on the situation of morbidity in the livestock in the originating areas of the animals and the animal products
- veterinary supervision of the livestock to be moved
- special veterinary hygienic requirements for the transportation on the road, by railway, ship and aeroplane
- exchange of diagnostic experiences and preparations for the veterinary hygienic control of exports and imports

There is no need to explain especially the significance of the capacity of veterinary service for the supervision of infectious diseases. It is decisive for the control of contagious and autochthonous livestock epidemics. To them belong foot and mouth disease, cattle plague, swine fever, rabies a.o. For this reason, national plans for the control of the individual livestock epidemic are to be elaborated. In the following, we shall discuss more in detail general items and some national particularities in the control of selected livestock epidemics. The increase of the capacity of veterinary service in most of the African and Latin American countries is absolutely nesseoary for an effective control of livestock epidemics.

Animal herds form an epizootiological unit. Today, the most effective control system in many tropical and subtropical countries is the supervision of individual animal flocks and production units, because of the insufficiencies of the other two control systems.
Under nomadic and seminomadic conditions of animal husbandry or in areas without exact data about the health conditions of local livestock the protection of the units of animal husbandry is of paramount interest. That includes:

- selection of location, considering veterinary hygienic parameters
- water supply
- tick survey
- spread of parasites
- analysis of the flora of fodder plants in the territory
- veterinary hygienic control of the animals to avoid an invasion of epidemics
- guarantee of an uniform immune status by vaccinations and prophylactic treatment
- isolation of stables or ranches by a fence from the surrounding
- elaboration of control programmes for the maintenance respectively the improvement of the health status of livestock. Here, reproductional disorders are of especial interest.

In the epizootiology of tropical livestook epidemics the game plays an important role. Since prehistoric times, autochthomous game species at tropical and subtropical locations have been confronted with epidemics so that only those mutants have survived which were especially resistant to these infectious pathogenes. Thus, a balance between pathogen and game species was formed. The pathogen propagates slightly in the game without making it clinically ill. That is the way the game becomes a reservoir of pathogenes and a source of epidemics. In case susceptible species of domestic animals come into this environment the epidemics will be transmitted directly (cattle plague) or through mediators (Trypanosomoses, East coast fever) and cause high losses. Under certain circumstances, for example in East Africa, game and local domestic animals form an epizootiological unit, so that from a veterinary and hygienic point of view there is no need for an isolation as long as the extensive form of animal husbandry is maintained. But it becomes necessary if the performance of the animals is to be increased through the development of fodder farming, the reduction of diseases transmitted by vectors, and other measures.

IV.5.2.2. Main points in the control of infectious diseases

On the base of their etiology and epizootiology the most important infectious diseases of tropical and subtropical countries may be classified into groups for which common strategic control measures are applied:

1. Vector epidemics, the effective control of which is not possible with immunoprophylactic measures
2. Classical bacterial and viral epidemics which leave if survived longlasting immunity and may be controlled effectively by immunological measures. They are often of emigrating character.

3. Soil infections (anthrax, quarter ill)
4. Epidemics with unclear etiology, epizootiology and/or control, as well as newly detected epidemics

IV.5.2.2.1. Vector diseases

Vector epidemics are infections of blood or tissue which necessarily need a living or non-living vehicle for their transmission. Mostly, they are specific tropical epidemics belonging to certain ecosystems with their vectors. It includes epidemics transmitted by ticks (tick borne diseases), infectious diseases with their hosts occuring in certain landscapes only (rift valley fever and others). Because of the wide spread of vectors tropical and subtropical countries offer optimal conditions for the development of vector epidemics. At present, three quarters of all livestock epidemics of these countries are transmitted by vectors. Since in each biotope certain transmitters appear as main transmitter or certain diseases are transmitted only by very specific vectors, research of the ecology of living vectors permits conclusions concerning the significance and potential spreading area of the vector epidemics. For example, in East Africa the East coast fever is transmitted almost exclusively by the tick Rhipicephalus apendiculatus. Researches undertaken in the field of occurence of this species of tick showed therefore the spreading area of the East coast fever. The tick is only present in areas with > 500 mm annual precipitation. In areas where the tick is wide spread and the epidemic occures enzootiologically an effective cattle keeping is not possible without expensive control measures to reduce the number of ticks. In setting-up a ranch it is recommended therefore to study intensively the ecological conditions with regard to the occurrence of potential vectors of livestock epidemics within the territory of the planned ranch. In case

the conditions are unfavourable one should think about establishing a sheep or goat ranch instead, because goats and sheep are resistant to East coast fever. In Central and East Africa the study of vectors is especially concentrated on ticks and is named "tick survey". Within the years 1972 to 1975 by an investigation unit in Tabora/Tanzania some 200,000 ticks from domestic animals were collected, identified and their spreading was mapped. Frequency of occurrence of vectors at individual animal species, seasonal variations and other epizootiological characteristics are also of importance. The maximal number of living ticks collected from one cow was 1,900.
Therefrom is is imaginable to what extent damages caused by parasites may occur. On the basis of these results suggestions for the development of animal husbandry (cattle, goat, sheep) were offered to the government of the country.
A survey on selected pathogens of important vector epidemics is shown in table IV.5.2.

Pathogen		
Group	Species	Epidemic
Protozoa	Trypanosomosa spp.	Trypanosomiasis (Nagana at almost all animals
	Theileria spp.	East coast fever, (cattle, buffalos)
	Babesia bigemina and other species	Babesiosis (cattle, sheep, goat, dog,a.o.)
Rickettsiales	Cowdria ruminantium	
	Anaplasma marginale a.o. spp.	Anaplasmosis (cattle)
	Bartonella (Haemobestonella, Eperythrozoon)	Haemobartonellosis, Eperythrozoonosis

Table IV.5.2. Pathogens of important vector epidemics

Table (contin.)

Pathogen		
Group	Species	Epidemic
Virus	Bunyaviridae (Arbovirus)	Rift valley fever
	Togavirus (Arbovirus)	Wesselbron virus infection
	Rhabdovirus (Arbovirus)	Three-days-disease
	Vacciniaviruses and Herpesviruses	Lumpy skin disease
	Myxovirus	Nairobi-Sheep-disease

Table IV.5.2. Pathogens of important vector epidemics

The most important vectors are ticks, mosquitos, flies and horseflies. The control of vectors depends on the

- kind of vectors and their biological behaviour
- the ecology of location.

In principle, two ways of controlling vectors are possible:

1. Control of vectors in the surrounding of animals
2. Control of vectors in the animal itself

Control of vectors in the surrounding of animals

Vectors are controlled by the destruction of the habitat or by eradication of transmitters in the habitat. The destruction of habitats is difficult and economically very expensive. As far as tick with one host are concerned they may be reduced by cultivation of the soil or by cultivated pastures. Mosquitos and tabanides may be controlled by exsiccation of pastures or water wholes. Practically impossible is the control of stable flies and biting flies by environmental measures. Contrary to this, the glossines, the vectors of Tryanosomoses, are sedentary and occur in savannas (glossina morsitans), at river beaches or in river forests, in tropical grassland (glossina palpalis), as well as in rain forests (glossina fusca). Deforestation or a selective elimination of the above mentioned kinds of vegetation leads to an effective reduction of glossines. Deforestations may also be used as a barrier against tsetse flies. With the Sahel zone extending, deforestation done in order to reduce tsetse flies will become more and more problematically.

Measures for the eradication of transmitters in the habitat by using chemical compounds

An areal treatment with insecticides is economically very expensive and leads to environmental contamination with insecticides. For this reason, it is recommended to use in certain areas instead of large quantities of insecticides in low concentration smaller in high concentration on the specific location or in the habitat of the vector (UNC-method).

These treatments may be repeated several times (e.g. for ticks - adding acarides to fertilizers on the pasture).
In order to eliminate Tsetse flies which need shady trees typical groups of trees may be selectively treated. On the whole, it may be summarized that the application of insecticides is of local importance only as it is too expensive and in the long run it does not guarantee the effective reduction of vectors in a wide area.

Biological methods

Besides chemical desinfection there are also biological methods under discussion. In the USA the "blow fly" causing in former times an epidemical occurrence of Myiasis, could be eradicated by the application of the "sterile male technique". Here, tsetse flies are cultivated in laboratories and serilized by radiation (X-ray). Released in tsetse areas, the sterilized males enter competition with the potent males copulate with the females, living in the tsetse area to prevent their propagation. In order to displace the males living in the habitat, sterilized animals in relation to healthy ones have to be released in the ratio of 1:1 at least. The price for one sterile male cultivated in vitro is about one dollar. In open areas the immigration of potent male from infected bordering areas is possible at any time. That reduces or even prevents the effect of the sterile male technique. Right now it may be applied successfully only in geographically bordered areas or infected islands in the midst of infection free areas. At Tanganjika Lake the liquidation of tsetse flies was successful by applying the sterile male technique on little, infected islands.

Control of vectors at the animal

This method is implemented by contact poison or other compounds which are applied to the host on different ways. The treatment with contact poison includes spray or dip. In general, it is to state , that by means of dip or spray and systematic application it becomes possible to eliminate the transmitters of vector epidemics. These preparations shall be applied in the dry season as well. The rhythm is subject to the developing cycle of the parasites. In case of totally regular treatment, e.g. in East Africa once a week, all tick borne vector epidemics may be prevented securely. In case of acute epidemic outbreaks it is recommended to dip twice a week. week. Sprays or sprayrace are cheap and applicable everywhere. However they need high amounts of insecticides and their effectiveness is not unfailing and depends on the intensity of treatment.

The dip, animals are going through, guarantees treatment all over the body and a reliable effect. In dependence on the applied preparation it offers also a residual effect. The establishment of dips is expensive, dips are locally limited, require much labour and the animals have to get accustomed to dipping. Because of the reliable effect dipping became the most effective method to control and reduce vector epidemics, especially tick borne diseases, in many countries of the tropics and subtropics. In East Africa dips are the "backbone" of the whole cattle husbandry. In areas with East coast fever cattle husbandry is possible only by systematic dipping. Dipping is the only method to interrupt effectively the developing cycle of the pathogen of this dangerous vector epidemic, eliminating the tick at the animal directly.
The construction of dips is strategically needed as a basis for the development of a ruminant husbandry, increasing of performance and reduction of losses. Within the last 15 years more than 1,600 dips have been built in East Africa and have proven well. A precondition for workable dips is a econon- omically and organizationally secured infrastructure, that controls the regularity of the treatment and the effec- tivity of the dipping procedure. Dips are to be built at producing units and/or to the areal principle. The aim must be a total coverage of the domestic livestock of one area.
Unfortunally, ticks often form resistant species. Thus, the maintenance of the proper concentration in cattle baths is to be guaranteed by regular supervisions. Test in intervalls of a fortnight have proven well. This requires the setting-up of small dip testing centres.

Elimination of epidemical vectors by systemically acting compounds

Organic phosphorous compounds are particularly well suitable for this purpose. By oral, dermal or parenteral application – according to the absorptability via the respective way of application – a more or less steady blood level is established so that sufficiently high amount of active substances is taken-in by blood sucking vectors. Expenses are low, the methods may be applied in less developed areas and should serve as assisting methods in the above mentioned programmes From the medical point of view doubts arise about milk cows because of the formation of residues. There are no risks with extensively kept fattening cattle, provided a sufficiently long period before slaughtering is observed.

Chemoprophylaxis against vector epidemics

A permanent application of chemotherapeutics may prevent the outbreak of vector diseases under field conditions. Parenterally acting drugs may be applied in mixtures with a long period of action, sometimes over for months e.g. prothidium and simular preparations against Trypanosomiasis of cattle. This chemoprophylaxis is used for a temporary stay in areas with tsetse flies, for instance during cattle movements.This method permits in cases of emergency a temporary use of infected areas. It may also serve the protection of imported susceptible breeding animals to make the acclimatization of these races easier. The preparations lead to a sterilizatia magna within the organism or they weaken the pathogen and permit the host to develop a defence mechanism in order to gain premunition. Then applies the above mentioned about premunition.

The main disadvantage, however, is the emergence of resistant strains. Altogether the chemoprophylaxis may be considered only as an emergency or additional measure. An eradication of vector epidemics will not be achieved by these procedures. With regard to the whole strategy it is risky to import susceptible breeding animals which may survive only with the help of permanent chemoprophylaxis. The keeping of races with high performance at tropical places where they need permanent chemoprophylaxis can hardly be considered as a real contribution to the development of that area.

IV.5.2.2.2. Viral and bacterial tropical livestock epidemics of emigrating character the control of which might be effective by immunprophylaxis

The development of effective vaccines and methods for immunization has made enormous progress for most of the known severe bacterial and viral livestock epidemics in the last decades. That is especially true for the contact epidemics such as cattle plague, foot and mouth disease, swine fever, Newcastle disease as well as for the shipping fever and the contagious pleuropneumonia in cattle,and several virus epidemics transmitted through vectors, e.g. Blue tongue, African horse sickness and so on. The following table gives a survey on selected livestock epidemics (table IV.5.3.).

On the basis of effective prophylaxis it is principally possible to control the livestock epidemics named in the table and numerous other infectious diseases. Countries, free of epidemics, focus their activity at the prevention of invasion of epidemics by strickt veterinary legislation.

Disease	Pathogen	Animal species	Natural immunity	Immunoprophylaxis	Immunity after vaccination
cattle plague	Paramyxovirus	domestic and game ruminants, pig	lifelong (if survived)	living vaccines once in the first year(> 3 months) once in the second year	lifelong immunity
Blue tongue	Reovirus, 16 types	sheep (cattle pathogen reservoir)	lifelong against homologic type	tetravalent vaccines from killed tissue culture	tetravalent vaccines 1 year
Haemorrhagic septicaemia	Pasteurella multocida of types B and E (Carter)	cattle	about 1 year	formalin vaccines	well protection effect, if it is repeated every year
Foot and mouth disease	Rhinovirus, 6 types	hoofed animals (different susceptibility)	about 7 months, partly longer, only against homologic type	formol adsorbate vaccines, living vaccines. (esp. pig)	if it is repeated every year, good immunity against homologic type
Pleuropneumonia contagiosa bovum	Mycoplasma mycoides var. mycoides	cattle	stable immunity	weakened living vaccines	1 to 3 years
Agalaxis of sheep and goat	Mycoplasma agalactiae	sheep, goat	solid immunity	In Rumania: formol- or phenoladsorbat vaccines, Recently also living vaccines are applied.	contains for one period of lactation

Table IV.5.3. Survey on selected livestock epidemics

Table (contin.)

Disease	Pathogen	Animal species	Natural immunity	Immunoprophylaxis	Immunity after vaccination
Rift valley fever	Arbovirus not classified yet	sheep cattle	lifelong immunity	neurotrope, weakened in passages in mice living vaccines or inactivated vaccines of cell culture	immunity
Wesselsbron disease	Wesselsbron disease virus	sheep	solid immunity	mostly mixed vaccines together with Rift valley fever virus	immunity
Ephemeral fever	Rhabdovirus	sheep cattle	about 2 years	not yet developed	
Lumpy skin disease (Dermatitis nodularis)	Vaccinia viruses (Allerton virus) and Herpes viruses (Neethling virus)	cattle	immunity for several years	South Africa: weakened tissue passage of Neethling-Virus and in Kenya weakened sheep pox virus is used	

Table IV.5.3. Survey on selected livestock epidemics

In areas that are sporadical or enzootical contamiminated systematical vaccinations have priority. Depending on the epizootiological situation, the character of epidemics, duration and reliabilityof immunity circle vaccinations, area vaccinations, transport vaccinations and other, as well as single and repeated vaccinations are applied. The realization of immunoprophylaxis depends decisively on financial means, on organization and capacity of the veterinary service. As for cattle plague

As for cattle plague the density of vaccinations is inversely proportional to the occurrence of the disease. Figure IV.5.6. shows the relations in India for the time 1957 – 1969.

By systematical area vaccinations of 290 millions heads of cattle the annual number of outbreaks was reduced from 8,000 in 1959 to 396 in 1969. This trend continued in recent years. The vaccination of at least 90 % of susceptible animals from one area leads to an interruption of infectious chains and to a reduction of the epidemic. A single vaccination gives an immunity of at least 8 years, if the animals are older than 3 months. The vaccination given secondly one year later creates a lifelong immunity. These immune animals should be marked for the fast control of immunity conditions in the herd, for instance branding an "P" (for cattle plague) into the hump of zebus.
The realization of area vaccinations in Asia and Africa is a great challenge for the veterinary service of these countries and requires the mobilization and participation of the population. Particular problems arise in countries of East and Central Africa.There some 60 different game species (hoofed animals) are susceptible to cattle plague. The disease persists in game and especially game reserves with a high density of game. One has to expect potential epidemic reservoirs in great natural reserves of East and Central Africa (e.g. Tanzania, Serengeti, Tarangire National Park, Lake Manyare a.o.).

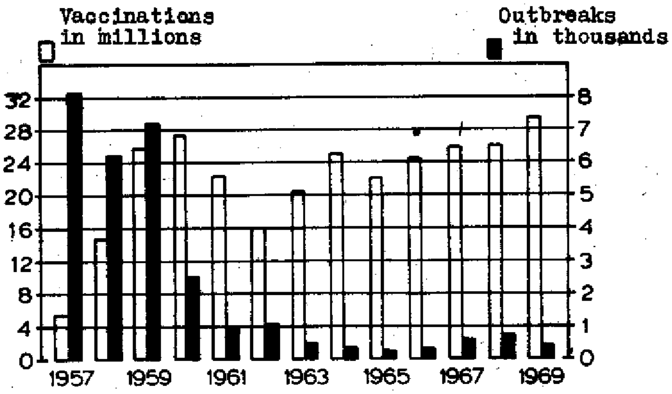


Fig.: IV.5.6. Contol of cattle plague in India (according to NILAKANTAN, 1970)
Vaccinations and outbreaks from 1957 - 1969

For this reason, today ring vaccinations are practised around wildlife reserves in Tanzania, Kenya, Ugunda, Burundi and other. Since the countries have not had any cattle plague from the late sixties (last outbreak in 1967) to the late seventies, it became possible to reduce the diameter of the vaccination ring around the reservations from some 300 km to about 100 km. But in recent years a number of new outbreaks was recorded, what is not only a threat to the animal husbandry of the countries affected but to the international epidemic situation too. The reasons for this are the reduction of the vaccination area, the expansion of animal husbandry, closer contacts with wildlife reserves, increasing density of traffic and trade relations with animals and animal products and other factors. What role tourism plays moreover, could not be clearified exactly. The outbreaks underline that the control and eradication of cattle plague shall find special attention in Africa.

In most of the developed countries with a high standard of animal husbandry foot and mouth disease is controlled by strong veterinary and hygienic measures at the border, and partly in combination with vaccinations in the area in order to keep the territory free of epidemics. In tropical and subtropical countries border control does not meet the security requirements regarding a prevention of invasion of foot and mouth disease. On the other hand there are not enough financial means available for an areal vaccination of susceptible hoofed animals let alone the fact, that here too game form reservoirs of their own and cannot be taken into consideration.

That is why vaccination must be concentrated on potential carrier-ways and mein infectious fields. These are transportation of cattle for commercial purposes, nomadic animal movements, ring vaccinations around wildlife reserves, valuable animals for breeding and performance and so on. Increasing the capacity of the veterinary service, improving the economic situation and increasing animal husbandry should lead to the increase in the share of animals protected by annual vacciantions and more and more reach the status of complete areal vaccination of the whole territory.

As far as virus infections are concerned which are transmitted by Arboviruses (Arthropode borne virus),e.g. Rift valley fever, Wesselsbron disease, Blue tongue, the vaccination follows to natural pathogen reservoirs and the spread of vectors. Several methods are being used which cannot be described here in detail.

Another group of livestock epidemics are the acute and chronical bacterial and viral infectious diseases, the main reservoirs of which are formed by the affected domestic animals themselves. They do not occur as contact epidemics with emigrating character. The occurrence of the epidemic is essentially favoured by so called predisposing factors that reduce the resistance of animals (dry season, hygienic defects, hyperalimentation etc.). To these belong Haemorrhagic Septicaemia, Contagious Pleuropneumonia bovum, tuberculosis, Brucellosis and others. They are controlled by a combination of diagnostic investigation, veterinary legislative orders for isolation of infected livestock and liquidation of infected herds as well as hygienic measures for keeping and immunoprophylactic measures. This means that special control programmes have to be elaborated, considering every epidemic condition in each country. Their realization depends decisively on the level of development in agriculture and on the qualification and capacity of the veterinary service. Numerous infectious diseases become more and more economically important because of an increasing concentration of livestock and development of animal production. The diseases concerned include Bruellosis, Vibriosis and other reproduction diseases, tuberculosis and others. Control should be started only if the level of production and economic possibilities of the countries make this a need. That is not the case with most African and Central American countries. At todays level measures should be concentrated on selected livestock with special importance, especially central breeding livestock as well as herds with a developed animal performance.

IV.5.2.2.3. Soil infections

Soil infections are caused by bacterial pathogens having their reservoir in the soil. They are spornlators of the family Bacillaceae, which are characterized by high resistance and may survive in the soil for centuries. The occurrence of diseases having a high letality is restricted to these districts. The most important are:

Pathogen	Disease	Animal species
Bac. anthracis	Anthrax	mammals
Cl. chauvoei	black leg	cattle, sheep, buffalo
Cl. botulinum	botulism	mammals and birds

Table IV.5.4. Most important soil infections

An ascertainment of potential areas of soil infections is of great importance for the location of agricultural producing units and animal husbandry. The infection of soil results mainly from carcass of dead animals. Therefore the condemnation of the carcasses is an effective method to control anthrax and black leg. Anthrax, black leg and botulism may be effectively controlled through vaccines. The annual vaccination of all susceptible animals in infected areas gives a secure protection from new infections.

Anthrax

Today the disease is common throughout the world although there are great differences between climate zones and soils. In humid, airy soils with a high share of organic substances, with a pH 6 and at temperatures above 20 °C the pathogen may propagate and concentrate before sporogenesis. A number of environmental factors influence the occurrence of Bac. anthracis. The following table gives a survey:

Factor	Effect	
	favouring	hindering
Vegetation	potatoes horse-radish	clover, timothy, ray, garlic
Climate	Epizootics develop mostly after hot and dry periods which follow abnormal precipitations or floods.	
Topographic conditions	moist valleys water beds	agricultural soils, dry areas, (deficit of nutrients and water), mountains
Animal movements		hinder accumulation tion of the pathogen

Table IV.5.5. Environmental factors influencing the occurrence of Bac. anthracis

Because of these characteristics, steppes of temperate latitudes and the subtropics as well as tropical areas with sufficient precipitation offer the most favourable conditions for spreading of anthrax. Tundra and Taiga are too cold, the soil is to poor in protein,too leached and the pH value is too low. The pathogen cannot propagate and accumulate there. Anthrax was transmitted from Europe to America and from Asia with Indian bone meal in 1847 to Australia. In mountainous regions the occurrence of Bac. anthracis is bound to water courses or wells. The same is true for deserts. Because of these geological and veterinary particularities anthrax will become increasingly a typical disease of the tropics and subtropics in the years to come. Simular conditions are true for Cl. chanvoei, whereby the spread areas often overlay. The control of the two diseases is therefore realized with a bivalent vaccine (Blanthrax).

Botulism

The disease is spread as soil infection especially in South Africa, Angola, Mocambique, Australia and South America as well as sometimes in hot summers in the temperate zone too. There are 7 types of toxins (A – G), which, by the way, produce the strongest toxin known. Stationary occurrence develops taken a deficit of minerals or protein forces the animals to lick or nibble the dried-up remains of dead carcasses. The pathogen lives in the digestive tract of those animals who live in enzootically ifected areas. When animals die huge amounts of toxins concentrate under the influence of high temperatures and the nutrient content of the carcass. At the maceration of carcass they will not be destroyed, but dry up and may survive in the environment for weeks and months. A grave danger are dead tortoise, the shell-saved body of which contains a lot of toxin. Just the licking of animals causes lethal intoxinations. The control is successive with annual vaccination of all susceptible animals with toxoid vaccines.
In South Africa and Australia 3 to 4 millions of cattle from infected areas get an annual vaccination. The deficiency symptoms should be corrected by additional feeding of minerals and protein.

IV.5.2.2.4. Unknown epidemics respectively epidemics of which the epizootiology and way of control is not yet cleared-up

The control of the African swine fever causes in European as well as in other countries special problems. The natural spread area lies in the south of 10 degrees latitude north in Africa. In the meanwhile it is stationary on the Iberian Peninsula and caused disastrous epidemics in a number of countries (Cuba, Brazil, Malta, Dominican Republic, a.o.). The pathogen is an iridovirus that is characterized by extreme resistance against alkaline solutions (pH - 13.4), acids (pH - 3.920), proteolytic enzymes as well as in the environment (soil) and even against sunlight. Three African species of wild boar such as wart hog (Phacochoreus aethiophicus), Red river hog (Potamochoerus porcus) and giant wild boar (Hylochoerus meinertzhagen) show clinically inapparent infections. More than 40 % of game are infected. Also the squash tick (Ornithodorus moubata porcinus) is a kind of natural reservoir for African swine fever, in which the pathogen does not only propagate but it is also passed in the saliva. Domestic pigs and European wild boars are very sensitive with a mortality of nearly 100 %. **The immunity, is not yet sufficient studied.** At present immunoprophylactic or therapeutic control methods do not exist. **Therefore, the prevention of an invasion through a strong prohibition of import or transit of pigs and pork from countries with epidemics stands in the centre of control. With regard to foodstuff carried along with passengers or wastes from the galley, international airports and seaports require special attention. Any outbreak in an enzootically not infected** country requires an immediate liquidation of the focus of disease by "stamping out".

The epidemic area is subject to a total ban.
(killing, eradication, desinfection)
A prohibited zone has to be declared for 10 to 15 km round, within which all pigs are to be slaughtered under observation of certain security measures. Wild boars are also subjected to elimination. The prohibited zone shall be under control of guards. Thepassenger traffic shall be totally restricted. Within a radius of 150 km a protected area shall be established. All pigs are subjected to a quarantine and veterinary medical control.

IV.5.2.5. Surveillance of commercial cattle

Examination of commercial cattle from areas with nomadic and seminomadic animal husbandry is a main point in the activity of the veterinary service. The wide spread of dangerous livestock epidemics in the original areas, insufficient information on the health and immunity status of the animals in delivery livestock, the length of transportation ways and the stress of transport increase the danger of spread of infectious diseases. The main task of the veterinary supervision is to prevent animal losses and protect against spread of livestock epidemics. Therefore veterinary control of the commercial cattle is necessary already on the cattle cattle markets regarding their health and to vaccinate them against dangerous infectious diseases just after buying which are enzootically spread in the territory or are potential there. In East Africa animals are vaccinated against foot and mouth disease, quarter ill and anthrax and under certain epizootiological circumstances against Haemorrhagic Septicaemia and cattle plague as well. The inoculation against soil infections became necessary because many of "stock routs", "night stops" and "holding grounds" were infected with quarter ill and anthrax due to an utilization for decades on end. For reasons of epidemic control in in the territory and for the prevention of the danger of epidemic spread through animal products, vaccinations against contact epidemics are being made. The prevention of animal losses requires a permanent diagnostic check of ill or dead animals. This includes the preparation of a blood smear of ill animals and a PM and laboratory-diagnostic study of dead animals. Commercial cattle are transportated "on the hoof" to the loading station or directly to the abbatoir. The daily distance covered should not exceed 6 to 12 miles. Special care should be given to the water supply and sufficient pasture capacity. For this reason it is recommended to go on a treck only within or at the end of the rainy season. One herdsman should be in charge of 200 animals as a maximum. Before the treck starts and on the way the animals should be treated with insecticides (spray race, dip) once in a week. Generally, habitats infected with tsetseflies should be avoided. Otherwise the cattle have to be treated with preparations effective over long periods (Prothidium a.o.). Having reached the holding grounds lying nearby the loading stations, the animals should be kept in quarantine for a fortnight. A veterinary staff should be stationed at the holding grounds controlling the health states. The following minimum requirements and guidelines should be met regarding number, size and equipment of holding grounds:

1. Avoid any contact of animals for trade with herds of local animal keepers
2. Sufficient size of pasture land corresponding to the average density on holding grounds (in East Africa 2 head of cattle per ha)
3. Keeping and pasturing should be decentralized with little herds of 200 animals per herd as a maximum
4. There should be places for the removal of carcass (bury, burn, condemnation of the carcasses) and a boma for ill animals. Ill animals should be selected and isolated.

5. All holding grounds should be equipped with wells for sufficient water supply.
6. **In selecting the area avoid areas with soil infections, mass occurrence of poisoned plants, potential habitats of dangerous ticks and especially areas infected with tsetse flies.**
7. **On the holding grounds sprayraces or dips should be installed.**

8. The veterinary and medical service is **provided by a tech**nical staff stationed on the holding grounds. Ill animals should be diagnostically checked and treated.
9. **Night-bomas should have a fence offering protection against predatory animals if necessary.**
10. The further transportation should be carried out by railway and at night.

IV.5.3. Animal hygiene in the tropics and subtropics from an ecological point of view

IV.5.3.1. Tasks of animal hygiene in the tropics and subtropics

The deficiency of animal protein in human nutrition urges developing countries to improve animal husbandry. Often attempts are made to increase the productivity of indigenous animals or to raise yield of fodder crops. However, from a global point of view this problem cannot be solved by this way alone. In most countries rather complex measures in completely new dimensions are needed. This may often involve a shift from present structures in agriculture and traditional forms of production to modern methods of higher efficiency. Animal breeding, artificial insemination, mineral fertilizers, good supply of soils with humous, cultivation of new, more productive crops and last not least improved health of livestocks are the most decisive factors of intensification of agriculture in developing countries as well.

A fundamental precondition for intensification of animal husbandry in general is the all-year supply with fodder and water. Satisfying results and good health cannot be expected from animals suffering from starvation in the dry season. In many arid and semiarid areas of Africa and Asia, however, natural conditions make it difficult to ensure the permanent fodder supply, so that extensive forms of animal husbandry will have to continue for decades on end.

Animal hygiene is a essential means to improve the health of animals. By animal hygiene we understand all measures taken in order to optimize the environment of animals and to improve their health and performance. In general, animal hygiene in the tropics and subtropics has to deal with the following questions:

- special and general protection against livestock epidemics
- control of parasitoses and their vectors
- hygiene of pastures, including the solution of questions concerning pasture farming
- water hygiene
- reduction of climate stress
- reduction of losses of young animals
- biohygienic safeguarding of genetic programmes, especially the import of semen and artificial insemination
- protection of human health ageinst infections, originating from animals
- meat hygiene to protect human health
- protection of environment and landscape against wastes from animal husbandry and processing plants

Livestock-hygienic measures must always be related to the specific forms and technologies of production of the case in question. That is why they will have a completely different character in intensive animal husbandry than in extensive forms of husbandry. The Sahel zone, savannas and steppes may serve as examples of areas lacking the natural preconditions for intensive animal husbandry and where nomadic and semi-nomadic breeders keep large herds without doing any fodder cropping. There, animal hygiene has the task to shorten stock routes in heat and dust, to ensure sufficient water supply along the stock routes, to assure acarizid treatments (cattle dip) against extremely dangerous disease vectors, to remove carcasses safely and without danger for other herds (anthrax prophylaxis), to safe the health of animals in the craal, etc. A fundamental task is the vaccination against important livestock epidemics, but this is mostly possible only when restriction of the migration of herdsman and their animals is done.

In Africa 54 per cent, in Australia 72 per cent, in Asia 36 per cent of the territory are arid and semi-arid. Here, non-migratory cattle husbandry is possible only in some places. The above mentioned animal hygienic measures are important and will be the dominating ones in a number of countries for decades. However, the following veterinary-hygienic tasks should be given priority in developing countries, intending to apply intensive technologies in animal **husbandry**.

Although, experiences gained in industrialized countries in the hygienic safeguarding of animal husbandry may be helpful to developing countries but they cannot be applied schematically. Intensive animal husbandry in developing countries may require quite different technologies because any animal husbandry system has to follow the given natural conditions. All forms and technologies of husbandry are subject to the climatic type and to the character of vegetation. It is illusive to hope that animals may be kept in air-conditioned stables on a large scale. To an increasing extend animal husbandry in developing countries uses the ranch system. Here, the production with modern technologies is characterized by fodder cropping throughout the year and based on scientific research. Around a number of cities in Africa, Asia and Latinamerica so called "milk belts" and industrial-like poultry farms are found. The following recommendations shall give new ideas from a animal hygienic point of view.

IV.5.3.2. Requirements on location

Appropriate siting of ranches is a major problem in the development of efficient animal husbandry. Any mistake made here is not correctable. The location of the farms determines decisively the cost of production and the quality of the products. It is obvious, that many aspects are significant for farm siting, especially those related to economy, management, social services and health of livestock. Some problems will be considered in detail:

a) In selecting a site for animal husbandry it is recommended to give preference to the vicinity of cities, i.e. centres of consumption, because there is demand and a market for the products and transport is short; roads, energy supply and other services may provided at low costs. On the other hand it is rather easy to process the raw products into a marketable goods nearby the city. The neighbourhood of big cities is especially important for the milk production ("milk belt"). However, it must be kept in mind that the steady supply of fodder from the surrounding territory must be guaranteed. Also poultry farming is favourably established in the neigbourhood of cities. The fodder (seed and animal protein) may be more easily transported over longer distances. On the other hand meat may be produced far away from cities because it can be transported over long distances too, a functioning traffic net provided. These aspects should be considered when national strategies for the supply with animal protein are devised. From this follows that extensive nomadical and seminomadical animal husbandry as it is practised in many countries should serve the supply with meat, while milk production of cities on the other hand requires intensive forms of husbandry, including processing dairies.

b) Among natural preconditions for intensive forms of husbandry sufficient fodder and water supply are essentials. There is a need for an all-year supply with fodder of high nutritive value. Malnutrition results in a reduction of performance and growing risk of diseases and questions the profitability of intensive livestock farming. In countries with dry seasons irrigation may be necessary. Fodder storage stored for periods poor in vegetation. Fodder storage is traditionally not known in many developing countries although it is possible in principle. New strategies under governmental control may achieve changes in this field. Such strategies have to include crop farming schemes in order to determine which crops and grasses may be sucessfully cultivated under respective climate and soil conditions in the respective region. A general aim should always be a balanced ration between number of animals and amount of fodder available in order to avoid overstocking. Cuba, for example, elaborated an outstanding example of such a fodder strategy.

The preservation of fodder in tropical and subtropical countries is possible. Haymaking, however, may become a problem in countries with high air-humidity. But also under these conditions it is possible to produce silages of high quality. The quality of water for drinking purposes and related problems will be discussed further below.

c) Requirements on climate

By climate we understand meteorological factors prevailing at a given place for a longer period, like temperature, humidity, air velocity, and in a wider sense air quality.

Climatic factors belong to the most important environmental factors with regard to domestic animals. As homoekilotherme animals they permanently regulate their body temperature on a certain level independently from the ambient temperature. Out of the mentioned factors the ambient temperature is the most important one. Humidity and air velocity may have an influence on the effect of ambient temperature upon well-being, productivity and health of domestic animals. Thus, high air velocity with high ambient temperature(but still below the body temperature) facilitates the thermolysis of animals and this way the regulation of temperature. Domestic animals emit surplus heat by heat exchange between skin and environment (radiation, convection) or by transpiration of water. Cattle, horses and other domestic animals have sudoriferous glands; pigs and dogs transpirate water by panting. Spraying with water (water buffalo, certain species of game) has the same effect. By evaporating one litre of water via the skin the body looses a quantity of energy of about 2,400 kj (what euqals about 580 kcal).

The intensity of transpiration is higher in case of low air humidity, thus making the heat exchange easier.

With high air velocity (max. 6 m/sec) and low air humidity the animals may better stand high ambient temperatures.

Thermoregulation consumes a lot of energy which is lost to the productivity of animals (meat, milk). If the thermoregulation of animals is overstrained, they reduce the digestion of food in order not to produce too much heat what results in less produce. Developing countries are situated in different climate zones of the globe and even within one country several climates may be found. Another important factor is the altitude.
Table IV.5. 6. gives a survey on the climatic zones of the earth.

Zone	Climate type	Earth's surface in per cent
Tropical rain climates	1. Tropical rain forest	23.0
	2. Savanna	13.1
Dry climates	3. Steppes	6.7
	4. Deserts	3.9
Warm temperate rain climate	5. Warm and winter dry climates	2.5
	6. Warm summer dry climates	2.6
	7. Humid temperate climates	23.1
Boreal or snow-forest-climates	8. Winter dry cold climates	1.5
	9. Winter humid cold climates	5.8
	10. Tundra climates	13.4
Snow climates	11. Climate of permafrost	5.4

Table IV.5. 6. Climatic zones of the earth

Explanations:

1. Climate of tropical rain forests with an annual rainfall of more than 150 cm; monthly mean temperature more than 18 °C; bush vegetation, tallest trees.
2. Climate of savanna with periodic draughts in winter or summer, savanna with evergreen woody plants.
3. Climate of steppes, annual rainfall on average 300 mm; grass steppe, partly with shrub.
4. Climate of deserts, annual rainfall on average 250 mm; dry and hot, strong daily change of temperature, almost no rainfall, after rain: grass and short-living shrubs.
5. Temperate warm climate with dry winter, maritime climate, Mediterranean climate.
6. like 5, but with wet winter and dry summer. Climate of China and the Mediterranean coast.
7. like 5, but with regular annual rainfall (GDR, France, England).
8. Boreal (i.e. northern, because it occurs only on the Northern hemisphere) climate with dry winter; climate of forests and snow, Transbaikalian climate.
9. Boreal climate with levelled humidity, climate of cold and humid winter, climate of forests and snow, Russian-Canadian climate.
10. Climate of Tundra, daily mean temperature in the warmest month less than 10 °C, treeless.
11. Cold coast of the polar zone, permanent frost, daily mean temperature less than 0 °C, plantless.

The above shortly described and therefore simplified relations between climate and animal performance have great influence on the siting of farms or ranches and on the setting-up of stables in warm countries. The most favourable locations there are the highlands, because the annual average temperatures are similar to those of temperate climates and the air humidity is low. Such locations are rather limited and missing in some countries. In these cases preference is given to mountain tops or locations near the sea, the natural flow of air is used. Valleys should be avoided. The animals may stand high temperatures better, if there are shadow-rooves or properly built stables. Spraying of animals, for example water buffalos, may increase the evaporative heat exchange of those animals that cannot sweat.

In countries with high ambient temperatures only native races adapted to the climate can be kept. Attemps are made to improve them genetically by cross-breeding with top performance animals. However, the keeping of races with high performance originating from temperate climate zones is impossible here. That is especially true for cattle that adapt well and have a high performance only where annual mean temperatures do not exceed 18 to 21 °C (max.). In case of Sri Lanka such conditions exist only at altitudes above 1,500 m, which areas are a mere per cent of the territory. Races from temperate climatic zones tolerate heat differently. The best tolerance to heat is shown by Jersey cattle. Also Frisian cattle and Brown-swiss cattle have relatively tolerance values. For domestic animals originating from temperate climatic zones the climate norms of the GDR may be taken as a guidline. (see Table IV.5. 7.).

	productive 2) temperature range, lower temp. limit	optimum 1) temperature range	productive 2) temperature range, upper temp. limit
Calf to 3. week	13	15 - 24	28
from 3. week	8	12 - 24	28
from 10. week	5	10 - 24	28
Young cattle, beef cattle	5	5 - 20	28
Cow	5	5 - 20	28
Sow with piglets	15	15 - 21	28
Piglets 1. week	28	30 - 33	35
2. week	26	28 - 30	35
3. week	22	26 - 28	33
4. week	22	24 - 26	33
5. - 8. week	20	22 - 25	31
9. -15. week	18	20 - 25	31
Fattening store and breeding pig			
35 - 70 kg	10	18 - 25	28
70 -120 kg	5	16 - 25	28
Breeding and young sow	5	12 - 25	28
Breeding boar young boar	5	12 - 25	28

Table IV.5.7. Climate standards for high performance livestock from temperate climates (in °C) (according to GDR-TGL 29084)

1) Optimum temperature range: Range of ambient temperature in which best performances can be expected

2) Productive temperature range: Range of ambient temperature in which animals have performances below the optimum but allow economic livestock farming

d) Requirements to the quality of air

Today, in the industrialized countries the prevention of air pollution caused by industry is of great importance for the health of human beings and animals. In setting-up farms in the vicinity of cities this problem should be considered in developing countries too, as industrial plants emitting harmful gas or dust always pose a risk if they are placed in the neighbourhood of stables. Consequently the siting of both animal farms and of polluting industries should be coordinated. The most frequent pollutants emitted by industry are shown in Table IV.5.8. (FENSKE, 19).

Domestic animals may take-up noxious substances from industrial pollution by breathing in contaminated air or with the fodder. The taking-up via the alimentary tract plays a dominant role as fodder crops are influenced by air pollution in different ways. Some substances are taken-up by the plants directly from the air as it is the case with sulphur dioxid and in particular with fluor. Secondly, pollutants may be taken-up by crops from the soil, which they enter by sedimentation or wash out from the atmosphere. Thirdly, air pollutions may be deposited on the surface of crops. Air-borne dusts from metallurgical plants contain often toxic elements such as arsenic, molybden, lead, cadmium and other heavy metals (Table IV.5.9.).

Three forms injury to animals through air can be distinguished:

- poisoning
- disturbances of the metabolism by trace elements
- and influences based on mechanical, physical or chemical processes.

Most notorious are poisoning by fluor, arsenic, lead, copper and other elements in the vicinity of relevant industries. In general these are chronic forms of poisoning because the concentration of the pollutants in the fodder is not high enough to cause acute poisoning. Especially cattle and sometimes sheeps and horses are affected, all being animals that graze on air polluted pastures all year. Effects of air pollutions on the nutrient balance are

Plant, factory	Emitted substances
Power industry:	dust, SO_2, CO, CO_2, HF
. power stations	hydrocarbons, odours
Chemical industry producing:	
. halogens	HCl, Cl_2
. sulphur and sulphur compounds	SO_2
. synthetics	styroles, aldehydes, HCl
. oil refining	SO_2, hydrocarbons, aldehydes, ketones, amines, NO
. viscose, synthetics, plastics, rayon	H_2S
. fertilizers, phosphates	HF, SiF_4
Metal producing and manufacturing industry:	
. iron and steel industry (furnaces, foundaries)	As, Cd
. non-ferric metals (lead, zinc, copper)	As, Cd, Cu, Pb, Zn
. aluminium plants	HF
Construction materials:	
. concrete plant	silicate containing dust, sulphate
. brickyards, porcelain manufacturing	HF, SO_2, Cl_2
Agriculture and food industries:	
. livestock farming	hydrocarbons, odours
. abattoirs, knackeries	amines

Table IV.5.8.: Sources of air pollution and ground deposition

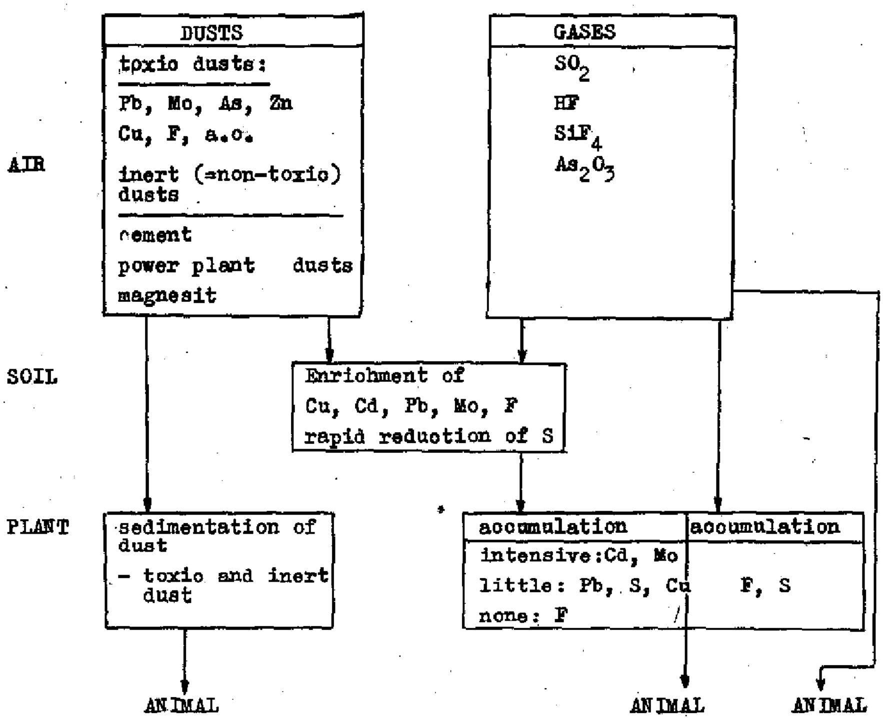


Table IV.5.9.: Injury to domestic animals caused by air pollution less known but gained much in importance in industrialized countries. Most frequently it is an influence on the copper metabolism by elements such as molybden, cadmium, zinc, sulphur, calcium. Antagonistic effects cause hereby more or less great deficiency of copper in the organism, despite of the fact that the fodder contains enough copper. That is why it is a secondary deficiency of copper. Typical copper deficiency diseases as the enzootic alaxia of lambs may occur. Often non-specific forms of this disease occur so that it is hard to detect them. The complicate genesis of copper deficiency cannot be discussed in detail here. This damage caused by air pollution is wide-spread in industrialized countries because it is caused first of all by flue gas from power stations and burning of coal. Burning of fossile fuels is accompanied by emissions of dioxide and dust which contains many elements acting antagonistically with copper in organisms.

The demand for a reduction of air pollution stands in the centre of all activities taken for the diminishing of damages caused by airborne noxious substances. Farms for animal husbandry should be established at least 10 km away from industrial plants in a leeward direction. To a certain degree the danger of copper deficiency is met by additional feeding of copper.

IV.5.3.3. Water hygiene in the tropics and subtropics

In many regions of the tropics and subtropics water is the limitating factor for animal husbandry. That is especially true during the dry season. Quite often animals die of thirst in this time or the water has to be rationed to quantities hardly enough to maintain the vital functions. The quality of the water supplied to animals is very often extremely bad. During continuing droughts water is polluted by anorganic elements and organic pollution of soil. The more herds come to water places the greater is the risk of spreading livestock diseases, especially when animals have a bad constitution at the end of drought periods. Under these circomstances high performances are not to be ecpected (milk, growth). Intensive animal husbandry requires sufficient and permanent supply with water of a good quality.

The amount of water needed for animals depends on age and species and differs in hot and dry and humid warm climates. In warm countries cattle drink above all, right after sunrise and short before sunset. Cattle need 30 - 40 l water in arid and semi-arid regions - under extensive keeping without night-pasture at high temperatures (up to 50°C) even more. Sheep and goats need 3 - 4 l daily, lactating animals one litre more. Young pigs drink some 4 l daily, sows with piglets need 15 - 20 l. The water supply in farms differs from that in extensive animal husbandry. Farms often have wells and a water supply system provides water in sufficient quantities (deep wells and reservoirs). If farms are combined with pasture farming, the hygiene of watering places on pastures calles for special attention. Pastures not subdivided into grazing lots should have several watering places. The watering bassins or troughs should be roofed in order to prevent sunlight and at the same time growing of algae. An iron bar placed right above the trough hinders the animals to step into the water or to bathe. All watery places artificial as well as natural ones should be safeguarded by a strong iron fence to keep wild game off. The water should be pumped into watering bassins and troughs, out of which the animals may drink. Deep wells generally supply hygienically acceptable water. Filtration through soil layers ensures that the water pumped from deep wells is free of noxious chemicals and pathogenic organisms, especially bacteria, viruses and parasites. Often drillings must be rather deep to find water requiring special drilling equipment causing high costs. Farmers are often not able to raise the money, so that this is a worthwhile task for government programmes and development projects as demonstrated in India in the 1960.

In contrast to the supply of water from deep wells, the watering of animals from surface water sources is usually risky from the hygienic point of view. Apart from the disadvantages, mentioned at the beginning there is an extreme danger that the water is contaminated with pathogens and thus the health of animals is threatened. Problems regarding water hygiene arise first of all at watering places used by herds of peasants and nomads. In most cases they depend on natural watering places such as rivers and ponds. The banks are scattered with hoof prints and muddy; game uses the same water place (danger of livestock epidemics) and in the dry season they become shallow, muddy pools. An improvement of this condition may be achieved by two ways:

1. Establishing artificial water places (deep well, etc.) with hygienically acceptable water.
2. Reconstruction of water places.

This involves first of all the stabilization of the banks and building of barriers, hindering the animals to step into the water. Additionally the above mentioned facilities (fence, roof, etc.) should be erected, if possible.

IV.5.3.4. Environmental problems caused by wastes of animal husbandry and processing plants

Wastes of animal husbandry are:

- animal faeces such as manure (dung), liquid manure
- stale air from stables
- waste water from animal production units (farms)
- carcasses and parts of them

Animal faeces occur usually in form of manure and liquid manure. While in industrialized countries animal faeces are used for fertilization of fields, it is different in many developing countries. Here, the dung is often dried and used asfuel for cooking because of the shortage of fuel wood as a consequence of a deforestation in the past (with sometimes dreadful ecological results, soil erosion, etc.) and the poverty of the rural population.

This is the more regrettable as especially under tropical and subtropical conditions manure is urgently needed to improve the humus supply of soils, because the decomposition of humus is very fast in countries of warmer climate. The nutrient supply of soils is also insufficient and might be improved by using animal faeces, particularly since mineral fertilizers are often too expensive for the peasants. The daily amount of excrements is given in Table IV.5.10.

In industrialized countries an increasing amount of liquid manure occurs in the installations of intensive livestock farming where the animals stand on gratings without litter bedding. The excrements pass through the gratings into canals below, the liquid by gravity flow and the manure by the movement of the animals. This technology of animal keeping is very economical because there is no need for manual removal of dung. However, it is not recommendable to developing countries for the following reasons:

- In contrast to industrialized countries, developing countries are not short of labour, so that there is little need for a special liquid manure technology.
- This technology requires huge storage capacities (tanks). Since it is impossible to manure most crops during the vegetation period, liquid manure has to be collected and stored for months.
- Fertilization with liquid manure is more difficult and risky than dung-fertilization, expenses are high and special vehicles are needed;
- Pathogens of livestock epidemics retain their virulence in liquid manure for a long time (in warm climate up to 100 days, anthrax even longer). While they may be killed easyly in dung, infectious bacteria may be eliminated in liquid manure by disinfection only, what is very expensive, requires special equipments and disinfectants.

From the dangers to health and the ecological problems that arise for man and environment from animal husbandry wastes, the following shall be discussed:

Animal species and age	Urine (kg/animal/day)	faeces (kg/animal/day)
Calf, younger than 3 months	3.5 - 5.0	3 - 5
Calf, 1/2 up to 1 year	5.0 - 8.0	10
young cattle 1 - 2 years	8.0 -10.0	20
cattle, older than 2 years	15.0 -20.0	25
cows (lactating)	20.0	20- 28
young pigs (up to 35 kg)	2.0	0.7
fattening pig	2.0 - 2.5	2.5 - 3.0
sows (pregnant)	1.6	2.5 - 3.0
sheep	1 - 2.0	2.0
poultry		0.175 - 0.2
horse	3 - 10.0	30

Table IV.5.10.: Daily amount of faecals and urine (without straw layers)
(according to MEHLHORN, 1979)

1. Depending on the presence of epidemics in the herds, all waste from animal husbandry may contain more or less pathogens which may become dangerous for other herds or even human beings. (Salmonellosis, brucellosis, tuberculosis, leptospirosis, anthrax, etc.). All these pathogens may stay alive in waste (liquid manure, dung) for a relatively long time. For example, pathogens of tuberculosis and brucellae may survive in warm climates for months, anthrax bacilli even for years. There should always be taken care that any contact of other animals, human beings, fodder, water and foodstuff with the waste is avoided. All countries have pertinent hygienic norms or even legal regulations to this end. If these are followed the risk is relatively small. On the other hand, many cases of infection through foodstuff, drinking water, soil and after floods show that any violation of these hygienic rules may result in severe diseases and casualties among people and animals.

2. The inappropriate disposal of waste may cause an environmental pollution. The discharge of liquid manure and dung into ponds, lakes and rivers and other surface waters must be condemned. The high nutrient content and the great amounts of organic substances often overstress the biological self-purification capacity of water, so that the ecological balance of waters is finally severely disrupted. The consequences are eutrophication of waters, mass-growth of algae, turbidity, silting etc. especially in warm climates. The persistance of pathogens in water is very high, they often loose their infectious nature only after several weeks or months. Contaminated surface waters, especially flowing water bodies (streams, rivers) may bring infections over great distances to herds (watering places at the river, fodder) or human beings (bathing, drinking water from rivers).

   The disposal of waste from animal husbandry on agricultural land is not only an essential precondition for intensive fodder and grain production (supply with humus, fertilizing), from an ecological point of view it is the best, respectively the only possibility for recycling farming. The biological capacity of soil, especially cultivated soil, is much higher than that of water. One gram of soil contains millions to milliards of microorganisms and microbes; the physical and chemical properties of soil, such as buffer action, sorption capacity, filtration effects, make soil ecologically efficient regarding the chargeability with foreign matter. The bacteria of the soil are adapted to the specific nutrient and humidity conditions of the soil whereas pathogens in the soil encounter ecological competition of soil microorganisms. They find little nutrients; propagation is hardly possible; and very soon they are killed by metabolites of soil microorganisms and by the unfavourable physical and chemical millieu. Under normal conditions, i.e. medium size of the production unit, a good coordination of crop and livestock farming and observation of hygienic norms and regulations environmental problems by wastes from animal husbandry will not occur. The following points should be considered:

- Wastes should not be stored over long periods to avoid loss of nutrients and odour problems due to microbiological processes and a concentration and propagation of disease vectors and rodents (esp. rats)
- Safe storage capacity has to be provided. Dung should be stored on concrete surfaces (2 – 4 m^3 per animal) with a pit below to collect percolating liquid; liquid manure is to be stored (1 m^3 per big animal) closed drainless pits. The storage of liquid manure from intensive livestock farms requires to establish sufficiently large tanks with pumping stations.
- In the application of animal waste on fields hygienic rules must be observed. Dung or manure should be spread on harvested fields only. Liquid manure must not be brought on fields with vegetables during the vegetation period, potatoes after blossoming, grain after shooting, fruits growing close to the earth (e.g. strawberries), and all areas with fodder plants only up to 21 days before harvesting or pasturing. A distance of 10 to 50 m should be kept from surface waters (depending on the gradient of the slope).

- Discharge of wastes into surface waters is an elementary violation of ecological principles. Only waste water from animal husbandry (from housholds and plants a.o.) may be discharged into rivers, depending on pollution and load capacity of the recipient, and as a rule it must at least be mechanically cleared but biologically is desirable too.
- Spreading animal wastes on soil requires drinking water protection. A certain distance (as a rule at least 20 m) from wells is to be kept, pits for liquid manure must be built at the lowest point of the farm, wells on the other hand on the highest point. Construction of wells must be in line with hygienic rules (e.g. dug wells must be covered, the area around wells must be paved, etc.). At places, where drinking water for large cities is extracted, special hygienic precautions must be taken, for which every country has its own detailled rules. If these rules and other principles are observed wastes from animal husbandry may be spread on fields without prior treatment.

In case livestock epidemics break-out animal wastes must be decontaminated. Liquid manure has to be disinfected. Dung heats itself, if it is piled loosely, i.e. accessible to air, because the aerobic decomposition of organic substance releases heat, so that temperatures of 65 °C up to 70 °C may be reached. At these temperatures, most of the pathogens of livestock epidemics (exept anthrax spores) die within some days.
While dung and liquid manure are the most relevant wastes from animal husbandry, there are generally little problems with waste air of stables under conditions of developing countries. Waste air from livestock farms contains:
- microorganisms originating from animals,
- certain noxious gases as NH_3 and H_2S,
- odours.

Microorganisms may occur in the air around stables and be transmitted by air over certain distances, but as a rule no danger for human beings arises. Animals from neighbouring stables, however, may be infected via the air. Germs are occasionally found in distances of 0.1 up to 1.0 km away. Long-range transport, sedimentation and dying-off reduce their number so that infections are very rare. Among noxious gases ammonia (NH_3) is environmentally relevant. In dependence on its concentration in the air there will ba a danger to the environment. Ammonia acts acidic on plants and causes necroses at the needles of coniferous trees if certain threshold values are exceeded. In the very close neighbourhood of large stables (so called industrially producing units), a zone (about 100 - 200 m) in which the forest dies off can be found. This problem is mainly restricted to industrialized countries of Europe and of the North, because only there such great concentrations of animals at one place were established.and the indigenous pine and other coniferous trees are especially susceptible to this gas.

The substances causing the odours from animal husbandry are well known. These are gases that result from the anaerobic decomposition of faecal matters, urine and other organic substances. Recent research discovered the nature of these substances. First of all, these are ammonia, indol, skatol, carboxylic acid, esp. butyric acid and valeric acid, mercaptanes, hydrogen sulphide, disulphide, aldehyde and amine (Table IV.5.1.). The intensity of smell depends on the number of animals, on the clearing-up technology, on the management of and on the hygiene in the stable. In Europe, where the majority of the environmentally conscious population has no professional or other relation to animal husbandry, many complain about the nuisance by odours although there will be no harm to the health and is related to the psyche.

Carcasses and parts of them are found in every animal husbandry unit. If a livestock epidemic breaks out there may be dead animals in large quantities. The environement is then threatened by: putretaction of dead animals producing a bad smell, the danger of spreading livestock epidemics (direct contact, soil, water) and

Substance	Odorous threshold (ppm (v/r))
ammonia	5.0
monomethylamine	0.02
dimethylamine	0.05
trimethylamine	0.0002
skatole	0.0004
acetic acid	1.0
butyric acid	0.001
formaldehyde	1.0
hydrogen sulphide	0.005
methyl mercaptan	0.002
ethyl mercaptan	0.001
dimethyl sulphid	0.001

Table IV.5.11.: Substances of stable odours and their threshold values (according to MEHLHORN, 1979) occasionally infection of human beings (e.g. anthrax). Dead animals and parts of them must therefore be removed and not left to vultures, hyenas and other carrion eaters, as it is done in many countries.

Safe methods of disposal are:
- burning
- burying
- processing in condemnation units

Fuels for the burning may be oil or petroleum, the quantity needed for one large animal is up to 250 l. This method is expensive and should be applied in cases of dangerous livestock epidemics (anthrax). Burying is often the only possibility; it should be done so that:
- pollution of groundwater is impossible (in 2 m depth no water should be found)
- the carcasse is covered by at least 1 m of earth
- deep cuts are applied to the skin
- the body of the animal is covered with chlorinated lime (esp. in case of acute livestock epidemics)

Animals should never be buried on agricultural fields, in water catchment areas or near stock routes. An alternative method is the disposal and processing of carcasses at condemnation units. To operate at reasonable costs such plants require a permanently high supply with raw material, i.e. intensive animal husbandry in the whole territory. In developing countries great abattoirs in large cities should be combined with condemnation units for carcasses. Only thus environmental problems may be avoided.
Apart from this, it is possible to produce highly valuable animal protein for feeding of pigs and poultry (bone meal, blood meal).
A condemnation unit for carcasses should meet the following requirements:
- plain, open area with a low groundwater level
- distance to human settlements at least 1 km on the leeside in the main wind direction (odours)

- good traffic and transport conditions, esp. roads
- sufficient water supply (standard value 10 - 30 m^3 water per 1,000 kg of processing material)
- the entrance of the condemnation unit must be equipped with a disinfection dip
- the technology of processing must be technically safe and the carcasses must be heated up to 130 °C for 30 min
- The management of a condemnation unit for carcasses is subject to very special and hygienic requirements, which cannot be described here.
- Effluents from condemnation units must be sterilized. They have to be heated up to 110 °C for 20 min. After this the waste water has to be treated mechanically and biologically, Thus, BOD_5 is intensively reduced. Only after treatment it may be discharged into a water body.

Environmental problems of processing plants

Processing plants for animal produce (e.g. dairy, abattoirs and tanneries) may have similar environment impact but on a lower degree as condemnation units for carcasses do (Table IV.512.). These plants have a high water demand what must be considered when siting. Therefrom results a high volume of sewage. Effluents from abattoirs and dairies may occasionally contain pathogens of livestock epidemics. They usually contain worm eggs and other forms of parasites. A thermic treatment (sterilization) or disinfection with chemicals is necessary only for abattoirs that slaughter infected animals (so called "sanitary abattoirs"). Mechanical and biological sewage treatment is sufficient for other plants, as these kinds of treatment may reduce the number of possible pathogens in the sewage, esp. worm eggs, considerably (Table IV.5.12) At the above mentioned processing plants, the most important environmental problem is the decomposition of organic substances and pollutants contained in sew sewage.

Plant/animal species	Unit	Equivalent of inhabitants 1)
dairy, without cheese dairy	per 1,000 l milk	25 - 70
dairy, with cheese dairy	per 1,000 l milk	45 - 230
abattoir	per 1 cattle= 2.5 pigs	20 - 200
	per 1 t live weight	130 - 400
cow-house	per 1 cow	5 - 10
pigsty	per 1 pig	3
poultry farm	per 1 hen	0.12 - 0.25
ensilage of fodder	per 1 t of ensilated fodder	200 - 650
tannery	per 1 t hide	1.000 - 3.500
wool-scouring plant	per 1 t wool	2.000 - 4.500
runned out mineral oil	per 1 t oil	11.000

Table IV.5.12.: Organic charge (oxygen demand) of waste water from animal husbandry and processing plants (according to IMHOFF, 1979)

1) 1 equivalent of inhabitants = average BOD_5 of alloted amount of waste water to 1 inhabitant (in Europe and America about 60 g/day)

Productivity of treatment methods	BOD	Reduction in per cent floating matter	bacteria
1. fine sieve	5 - 10	5 - 20	10 - 20
2. chlorination of raw water or sedimented waste water	15 - 30		90 - 95
3. sedimentation tank	25 - 40	40 - 70	25 - 75
4. flocculation tank	40 - 50	50 - 70	
5. chemical precipitation tank	50 - 85	70 - 90	40 - 80
6. high-rate trickling filter	65 - 90	65 - 92	70 - 90
7. low-rate trickling filter	80 - 95	70 - 92	90 - 95
8. high-rate activated sludge process	50 - 75	80	70 - 90
9. low-rate activated sludge process	85 - 95	85 - 95	90 - 98
10. soil filter	90 - 95	85 - 95	95 - 98
11. chlorination of biologically purificated waste water			98 - 99

Table IV.5.13.: Productivity of waste water treatment methods (according to IMHOFF, 1979)

Effluents from abattoirs and dairies have a BOD_5 of 1.500 up to 6.000 mg/l. These concentrations must not be introduced into receiving water, especially in case of large plants. The self-purifying capacity of surface water is mostly not sufficient to decompose such heavy organic pollutions. But this depends on the volume of sewage, the total pollution load (cities, other plants) and on the quality of receiving water. The degree of treatment of dairy or abttoir effluents must be determined on a case-to-case basis depending on the respective conditions.

In Europe hygienic and water authorities demand that all purification plants reduce the BOD_5 load to 20 - 50 mg/l O_2.
Since urbanization and industrialization rapidly advance in developing countries similar problems and requirements become quite acute there too, when processing plants for animal produce are established. Suitable effluent treatment processes are mechanical (sedimentation tank, grease trap) and biological (trickling filter, activated sludge process, sewage oxydation and stabilization and fish ponds) as shown in Table IV.5.[13].
Where local conditions permit it, waste water may be introduced into the sewer system for subsequent treatment in municipal treatment plants. In exceptional cases agricultural utilization of mechanically pretreated effluents from dairies, abattoirs, tanneries or rendering plants may be recommended. The treatment processes are described in another volume (subject VI) of the study material.

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