SECTION 3

The 1986 Symposium on COMPUTERS, ELECTRONICS AND CONTROL ENGINEERING IN AGRICULTURE

Feeding and management of dairy cows for efficient production and good health

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Summary
When talking about the use of computers and electronics in dairy production in the Nordic countries - particularly the Scandinavian - it should be con sidered the sometimes very special conditions which exist, e.g. majority of small herds and tied-up cows, long indoor feeding season, limited possibility for feed production, but comparatively intensive systems with very high producing cows. Thus, adoption of systems developed under other conditions may be limited to principles, sometimes even for systems aimed for larger free stall units.

The dairy farmer has a need for both long and short term feed and management planning. The long term planning must cover at least a feeding season, while the short term is a planning for the nearest future, often shorter than a month. The daily advice, regulation and control of feeding and management requires certain attention.

The long term feed planning requires herd-specific data about feed quality and quantity available for the feeding season, calving pattern and the goal for the herd with regard to produciton level. Computer programmes for the prediction must contain general knowledge about lactation curves and feed imput/milk output relationships. This type of planning can use fairly general programmes.

The emphesis to develop systems for the daily regulation and control through electronics must to a great extend consider the specific management conditions, which are applicable for each type of herds.

There exist many possibile feeding systems for dairy cows, but they will influence on milk production level, feed efficiency and also the health of the animals. In general the high producing cows require special attention during the first

part of lactation. Daily variation in concentrate allotment of ± 15% has proved to reduce the production by apr. 5%. Control of roughage intake is particularly important in feeding regimes with minimum amount of structural feeds. During later stage of lactation the amount of feed must be limited to avoid low efficiency, fat cows, calving disturbances and low feed intake during the successive lactation. Although individual feeding will result in the best feed efficiency and care of the animals, it might not be possible and feasable in bigger units.

Besides tools for daily registration and control of feed intake, milk yield etz, great attention has been given the possibilities to register the health conditions fo the cows, like body or milk temperature for health or heat check, conductivity fo the milk for early detection of mastitits etz. So far the attempt have not been particularly sucessful, but it seems quite likely that future development of analyses technic will make it possible to use the "milk profile" as indication of the conditions of the cows.

Herd size and management systems

The dairy farming in Scandinavian countries is dominated by the so called family farms, which means comparatively small units managed by the owner or the owners' family. As in most other Western-European countries there is a slight overproduction of milk. The total production is controlled by quota systems.

When looking into the future, the number of small herds (up to nine cows) is expected to be still more reduced, at least in Sweden. In Table 1 is given the numbers and sizes of dairy herds as by 1971 and 1985 and the most likely figures for the years 2000 and 2010.

In Norway and Finland the situation with regard to herd size is similar while the units in Denmark are bigger.

Table 1. Number of herds and dairy cows per herd in 1971 and 1985 and prediction for 2000 and 2010 to supply the domestic demand of dairy products. Sweden.

Herd size	Year			
cows/herd	1971	1985	2000	2010
1 - 9	59,900	9,700	1,000	500
10 - 24	22,700	17,000	7,000	4,500
15 - 49	2,400	7,100	9,700	9,500
50 -	500	1,200	1,400	1,500
No of herds	85,500	35,000	20,000	16,000
No of cows	687,00	648,000	550,000	500,000

Source Oscarsson, G. 1986

At present the number of cows in loose housing systems is very small in Sweden, or apr. 2 percent. This is expected to increase if good systems will be available also for 20-40 cows units, but it will take very long time before it will become the predominant system. The milk yield per cow is expected to increase by apr. 75 kg per year, from today an overall mean of 6000 kg to apr. 7000 kg year 2000.

Feed planning

The dairy farmer has to make plans for the feed supply both for the long and short term.

The **long term** planning covers primarily the indoor feeding season, lasting for 7-10 months of the year, if pasture is used during the summer. It is neccessary to have a good estimate (dry matter, energy, protein) of roughage available in various lots, as will as herd specific data, like calving pattern, and age and size of the cows. It is also neccessary to know the production goal (e.g. if the farmer wants 5000 kg. 7000 kg or higher milk yield per cows per year) as well as having standard figures for lactation curves and general relationship for feed intake/milk output, substitution rates etz for various feeds.

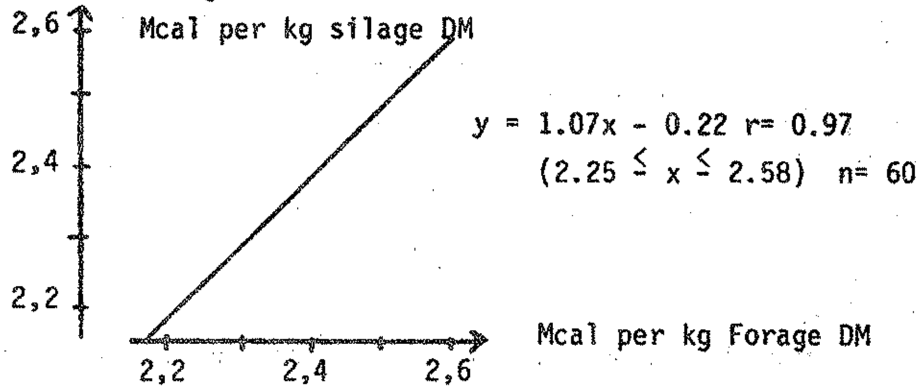
This type of computerized planning is at present organized in Sweden through the Swedish Association for Livestock Breeding and Production (SHS). The over all goal with such a planning is to get a better view of the use of available feed and enough for the whole feeding period.

Short term planning covers as a rule the coming 2-4 weeks feeding period . At present this type of planning is in Sweden primarily organized in cooperation with the milk recording sceeme (SHS) with on-the-farm recording of milk yield, milk sampling, information of available feeds (amount and nutritive value). All this information is sent to the milk recording centre for analysis and processed through computer. A list with recommended feed ration for individual cows are sent back to the farmer within a few days.

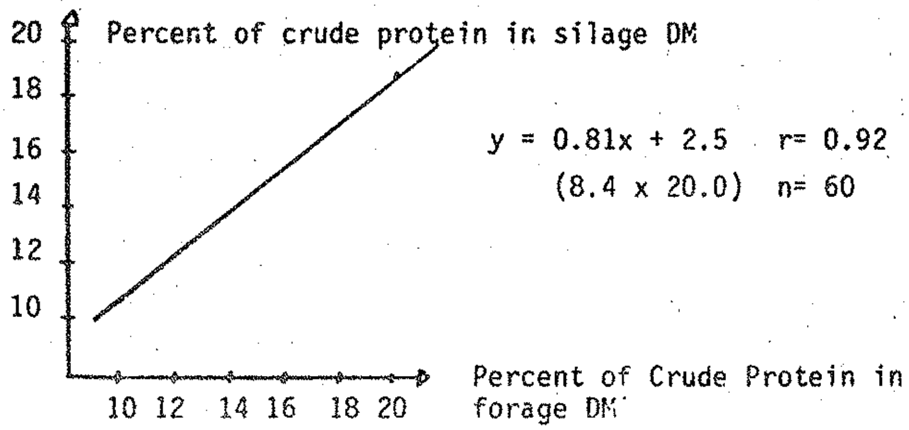
It is also possible to be on line via telephone with the computer centre to get a up-to-date feeding list.

Information about the quality of the roughage which will be used during the comming period is either based on analysis of samples taken at the time of storing (preservation or drying) or samples taken a couple of weeks ahead of the feeding time.

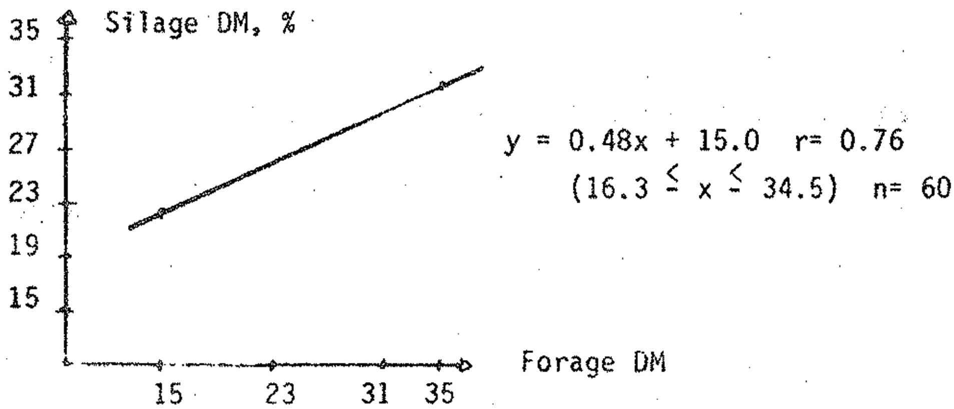
Figur 1. Relationship between energy content in green forage and silage.



Figur 2. Relationship between crude protein content in forage and silage.



Figur 3. Relationship between dry matter (DM) content in forage and silage.



Source Lingvall, P. 1975.

Both ways of sampling have certain difficulties. Sampling and analysis of the roughage at the time of storing seems to be releant for energy and protein determination, but of less accuraceness for dry matter content (Figures 1-3).

Of special interest to discuss in connection to this type of planning is the frequencies of milk recording and sampling, feed analysis, and of course the principles for ration composition, and nutritional supply as well as amounts of roughage and concentrate in different stages of lactation, e.g. flat rate feeding, lead feeding etz.

Daily herd control

Most attention has been given the daily feeding advice, management control as well as health registration on the farm.

While controlled feeding systems for individual cows have been fairly well developed for concentrate feeds, less attention has so farm been given the control of forage feeding. There is no doubt but the amount and quality of concentrate shall be controlled in order to avoid health disturbances and overfeeding resulting in fat cows and low efficiency. It is shown that a daily variation of ±15% in concentrate feeding results in 5 percent less milk on the same amount of feeds (Wiktorsson and Knutsson, 1977). It is also shown that individual feeding resulted in higher milk production than group feeding of cows, either tied up or in a free stall system (Herland and Wiktorsson, 1982).

The benefit of controlled roghage feeding has so far not been thoroughly scrutinized and investigated. From many points of view (a.o. nutritional, cow health management and feed efficiency) more attention should be given this field both to tied up cows and to cows in free stall systems. A preliminarly benefit analyses (Andersson and Wiktorsson, 1986) - considering feed intake, milk output relationships, the health risk of underfeeding of cows during the first part of lactation and overfeeding in later stages, cow behaviour, effect of roughage quality on feed intake - indicate that a system which allowed individual feeding of roughage in a fee stall system for 30 cows should give a range of SEK 33000-86000 per annum for the investment costs.

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Program section III: Feeding, milking, reproduction and animal health. Biological demands and conditions.

RECORDED AND CONTROLLED ENVIRONMENT AND MANAGEMENT IN MILK PRODUCTION BASED ON BIOLOGICAL CRITERIONS:

by ANDERS NYGAARD

Farm buildings under our climatic conditions are from the farmers' economical point of view, just a mean for putting through a production program. Besides the climatic protection, there are also other factors of fundamental importance. Among these are the species' spesific characters such as body measurements, hierarchy, agnostic distance etc., which have to be observed in lay out and area disposal. This static part of the environment is formed already on the drawing board. The starting point of this is a herd program which gives information about: How many animal by which age and what condition are where?

The herd program

Many genetic/physiological, environmental and management factors have to be coordinated by continuous running of a herd. In order to predict how the factors are acting in the process of reproduction, one has to know:

* The interactions between the factors (fig. 1).
* Parameters for the herd.

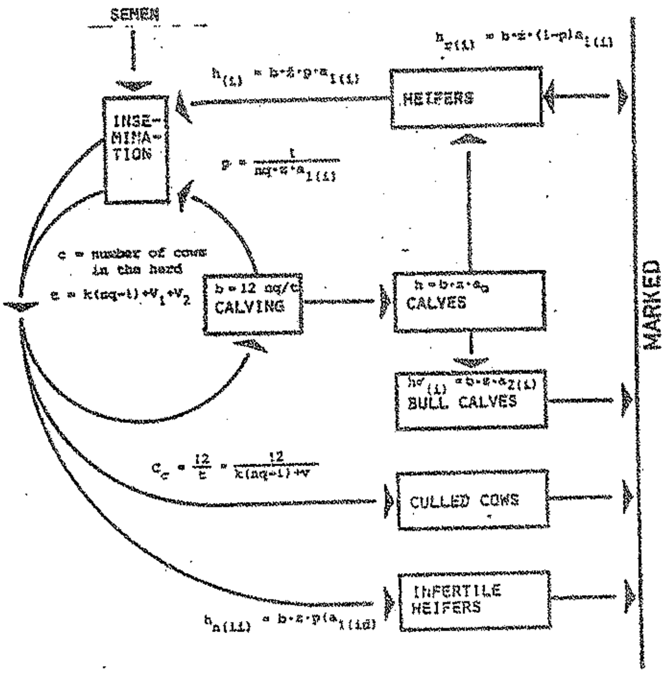

Fig. 1. Flow chart model for a herd of cows.

where

t = time from 1st calving to culling plus time until replacement heifer calves.

k = interval between calving.

n_q= average number of calving in time t.

V_1= average time from last calving to culling.

V_2= average time from culling until replacement heifer calves.

c_c= fraction of c culled per year.

b = average number of calvings per cow per year

h_i= needed heifers as fraction of c.

z = average number of calves per calving.

p = fraction born heifer calves to be kept for maintaining c.

$a_{1(i)}$= the probability that a born heifer calf lives by an age (i) suited for replacement.

x = average age by 1st calving.

$h_{r(i)}$= born heifer calves not needed for replacement.

$h_{n(ii)}$= infertile heifers.

ii = age by 1st insemination.

id = age by culling of infertile heifer.

$h_{♂(i)}$= bull calves for sale.

$a_{2(i)}$= the probability that a born bull calf lives by age i.

c_b = calving program. Percentage of calvings per month.

All the data needed for calculating the model (fig. 1) are continuously recorded by the Norwegian Board of Animal Production Recording, which counts for about 80% of the cows in Norway. The model is primarily designed for working out a building program. With some modifications the model could be fitted for use in continuous planning and managing the reproduction process in the herd. For the milk production of the herd it is important to keep the "cowcircle" running with as many cows as possible on high lactation. In order to achieve the best genetic progress, efforts have been made to shorten the generation interval by high replacement rate. In the short run it does count more for the farmer to minimize the time (V_2) from culling of a cow until replacement heifer calves. This has to be steered through a conscious programming of the replacement - positively in the way that the first calving of an heifer culls the least profitable cow in the herd. A cow on the culling list does not pay for her place when she is passing approximately 10 kg milk per day. Correspondingly, every culling has to be followed up by programming of a replacement.

Other factors the farmer has to consider and follow up are the calving program (c_b) and the intensity of reproduction (p). Wanted calving program over the year is surely dependant on geographic/topographic/climatic conditions and seasonal work peak points, but even distributed (continuous) calving gives the best utilization of the housing system. The intensity of reproduction has increased the later years, and in Norway approx. 70% of all born heifer calves have to be saved for replacement. The cow is hardly fully grown before culling. Many farmers in combined milk and meat production save all the heifer calves and test them for 100 days in the first lactation. Alternative constellations in the reproduction program give interesting perspectives.

For the farmers' daily work with the reproduction of the herd the detection of heat and pregnancy establishment is of vital importance for efficiently putting through a scheme.

Grouping of the herd

Biological and other criterions for grouping may be:

* Physiologic/anatomic stadium of development.
* Feeding (quantity and quality).
* Behaviour (learning, rang order a.s.o.
* Climatization.
* Chore work.

Without any further discussion, I will just present my favourite grouping, which I think takes positively care of most of the criterions:

Sex	Age and group	Comments
♀♂	0- 2 months	Raw milk. Dev. of ruminant.
♀♂	3- 6 "	Balanced growing.
♀♂	7-12 "	Sex sorting at end of period.
♀	13-15 " } *	First insemination.
♀	16-18 " }	Pregnant.
♀	19-calving }	
cows	Lactating } *	Learning to become cow.
"	Dry }	
	Treatment unit	
♂	13-15	If meat production on the
♂	16-slaughter	farm.

* Could be grouped together in smaller herds than 20 cows.

Feeding

In whole we do have an enormous knowledge about feeding of <u>one</u> animal from birth through the different life time periods. An attempt (a double-double short-cut) is done in fig. 2 to consentrate/compress the volume down to practical engineering jobs - about 7 rations (quality and quantity continuously regulated).

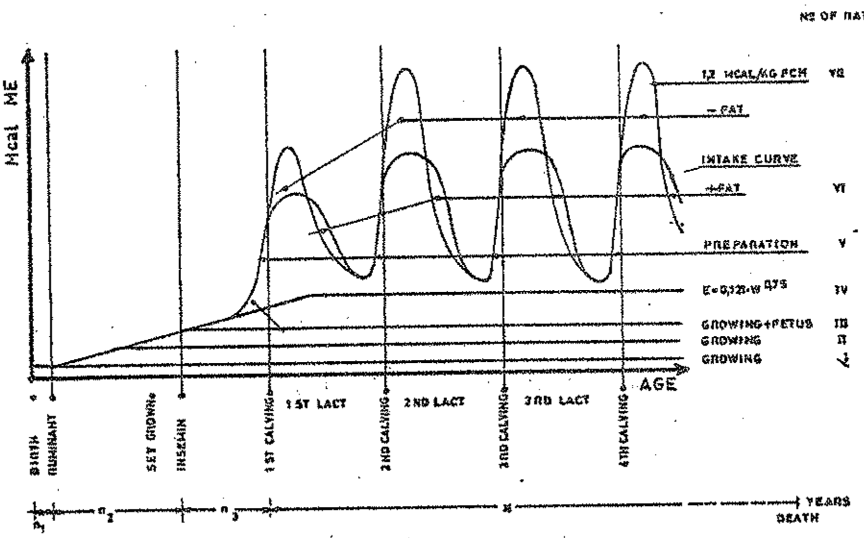

Fig. 2. Graphical picture of the feeding of one cattle through the different biological periods from birth to death.

We try to overcome this by age and state of lactation-grouping the animal. Concerning the cows, the roughage is mostly given ad.lib. in Norway. Adjustment by the consentrate. This could lead to overfeeding of low-yielding cows or dry cows grouped with higher and high yielding cows. The use of several kind of roughage and semiautomatic distribution could be tackled in stanchion. In loose housing on the other hand, one has to use "Sperrgitter" (lock-front) - especially if rootfruits are used. Several cow groups in smaller loose housing should be avoided.

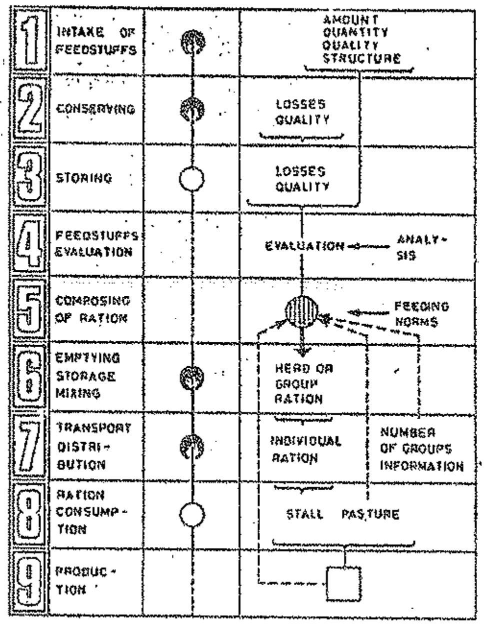

Fig. 3. Activity diagram for feeding.

Besides correct feeding of one animal or a uniform group, other components (activities) come into the lapse. This activity diagram consists of the building related part, and we have already examined the three first activities. In the rest (4-9) it is usually the activities 6 and 7 we characterize as work. A "blind" mechanizing of these activities may lead to malinvestment. A pretty accurate and costly transport and distribution of the ration (act. 7) is thrown away if the installation at the feed bunk does not ensure that the right animal consume the right ration. On the other end of the line it is well known (act. 4) that feedstuffs evaluation is the pre-condition for being equipped to compose the right ration. Feed backs about production are as well needed.

Every plan for action (investment) of one point should therefore be done according to the analytical in the line importance of the point.

In a development period we do mostly have to go by step by step to reach a balanced system solution.

Milking

The milking work amounts to 60-70% of the chore work in operations with fairly good mechanization of the feeding and manure handling. The milking is in addition heavy work in stanchion barns.

It has been, and still is, characteristic and important with the near physical and visual contact between the herdsman and the cow. By skilled subjectivity the milker could observe:

* Reaction from the cow.
* Cleanliness.
* Physical condition of teats, udder. and legs/hoofs.
* Forewith control
* Let down.
* Milk amount.
* Teatsdipping a.s.o.

How to substitute this and take action? In addition there is a need for

* Continuous milk quality control (sample of individual).
* Bacteriological control of the clusters and pipe line system after washing/cleaning.

Health

The Norwegian disease recording system for cows is operated in the following manner:

All cows have a so called health card. This card accompanies the cow all her life. All veterinary treatments performed on the cow are recorded on this card. This information is reported together with the milk recording data. The disease data are then stored on magnetic tape together with the milk recording data.

The present summary represents the year of 1984.

The conclusions can be summarized as follows:

1. Over 95% of all milk-recording cows in Norway are also included in the disease recording system.

2. Mastitis, ketosis and milk fever are the three dominant diseases. Together they account for 68,3% of all recorded treatments.

3. 42,3% of the cows have been veterinary treated once of more during the year. These cows have an average of 2,09 treatments. For mastitis, ketosis and milk fever the frequencies of treated cows were 19,2%, 15,5% and 4,8% respectively.

4. Relatively few cows have been treated for reproductive disorders during the year.

5. There is an increase in disease frequency from first to later lactations. While less than 1/3 of the cows in first lactation are veterinary treated, more than 1/2 of the cows in 3rd to 8th lactations are treated.

6. For milk fever there is an increase frequency with increasing herd sizes. For ketosis, mastitis and fertility diseases the tendency is opposite.

7. There is a tendency of increasing disease frequencies with increasing average herd milk yield. This increase is most outspoken for milk fever and reproductive disorders, but it also applies for mastitis. For ketosis highest frequencies are found in herds with intermediate herd milk yield levels.

Today we call for the veterinarian when we observe or think something is wrong. It is very important to develop detectors (at least for mastitis), which could give the diagnosis and inform about possible actions immediately and in front of the veterinarian.

Environment (The building related part)

In association with the health card in Norway there has been carried out a test with environmental barn cards. The data from the two cards give information about the interactions between diseases and the housing system, management and details about installations and equipment. This information is first of all useful for selection by planning or rebuilding and it could be used in sorting out problems for further investigation.

The daily running control and steering of environmental factors by automatic/semi-automatic means limits to installing thermostatic regulated room-ventilation based on temperature.

What about:

* Humidity.
* Conditioning the animal according to year sycle.
* Gas, dust, noice.
* Tv-controlling the barn.

COMPUTERS, ELECTRONICS AND CONTROL ENGINEERING IN AGRICULTURE
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THE CONTROL OF ANIMAL HEALTH WITH THE NEW TECHNOLOGY

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The important aim of animal health control is to maintain animal health and production at the most effective level that will provide maximum economic returns to the animal owner. Equally important objectives of health control programs are to ensure reasonable animal wellfare, to minimize pollution of the environment by animal wastes, and to prevent transmission of diseases from animal to man.

Principles of a herd health program

The most developed phase of preventive veterinary medicine includes integration of health maintenance plans with production and management plans to give to the whole farm the best efficasy. In this phase, the practicing veterinarian makes regularly scheduled visits to the herd, examines the animals and records clinical and subclinical diseases, and then analyses data with assistance of the computer. Thus, there has to be a continious data collecting on the farm. After the first analysis of the health condition of the herd, the veterinarian obtains more information of the possible problem diseases. In this work he uses the data banks of common main-frame computers. By using all the information produced the veterinarian plans a therapy and preventive program for the herd. The continious data collection makes it possible to evaluate the efficasy of those programs afterwards.

The data collection

One of the most important components of a succesful herd health program is a good recordkeeping that can be used to monitor and evaluate the incidence of diseases and production. The records will vary considerably, depending on the type of livestock and the stage of the herd health program. In the simplest and most common form used e.g. in dairy herds, there is an individual lifetime card for each cow. All events of the reproductive cycle and incidents of clinical diseases are recorded on the card. Such a cow card has been used in a health monitoring program for dairy herds in Finland since 1982 (Saloniemi 1982).

The new technology already gives some help in raw data collection. For instance, Dill et al.(1985) reported a system for automatic collection of data on milk yield, milk temperature, and electrical conductivity of milk from each quarter at each milking. Their system included also automatic collection of data on cow entries, occupancy time and feed dispensing time with an automatic concentrate dispensing system. The collected data are useful in estrus detection and mastitis control. Mastitis detection is based on a fact that the values for electrical conductivity of milk are associated with the health status of udder. The measurement of the electric conductivity of milk for detecting of mastitis may soon be in common use in bigger dairy farms. The automated appetite control in connection with the concentrate feeding, which already is in use in many loose housing dairy herds in Nordic countries, helps the farmer to find sick animals. One new possibility in disease detection is a telemetric control of electrical resistance of mucous membranes of the reproductive organs (Aizinbud et al. 1985).

The analysis of data

After the animal health and production data are collected from the farm, they must be transferred to and incorporated into the previously collected data and analysed periodically. In the Finnish system, the AI technicians transfer the disease data from the cow card to the Agricultural Data Processing Centre . The time from the disease outbreak to collecting and analysing data is too long in this system. This slow method has been chozen because the system is inexpensiv. The collection and analysing of health data costs in our system about 0.1 FMK per cow per year (about 0.13 SKR). The quickest possible turnaround time for analysis of data and reporting back to the farm can be reached by using the terminal or microcomputer on a farm connected to the main-frame computer via a telephone modem. About 300 advisor terminals are already now in use in Finland, but the development of a computer program for this purpose is still under preparation.

Herd health reports are issued on recorded health data and provide a survey of the previous 12 months results. Reports are made and mailed to the farm three times per year. The veterinarian receives a summary of his own recordings as well as frequency of diseases in the herds within his district.

The planning of a health control program

An effective herd health program is one in which the farmer reacts to advice onhis performance by trying to improve it, often in a particular area of his work. An effective computerized program is designed to interact with the farmer and with the veterinarian. That is, the computer produces analyses of the health status and performance, the veterinarian reacts to them, and then feeds more data into the program, which reacts by producing a new analysis. An effective dairy herd health program serves for instance the following functions:

- The farmer gets repeatedly, e.g. at mounthly intervals, a herd health report. This includes the current disease incidences and the interherd comparisons. The report points out the possible disease problems in the herd.
- The computer generates a list of cows that need to be examined. The cows are selected for examination because of reproductive performance or mastitis or other diseases. A good program recounts the cow's immediate past history on which the decision to examine was based . This helps the veterinarian in his clinical work.
- The computer reacts when new findigs enter into program by giving an up-to-date report of the health status in the herd and by proposing possible actions.

The Finnish program produces only the herd health report, which is mailed to the farm. Already this makes it possible to plan a satisfactory health control program.

Some other possibilities in the health control

The breeding of animals for better health needs an extensive and individual health data. The selection for disease resistance cannot be only based upon the phenotype of a cow (sick or healthy), as the environmental influence is very high in the most common farm animal diseases. The health control program in Finland enables a collection of data from large progeny groups. The first progeny testing on health control data was performed in autumn 1985. More detailed genetic analyses are under publishing (Gröhn et al. 1986). The progeny testing program for the health breeding has been in use in Norway already a couple of years (Solbu 1983).

In the university of Minnesota, an interactive computer-based guide was developed to demonstrate for pig producers the expected level of pneumonia in pig herds (Morrison & Morris 1985). The program evaluates the combined effects of known risk factors present in the particular herd on the prevalence of lung lesions in slaughter pigs. The program is a demonstrative teaching tool for producers and students, but it is also useful when the farmer and his veterinarian plan improvements in the environmental and management circumstances in the farm.

Conclusion

The new technology gives already now many helpful tools to the maintenance and improvement of animal health and production. The development of practical computer programs for herd health control is an important and economically profitable field in utilization of the new technology in animal production.

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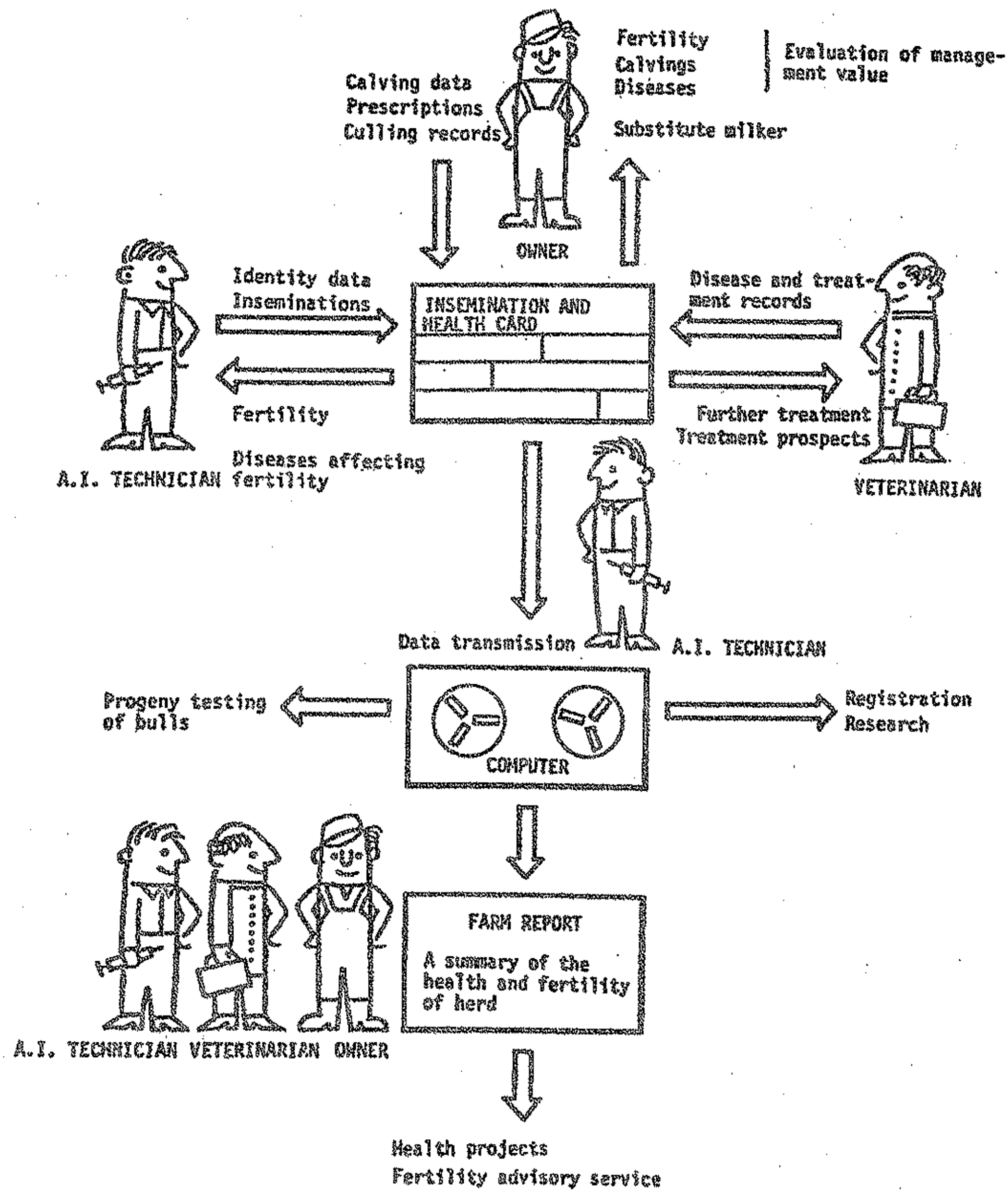
THE HEALTH CONTROL PROGRAMME



COMPUTERS AND ELECTRONICS IN SWINE PRODUCTION: ADVANTAGES AND DISADVANTAGES

by Jörgen Svendsen, Research Leader, Department of Farm Buildings, Swedish University of Agricultural Sciences, Box 624, 220 06 Lund, Sweden.

Over the past two decades, structural changes within swine production have been considerable in most countries. The very small herds with only a few sows and gilts are rapidly disappearing, larger sow herds with a specialized production of weaner pigs are becoming increasingly common, and large, highly mechanized feeding-finishing units are having an ever-growing share of the hog market. The need for a competetive pig production in a broad sense of the word has provoked and forced through these changes, and today, modern swine production is managed by highly educated and capable producers who handle an increasing number of animals by applying new techniques.

For the purposes of this discussion it may be useful to divide swine production into two basic steps: A. the production of weaners, and B. the production of fatteners for slaughter.

A. WEANER PRODUCTION

The profitability in weaner production is very much related to the number of pigs weaned per sow per year. This again, is dependent upon farrowing interval and litter size at the time of weaning, and thus on a series of extra- and intrauterine events at the time of breeding, ovulation and implantation, continuing through the period of gestation until birth and suckling (Fig. 1). Thus, weaner production in a given environment consists basically of (may be broken down into) a series of steps or periods, each with special biological problems to be solved. The understanding and control of these events, and factors influencing them, will decide the outcome.

The farrowing interval will determine the number of litters per sow per year, and depends upon lactation length, gestation period, and the number of days which elapse from weaning to the time the sow is pregnant again (dry period). While the length of the gestation period in sows is independent of most external factors, the length of the lactation and dry periods are dependent upon a series of factors, such as, age of the sow, litter size, boar, season of year, management practices, housing, feed, and diseases of boar and sow.

The number of liveborn pigs and pigs at weaning - litter size - depends upon ovulation rate, fertilization, embryonic and fetal morbidity and mortality, piglet mortality at farrowing, and the morbidity and mortality of the suckling pigs (Figure 1). Many of these problems are age-related. Again, these events may be influenced by many "internal" and "external" factors, such as, age of the sow, boar, husbandry and management practices, housing systems, close environment, feed and methods of feeding, diseases, disease control, and preventative measures.

COMPUTERS AND ELECTRONICS IN WEANER PRODUCTION

The aid of computers and electronics may be of particular relevance within the following areas of weaner production: 1. management systems; 2. feeding; 3. environmental control; and 4. health surveillance. It may be useful to consider the applications relative to the various steps in weaner production, as outlined in Figure 1.

1. Management Systems

The key to better and more efficient management, and to understanding and controlling problems in weaner production is to establish an animal identification system and a record keeping system on an individual sow-litter basis. The system should contain information relative to the individual sow's production and should be able to analyse and present this information in an understandable and relevant form. Computers and electronics may be used for this purpose and several management-production systems are available to swine producers. Some systems have been in operation for several years and improvements are still being made. Besides offering a variety of outprints aimed at helping production control, management decision and record keeping, the various systems may also be used for trouble shooting, especially if the various steps in the weaner production are analysed separately.

One such system for handling production results has been developed at the Department of Farm Buildings (LBT), in Lund. It consists of an in data and out data section (Figure 2), and is constructed for the continual entering of data. This means that both the data base and the animal house will always contain current information about each animal. Examples of outdata lists are shown in Figure 3.

The advantage of these systems lies in the rapid handling and analysis of large amounts of data; the need for the producer to be aware of the individual sow and litter; the discipline which the system imposes on the producer to keep up the recording system; the possibility of developing a data base reference system; and, of course, the advantage to the producer and advisor in having access to key information on production, thus helping in trouble shooting and decision making with regard to production planning (the movements of animals, reproduction programs, culling, recruitment of animals and boar use).

The disadvantages lie in that computers and software are expensive, need a constant supply of electricity to function, and are expensive to repair. Electronic herd management systems supplement and expand existing manual data analysis systems but they do not, at present, remove the need for the continual, manual, everyday recording of data using a reliable recording system. In addition, the individual identification of the sow and her litter is still done using some type of tag system, which at present cannot be used in electronic systems. Finally, it should be emphasized that whatever the output of the machine, it will be dependent on the relevance of the input.

Future

Future research activities ought to be directed towards simpler routines for data entering, so that "double entering" may be avoided as much as possible. Portable (hand-held) terminals are still rather heavy, very expensive, and too little is known about their sensitivity and reliability within the harsh environment of pig houses. There is also a need to compare the various programs and systems available for managing pig production, not only with regard to technology and ease of use, but also on a cost-benefit basis. Perhaps the most challenging research area in this field is for the biologists and producers to define which data should be entered in the system.

2. Feeding

Electronics have for several years been applied in the formulation and mixing of feeds for animals, and will not be discussed here.

The problems of feeding in weaner production primarily lie with the sow. While generally suckling pigs and pigs up to 25 kg weight are fed ad libitum, sows and gilts are fed restrictively, and individually, according to size, reproduction stage, climate, and method of housing. At present, this may only be achieved for individually housed sows, and thus puts serious limitations on the development of group housing systems, family pens, and other systems where the animals have more freedom of choice. Therefore, housing systems where group housed loose sows are individually fed and monitored using a feed dispensing device that recognizes the individual animal by electronic identification, are now being developed and tested.

At LBT in Lund, one such system for sows in gestation (Alfa-Feed, Sweden) is being developed and tested in cooperation with the Alfa-Laval Company and the Department of Agricultural Engineering of the Swedish University of Agricultural Sciences. This system, using computer-controlled feeding and a transponder on a neck collar as an indentification device (Figure 4), has previously been used for cows, but not for sows. At the Department, the cow feeding station has been modified to fit sows, and equipped with a mechanical gate system which the sow closes upon entering the station, so she is protected from the other sows when eating. A front gate has also been added to the stall so the sow may leave at the front after she is finished. Thus, sows do not have to back out after eating. Behaviour studies showed that problems with sows having weak legs and with aggressive sows occur if the sows are only able to back out of the feeding stall.

The computer in this system automatically notes the daily feed consumption of each sow. By precisely monitoring deviations from a normal feed consumption, possible disturbances in the animals or in the equipment can be detected at an early stage. This individual distribution of feed and control of intake permits adjustment in the feed ration to even out growth and condition within groups.

The advantages of such systems lie in the individual feeding and monitoring of group housed loose sows. The equipment in this system has functioned very well. The transponders occasionally stop functioning, but this has happened very rarely during the two and a half years use. The sows quickly learn how to manage the system, especially when housed in somewhat smaller groups. Another advantage is that such systems may permit the use of alternative types of feed (forage, etc.) and the construction of unconventional types of housing systems.

However, there are also some important disadvantages. Since sows gain 30-40 kg during the gestation period, the transponder collars must be checked and adjusted 3-4 times over this period to prevent injuries. When adjusted properly, injuries are very rare, but it is impossible to guarantee that a similar adjustment can be made in all possible situations. Therefore, the development of a smaller transponder which may, for example, be attached to a standard ear tag, is in progress. In addition, if transponder controlled feeding systems are to be used in slaughter pig production, smaller transponders must be used.

Before making transponder feeding for sows in gestation generally available, it is important to determine how animals, normally fed in groups, will react to suddenly being forced to eat one at a time, and perhaps being housed in larger groups. The design of the pen and the number of sows per pen are other parameters which may affect the functioning of the system and therefore must also be studied and described. If incorrect recommendations are given at the introduction of a new technique, the possibility arises that instead of solving existing problems, a number of new ones will appear in addition to those already present.

A major disadvantage is that at present these systems are expensive, and thus only large groups of sows can use these systems efficiently.

Future

Future developments for feeding systems could be to weigh the individual animals when eating, and adjust their ration appropriately. Perhaps systems could also be developed that detect environmental temperature so the production animals could be fed accordingly. This might prove particularly interesting for extensive outdoor housing systems. Feeding bulk food and a concentrate supplement to sows may also be possibile if an electronic feeding system is at hand. In the future, it may be feasible to transfer information from the production program and use it to evaluate the feeding regime. For example, information such as date of service for a sow in the production program could be used to control an automatic increase in the feed ration during the gestation period, via the feeding program.

3. Environmental control

In weaner production, the greatest challenge for securing an optimal environment is in the farrowing unit. While the newborn pig needs an environment of 34°C, in a well-insulated, draught-free and clean area close to the sow's udder, the sow only needs an environmental temperature of 16-18°C. To complicate matters, the specific needs of the newborn pig changes rapidly with age. Existing heating devices for farrowing boxes (lamps, heated roofs, heated floors) are usually placed in one corner of the pen, and many piglets are dead before they even find them. These heating devices have no fine control, and may only be adjusted by turning on or off or by lowering or raising. It appears logical to develop sensors and control systems which may secure an even draught-free climate in the creep, and computer programs to adjust the output of the heater according to litter size and age. Only few attempts have been made to develop such a system.

4. Health surveillance

Disease control and prevention is important to all livestock production. General indicators of ill-health may be decreased feed intake, changes in water consumption, changes in body temperature (fever, sub-normal temperature), and in animal activity.

At the moment, the only routine use of electronics in disease control in weanner production is through the feedback of disease information at slaughter (as a printout), and indirectly through the herd management system. Providing the animal identification is correct, such information may be very valuable, particularly in integrated herds. Along with electronic identification and feeding systems for sows, as outlined previously, methods of determining changes or irregularities in feed consumption and feeding patterns may be developed which can indicate when there are disturbances. In the future, it may also be possible to monitor water intake, body weight, body temperature, and animal activity, which may be helpful in predicting problems.

B. SLAUGHTER PIG PRODUCTION

Mechanization in slaughter pig production is quite advanced, and may not increase much over the coming years. This has been possible because slaughter pigs (from 25 kg and up) have rather similar biological needs with regards to feed, climate and housing, and are able to adapt to much the same "stressors"; because of improvements in management systems and housing, and because more is known about disease control and prevention. This development has been necessary due to the need to reduce labor costs; to improve the human work environment; and to improve feed conversion in pigs, which are primarily selected for fast growth and meat production.

The intensification of slaughter pig production and the application of new "techniques" may, in general, have increased profitability, but has also made the production more sensitive to disturbances, and has caused the emergence of complex disease syndromes, where common denominators appear to be the environment and stress. These include vices such as tail biting and stress, complex respiratory diseases, diseases associated with usually nonpathogenic bacteria, hemorrhagic bowel syndromes. Indeed, many have for these reasons voiced criticism of "modern" slaughter pig production methods, and some have been right.

COMPUTER AND ELECTRONICS IN SLAUGHTER PIG PRODUCTION

Environment, environmental stressors, feeding and feed conversion are very important factors in all modern slaughter pig production, independent of the manner production is organized and managed - integrated herds, specialized slaughter pig production, all in-all out, etc. Electronics and computers may be applied in the control and management of these factors.

1. Environmental control

Climate, hygiene and technical installations are important components of the environment. A "poor" environment influences feed conversion negatively and increases the incidence of disease. Since large units may be more difficult to ventilate than small units, or a low hygiene level may be more common in large units or in herds with continuous production, it may be very difficult to actually pinpoint whether it is primarily "poor" environment or incorrect management procedures, faulty building design or other factors which constitute the basic problem. To complicate matters, the hygiene level may be high in houses with fully or partly slatted floors, but the stresses which this type of housing incur may be more negative than low hygiene levels. Therefore, given an identical environment and with the same type of pigs and feed, the productivity may be very different, depending upon managment, building design, and other factors.

Although poor environment may not be the only or primary cause of faulty production, the environment should, as a rule, be good. This means a high level of hygiene, dry floors and walls, low levels of noxious gases and of noise and dust, and a thermal environment that feels comfortable to the individual animal. There is certainly a role for electronics to play in the achievement of this situation.

Future

Control of the environment should be more adapted to biology. Thus, it may be better to measure the heat loss of animals and use this to regulate the thermal environment instead of, as now, using air temperature. In addition, better humidistat controls may be developed. Sensors for detecting gases and dust may be developed which can also help in controlling the environment. In the future, it may also be possible to develop environmental systems which the animals can operate themselves, according to their needs.

2. Feeding

Feed is responsible for approximately 70 per cent of the costs in slaughter pig production. Besides their use in the formulation and mixing of diets, electronics are to some extent used in different feeding systems. At present, slaughter pigs are either fed ad libitum, or are fed restrictive diets during the last part of the growth period, according to the average weight (or age) of the pigs in the pen. Such feeding regimes are calculated for slaughter pigs as a group, and not as individual. However, these pigs are individuals, with quite different capabilities for growth and feed utilization. With the advent of electronic identification systems, the possibility arises of feeding group housed pigs individually according to weight.

Such a system is under development at LBT in Lund , in cooperation with the Alfa-Laval Company and the Department of Agricultural Engineering, Swedish University of Agricultural Sciences. The technical basis is the same as described for sows. However, using a scale as the floor, each animal is weighed individually upon entering the feeding station, and the pig's weight is taken into account when the feed ration is dispensed. This system is in its infancy and it is too early to discuss possibile advantages or disadvantages.

Future

Thus, it may be possible in the near future to feed group housed pigs individually according to weight, while at the same time having a record of the daily consumption of each pig. The impact of such a system on feeding trials and breeding programs could be significant, in particular if also coupled to a disease recording system. The greatest difficulties apparently lie in designing the feeding station so only one animal may enter at a time. Future research in this area could be in the development of feeding scales for individually fed animals, and in improving the electronic identification system. In addition, much work is needed on the design of the pens, and determining the reactions of animals in such systems.

3. Management systems and health surveillance

The requirements for slaughter pig production, although not as complex as for weaner production, are much the same. Electronic systems which can indicate problem areas will greatly simplify the labour requirement and reduce costs.

Computer assisted systems are developed which may help the producer in the management of his slaughter pig production, and which also makes it possible to retrieve slaughter statistics. It is possible with existing systems to obtain slaughter information for individual animals. This may be particularly useful in integrated herds for purposes of selecting breeding stock, studying genetics, etc.

Many of the diseases appearing in slaughter pig production appear to be stress-related. It would be a great advantage if methods of detecting physiological and biochemical changes due to stress could be developed. This would enable treatment of the problem before it became acute, thus avoiding losses during the fattening period and during slaughter.

CONCLUDING REMARKS

At present, computers in swine production are mostly used as an aid in production control and planning. A more widespread use, for example, feeding of sows, may permit the holding of animals under more suitable conditions, for example, loose housing, and the development of other housing systems, without losing the possibility of individual monitoring and treatment. However, reliable functioning is a must in this type of situation, and when designing systems it is extremely important to keep in mind that all of the systems must both withstand a potentially corrosive environment and continue to function, even in times of "crisis".

Much of the technology necessary for use in pig production exists today. For example, electronic equipment is available for analysing all kinds of blood serum and whole blood parameters. What is lacking is biological specifications of demands, and an understanding of how biology and technology interact, suitable incentive to adapt, and an active imagination to determine uses. However, caution is important when thinking of possible areas of usage. While some things may be feasible, and to a certain extent even desirable, the cost-benefit relationship must always be kept in mind. Another point which should be mentioned, is that the farmer should not expect that using a computer will improve an already bad situation. A poor producer will not be improved by technology.

At the present, the number of computers which can stand the stresses of the farm environment, such as, dust, noxious gases and mice, and the number of usable programs for the use of farm personnel are relatively limited. Therefore, continued development is necessary for the computer to have a more general use within agriculture. This development must take place in cooperation with both farmers and biologists, so products may be produced which are needed in agriculture and, at the same time, will avoid "biological" errors with the introduction of the new techniques. In addition, good impartial investigations are necessary, using objective methods, to report the advantages and disadvantages of the techniques studied, both with respect to their function and the effect on the animals.

SUMMARY

Swine production may be divided into 2 basic steps: the production of weaners, and the production of fattening pigs for slaughter. The help of computer and electronics in swine production may be of particular relevance in the following areas: management systems, feeding, environmental control, and health surveillance.

The key to better management and to controlling problems in swine production is to establish an animal indentification and record keeping system. Computer and electronics may be used for this purpose, and several management-production systems are available to producers. There is a need to develop simpler routines for data entering, so double entering may be avoided, and to compare the various systems available with regard to technology, ease of use, and cost-benefit.

Sows and gilts should be fed restrictively and individually accordint to size, reproduction stage, climate, and method of housing. At present, this may only be achieved for individually housed sows. Therefore, housing systems where group housed loose sows are individually fed and monitored using a feed dispensing device that recognizes the individual animal by electronic identification are now being developed and tested. Similar systems may be developed for slaughter pigs, and in the future, it may be possible to feed the animals according to their individual weights at eating and the environmental conditions.

Climate, hygiene and technical installations are important components of environment. Control of the environment should be more adapted to biology. Thus, it may be better to measure the heat loss of animals and use this to regulate the thermal environment instead of using air temperature. In the special case of newborn piglets, there is a need to develop sensors and control systems which may secure an even, draught free climate in the creep, and adjust the output of the heater according to litter size and age.

Disease control and prevention is important to all livestock production. At the present, the only routine use of electronics in disease control is through the feedback of disease information at slaughter, and indirectly, through herd management systems. In the future, it may be possible to monitor water intake, body weight, body temperature, and animal activity, which may be helpful in predicting problems.

When applying technology in pig production, caution is necessary. Reliable functioning is a must, and the cost-benefit relationship must always be kept in mind. In additon, a poor producer will not be improved by technology.

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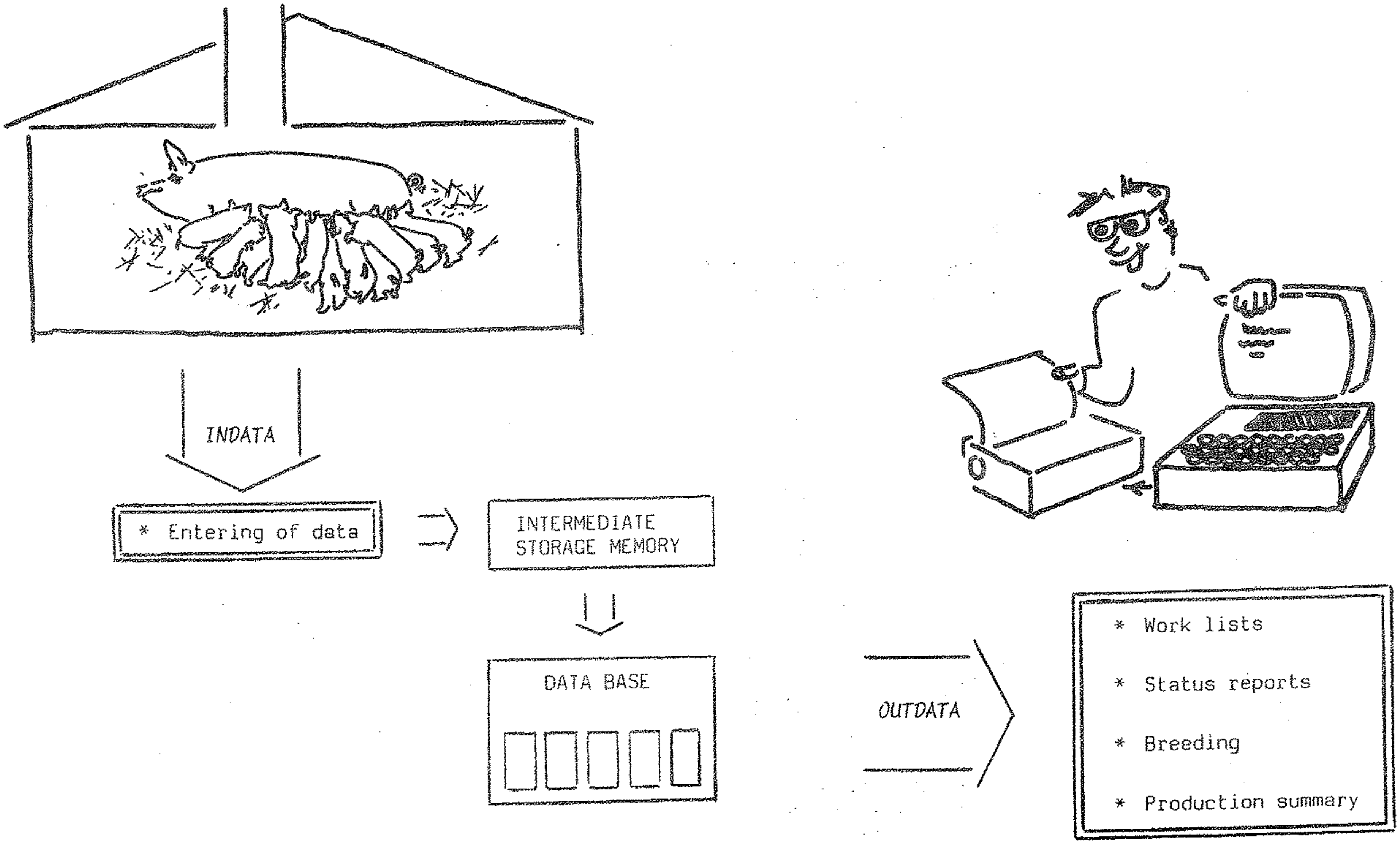

Figure 2. Pig production computer program: Data flow. (Bengtsson et al, 1986).

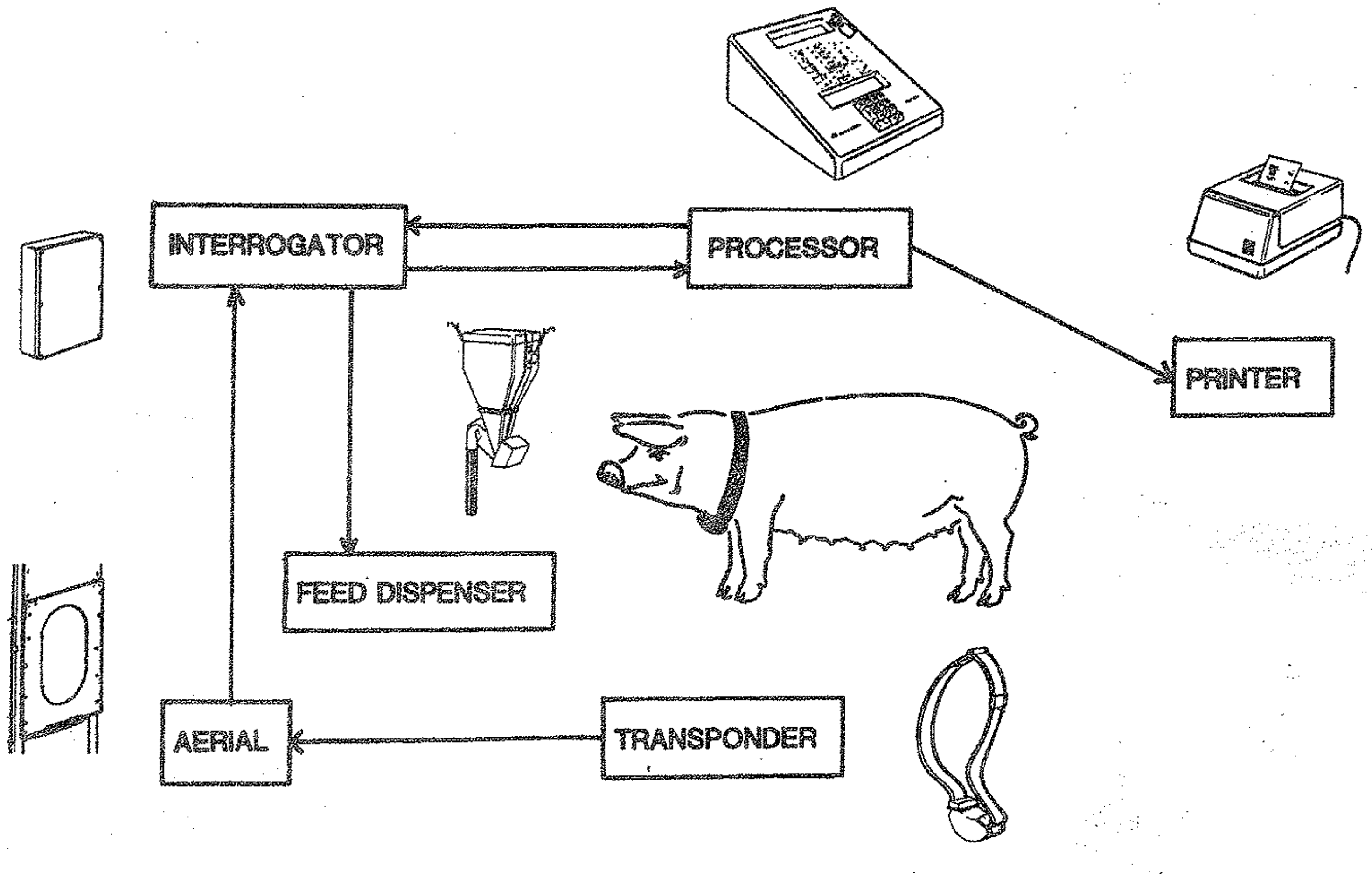

Figure 3. Computerized individual feeding of group housed sows in gestation. (Bengtsson et al, 1986).

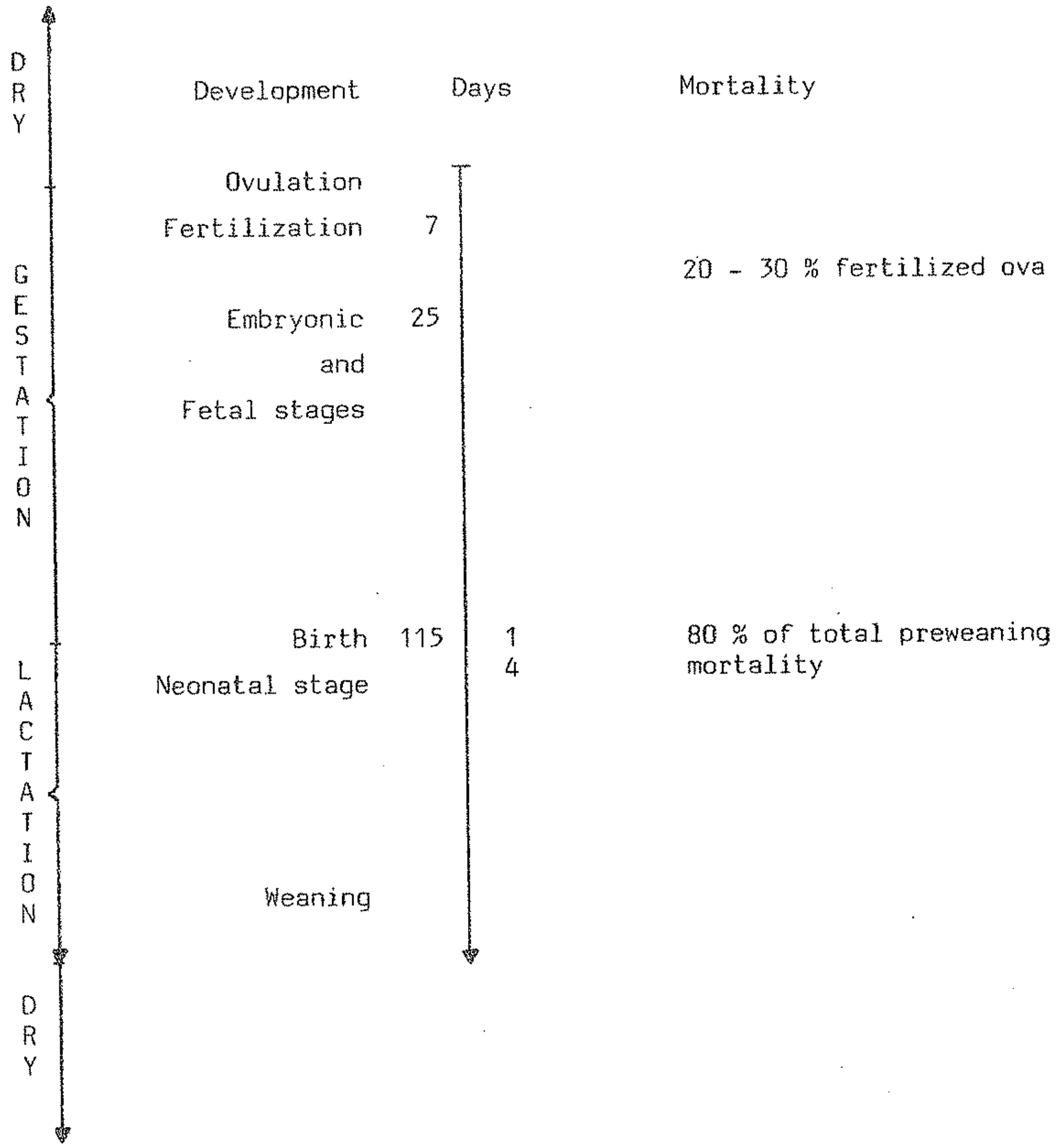

Figure 1. Factors affecting the number of pigs per year sow: litter size and number of farrowings per year.

AUTOMATION IN DAIRYING - Now and in the near future

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ABSTRACT

Investigations into the possibilities of automation in dairying have been developing very fast in the eighties. With the application of automatic cow identification, which is already in use in a large number of dairy enterprises, processes can be controlled and the required animal data collected.
By means of the identification system, the concentrate and forage can be dosed individually to the animals. Individual milk yields can be determined in the dairy industry. Sensors have been developed which can signal animals which are sick or on heat and report the temperature of the milk and the animals' activity/lying times. A sensor which signals the presence of mastitis can be incorporated in the milking claw.

With the aid of computer systems these data can be made available to the farmer in the correct form.

As sufficient sensors are now available to indicate anomalous animals, the last milking phase, attachment of the milking machine, which is still done by hand, can also be automated. An investigation was carried out to determine whether the feed dispensing station in the cowshed is a good place for such automatic teat cup attaching. It was found from the investigation, that the animals came to the feed station on average 5.4 times a day and were milked four times a day. During this test a considerable increase in milk production was confirmed.

Fig. 1 - Transmitter on collar for automatic identification.

INTRODUCTION

At the beginning of the seventies the first steps were taken in the field of dairying automation. In 1970 a system was introduced in the Netherlands in which a transmitter was used to dose concentrate for cows in the milking stall. Directly after this an animal identification system was developed and installed in 1973. The industry adopted these innovations and, in 1975 the first practical systems were in use. Thanks to further developments in the field of microelectronics, sensors were developed with which the required animal data can be obtained. Microcomputer systems can process the data and submit them to the dairy farmer in the required manner. In spite of the many different forms of automation, the physical effort on the part of the milker is still very great. The animals have to be milked at least twice a day, seven days a week. IMAG carried out a number of orientating tests to establish the potentiality of automatic attaching of the teat cups. IMAG, in cooperation with the industry, is also actively engaging in the development of the required technical installations for this purpose.

SENSORS FOR DAIRY MANAGEMENT SYSTEMS

Cow identification systems

The automatic cow identification systems have made it possible to collect the required data and control the various processes.
In the Netherlands on about 3500 dairy farms, about 12% of the milking cows carry a transmitter for identification purposes. These systems are used mainly for automatic concentrate dosing (Rossing and Ploeghaert, 1975).

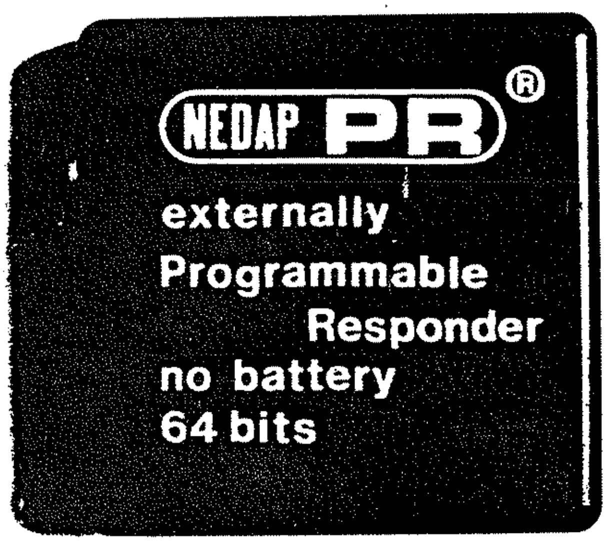

Fig. 2 - Small unit with single chip for identification.

Modern electronics have made it possible to combine the various components of a transmitter on a single chip (Fig. 2). This not only enables a transmitter to be miniaturised, but also to be produced more cheaply. A number of firms are already making use of a chip which has been specially developed for the purpose. In the case of eventual automation of the official milk control, the life number of the animal can be incorporated in the transmitter. In the official milk control the transmitter is required to be permanently attached to the animal's body. This can be done by making it in the form of an ear label or by implantation. The last-named should be possible in a simple manner. It is too expensive as a surgical operation. For efficient use it is desirable for transmitters to be able to be read out at different dairy parlours, for which purpose some form of standardisation is needed. This is no longer possible in the case of the chips now in use, but in the development of the next generation of chips that will have to be borne in mind.

Milk yield recording

The milk yield per cow provides the dairy farmer with valuable data for cattle breeding and management.

A number of systems have been marketed for the automatic recording of milk production during the milking process. The milk-measuring glass is provided with special devices and use is made of flow-meters. In the milk-measuring glass, either the height of the milk is recorded or the milk is weighed in the course of the milking. Various types of flow-meters have been put on the market by different firms (see Fig. 3).

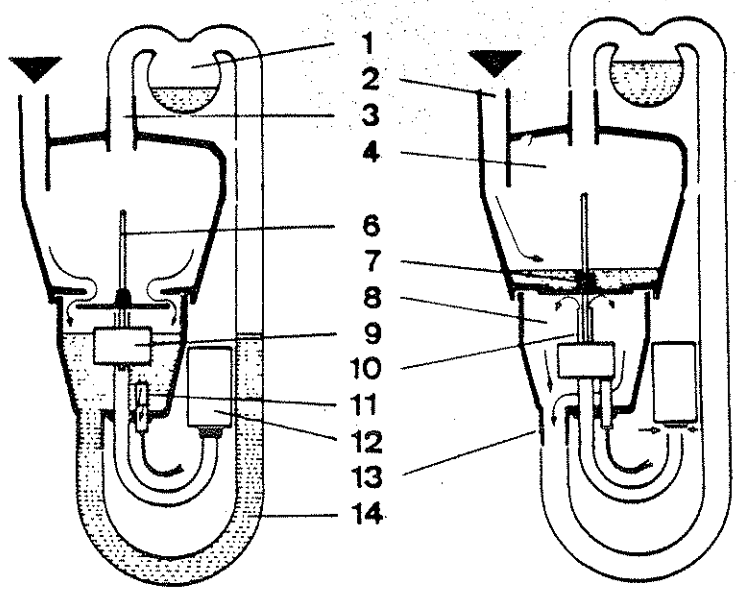

Fig. 3 - Milk flow-meter

For the purposes of the official milk control, the meters have to satisfy the regulations that govern the required degree of accuracy to which the milk yield, the fat and protein content is measured.

Signalling animals sick or on heat

Cows on heat or sick can be found by means of a system that signals anomalies. Parameters which can be measured automatically and quickly are used for the purpose.
The following are suitable parameters:

- milk temperature
- activity
- electrical conductivity of the milk.

The normal state of every cow is determined by a number of parameters and at every fresh observation the new values are compared with the normal values for the animal. Every new value which deviates too much from expectation is an anomaly and is signalled.

Milk temperature

The normal body temperature of a cow is about 38.6°C. Research has shown that the temperature is higher than normal when the animal is on heat. Sickness is also attended by an increase in temperature. For automatic management systems these data must be able to be measured automatically.
It has been found that milk temperature is a good guage of body temperature (Maatje and Rossing, 1976). In these first experiments the temperatures were measured in the milk claw during milking. Industry produced a sensor which can be placed in position in the long milk tube. Considerably greater heat losses occur there,however. These heat losses are dependent on milk yield and milking speed (Fig. 4).

It is found that the temperature deviation in measurements in the long milk tube is clearly greater than when the temperature is measured in the milk claw. From tests with a sensor in the short milk tube it has been found that there the milk-temperature reading lies very close to the body temperature of the animal. Table 1 gives the average temperature measured in the milk claw, in

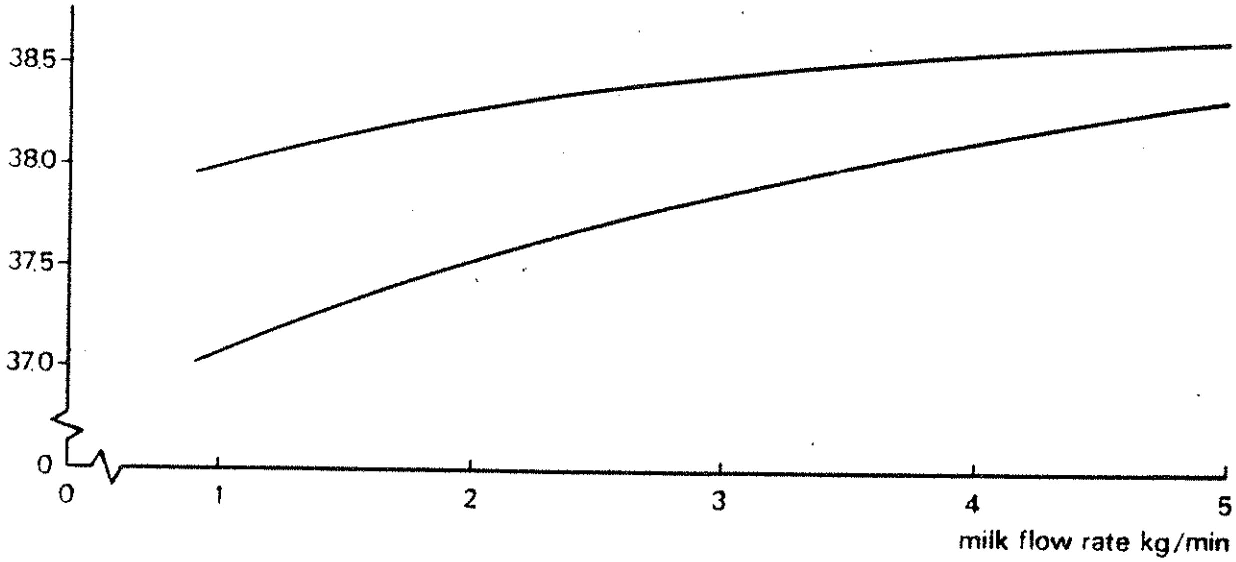

Fig. 4 - Relation between milk temperature in the long milk tube and the milk flow rate

the long milk tube and in the short milk tube. The number of animals in which heat was signalled in these situations is given.

From these observations it is found that a sensor in the long milking tube is not the ideal place for taking the milk temperature in order to signal the presence of cows that are either sick or on heat. From tests with a sensor in the short milk tube it has been found that there the milk-temperature reading lies very close to the body temperature of the animal.

It is thus advisable to place the temperature sensor either in the short milk tube or in the milk claw. The milking claw is preferable in view of the electrical connections.

Table 1 - Average temperature measured in long milk tube, the short milk tube and in the milk claw during milking and number of animals on heat signalled by means of these tests

Measuring station	Average milk temperature (°C)	Average temperature during period on heat (°C)	Number of signalled cows on heat (°C)
Milk claw	38.55	39.15	84
Long milk tube	38.00	38.45	60
Short milk tube	38.45	38.90	81

Activity

It is known that animals on heat are more restless and hence more active. On first tests carried out with a step-counting, collar-mounted transmitter it was found that during the period on heat, activity was three times greater than normal. The tests were carried out with an activity meter which courted the number of steps (movements) electronically and stored them in the memory of the instrument (Fig. 5). When this instrument is coming close to the receiver, the memory is read out, including the cow's number. Tests have shown that the activity, measured with this equipment during the animal's period on heat, was from 30 to 200% higher (Rossing, Ipema, Maatje, 1983).

Fig. 5 - Activity meter attached to cow's foreleg

Detection of mastitis

Mastitis still constitutes a problem in many dairy enterprises. The ailment causes a loss of production and lowers the quality of the milk. Mastitis has also been found to alter the composition of the milk. Good correlation has been established between the specific conductivity of milk of each quarter and the level of sodium and chloride ions.

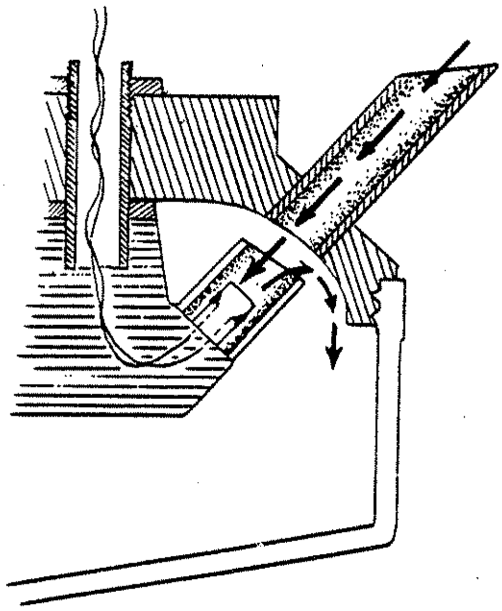

Fig. 6 - Cross section of part of the milk claw showing milk flowing into one of the conductivity cells

A sensor has been developed jointly by IMAG and IVO (Research Institute for Milk Production) which makes use of the change in conductivity of the milk (Maatje, Rossing, Garssen en Pluijgers, 1983) (Fig. 6).
The conductivity of the milk of each quarter is measured by means of two electrodes. During milking, the milk from each quarter flows through a chamber equipped with these electrodes. Four such chambers are combined to form a pick-up and can be built into a standard milk claw (Fig. 7).

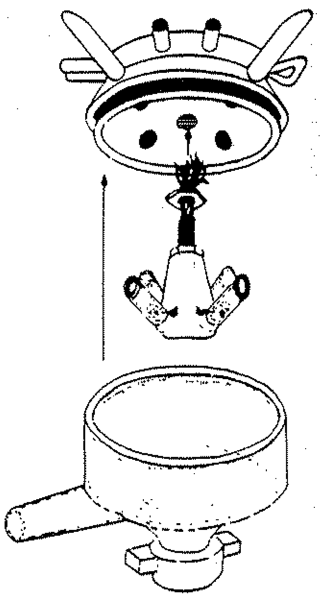

Fig. 7 - Milk claw with set of conductivity cells in exploded view

From experience gathered at the IMAG experimental station and in a number of practical enterprises, it has been found that there is a good relationship between the milk conductivity and the number of cells in the milk.

FEEDING

On a number of dairy farms the automatic identification system is in use for feeding the concentrate outside the milking parlour. However, in the production of milk from feed by the cow, there is as yet a lack of adequate information on the forage intake. Investigations have shown that there may be a considerable variation in forage intake irrespective of milk yield. Information on the forage intake may thus contribute to more efficient milk production from forage and concentrate feeds.
Furthermore, it is becoming increasingly important to the whole process "feed production - feeding - milk production" to match the individual parts to one another. In this connection, the need may clearly arise to present certain forages (types of roughage) individually to cows.
Data on the individual forage intake can be important to the management of a herd, because deteriorations in health may be deduced from sudden changes in the feed intake pattern. Accordingly, a system for individual dispensing of forage has been developed by the Institute of Agricultural Engineering (Instituut voor Mechanisatie, Arbeid en Gebouwen), Wageningen.

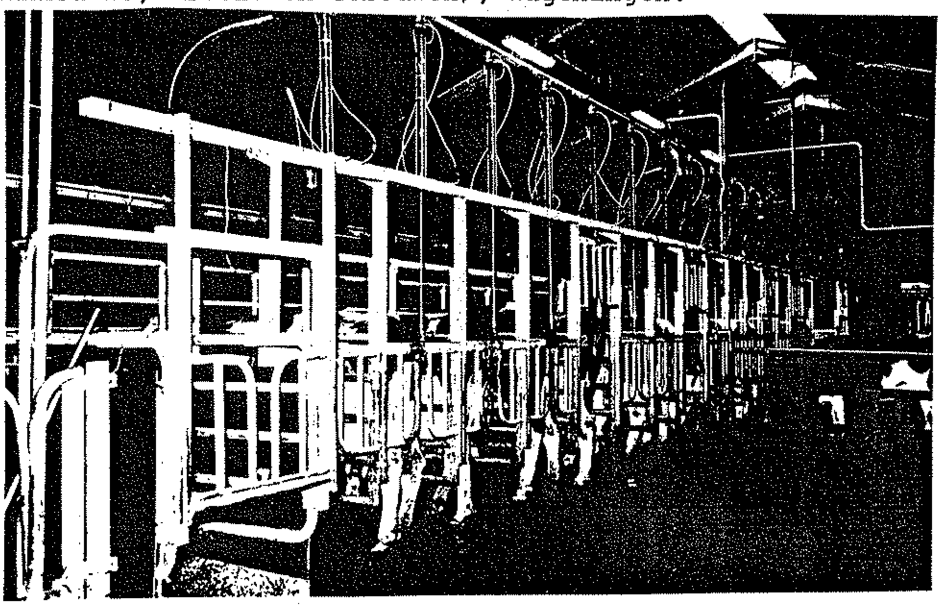

Fig. 8 - Feedboxes for individual forage feeding

When a cow is identified in a feedingbox (Fig. 8), the gate at the back of the box is closed and the relevant cownumber is passed to the computer. Depending on the need of the animal a weighed portion of forage eventually mixed with concentrate is dumped in a small bunker which is guided along a rail to the appropriate position and the mixture is dumped in the manger.

MANAGEMENT SYSTEMS

A number of firms are already supplying computer systems, by means of which various signals, such as milk quantity, temperature and conductivity of the milk can be processed. These systems signal the anomalies occurring among the individual animals as well as the herd as a whole. Programs are also available for the cow calendar and animal management.

AUTOMATIC ATTACHMENT OF TEAT CUPS

As signalling of the various anomalies can be done automatically; the last part of the milking process, attachment of the teat cups, can also be automated. In many dairying enterprises, automatic cow identification systems are linked up with feed dispensing stations in which the concentrate is dosed. If such a feed station can also be used for milking, then the milking parlour is in principle no longer required. As the animals remain there all day, it will be possible for them to be milked several times a day (Rossing, Ipema, Veltman, 1985).

At the IMAG experimental farm a test was run to find out whether this feed dispensing station is also a suitable place for doing the milking. The feed station was therefore equipped accordingly. During the test period of 11 weeks, 20 cows were milked in this milking-and-feed station. The feed station was manned continuously. When a cow presented itself at the stall, the teat cups were attached if the animal had not been milked in the preceding period of three hours, and the yield was expected to be 3.5 litres at least. It was found from the investigation that the cows presented themselves at the stall, on average, 5.4 times a day and that they were milked, again on average, four times a day. The frequency of presentation at the stall and the number of milkings are shown in Fig. 9.

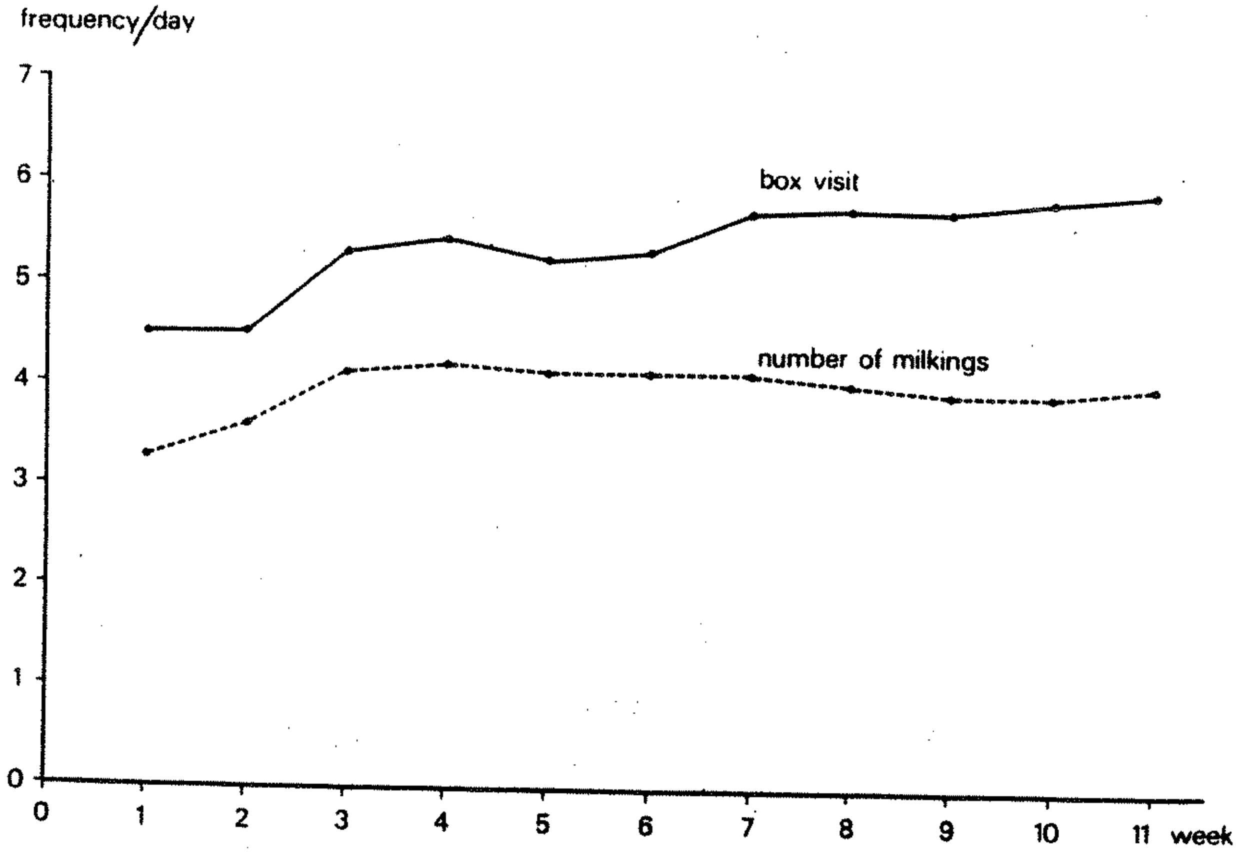

Fig. 9 - Frequency of presentation at the stall and number of milkings a day (average a week)

It was also established that productionrose during the test period. The trend of the standard cow production in the test group and that of the rest of the herd are given in Fig. 10.

From the large number of samples taken from the individual milk yields it was found that the fat and protein content remained constant during the test, and that this was also the case in the periods preceding and following the test. The animals were unusually placed during the test period. In view of the prospects, IMAG, in cooperation with the industry, has commenced the development of a system in which a robot will attach the teat cups to the animals.

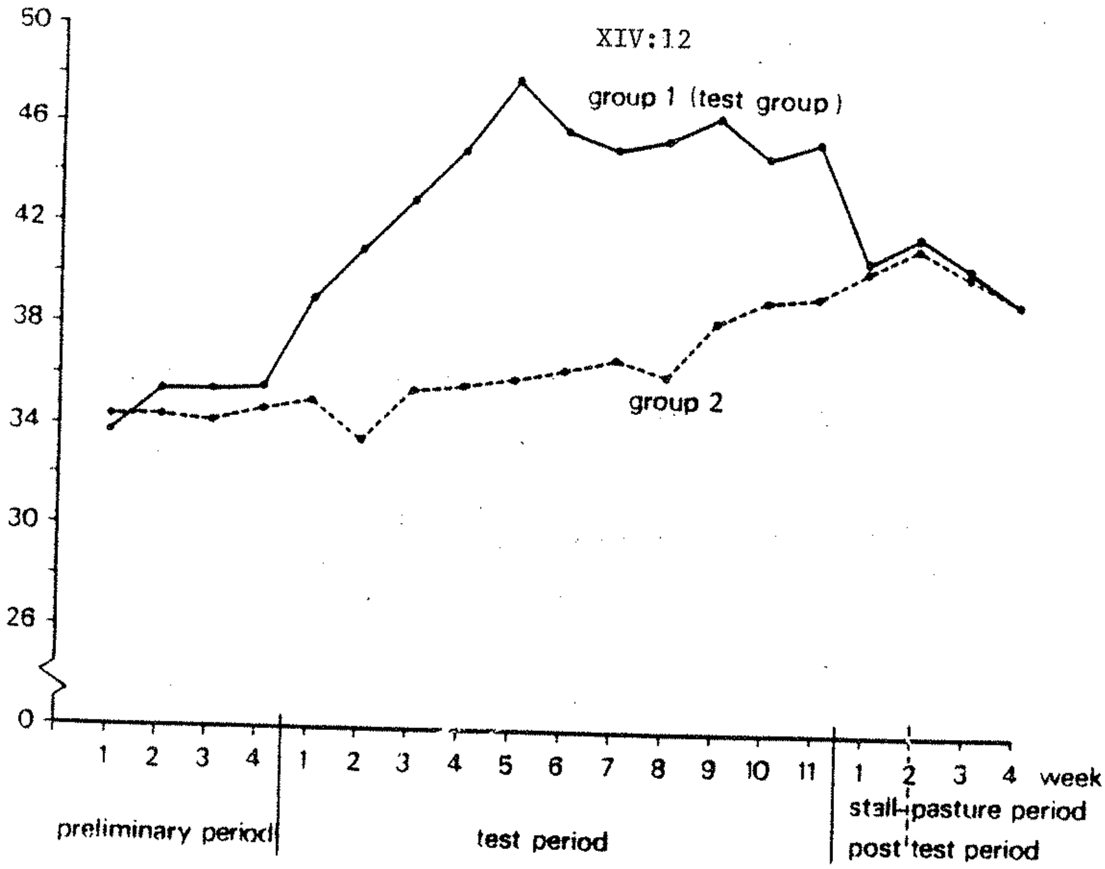

Fig. 10 - Trend of standard cow production of test group and of the rest of the herd at the experimental farm

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Basic Biological Conditions for a Simplified Automatic Cluster Attachment

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Automatic cluster attachment and quality control of roughage are the two main missing parts in an automation of milk production if todays knowledge about cow identification, yield and body weight recording as well as oestrus and sickness detection are put together within a management system.

In our point of view, automation differs qualitatively from mechanization. Mechanization deals with averages and individual variances are regarded as disturbances. Therefore any solution within mechanization demands for larger numbers of animals for cost sharing. The central part of any solution within automation is the handling of information about individual values, i.e. it does not regard variances as disturbances but as production potentials. Therefore there is much less economical pressure for large-scale solutions in real automation.

Therefore we hesitated to determine on a robot-solution for the cluster attachment problem. Our analysis of the cluster attachment process revealed a sharp threshold of complexity and costs at the identification of the single teats and the attachment of the teat cups on them. Either too many udders would be excluded or a very expensive robot-technique would be needed. Both measurements demand larger herds in order to share costs.

The next question was, why double chamber teatcups with collapsing liners are needed. The answer is that the conventional milking technique developped purely historically and empirically. Up to 1981 there did not exist a reasonable description of the biological function of pulsation.

At that time - roughly 80 years after the introduction of the double chamber teat cup and many years of it's world wide use - WILLIAMS et al. (25) published that the collapsing liner mechanically presses superfluous blood- and lymph fluid away from the teat tip area. Therefore the streak canal diameter is wide enough again for a satisfactory flow rate in the following suction phase. It had been known since 1973 that the teat tissue volume increases during a milking event up to 100 % due to that congestion (15). The next step in our analysis (11) was to ask, where this congestion in detail may arise from:

1) Many researchers (7, 26, 27) in the milking field refer to the vacuum level. Indeed, vacuum in milking machines has three functions compared with a single one in suckling. In addition to the opening of the streak canal it also has to keep the cluster on the udder and to lift up the milk from the claw. Roughly the average vacuum level of milking machines is at least twice as high as that of the suckling calf (1). Both additional functions may not be needed in automatic milk production. Already today the transport of the milk is delt with separately sometimes, and it is easy to imagine that any mechanical device for cluster attachment even can support it during milking.

2) There are strong indications that the lips of the liner mouthpiece mechanically counteract venious blood flow and in this way essentially contribute to teat congestion (10). There is no realistic function description of the liner mouthpiece either, despite of that commercial milking equipment producers hold several patents on mouthpiece configuration. Fortunately in 1978 BOTHUR and WEHOWSKY (3) analysed the formation of stripping yield. Due to their work we know today that the mouthpiece lips are the last contact between cow and machine and the last seal against atmosphere at the end of the constant flow phase when the teat shrinks and the contact to the liner barrel is lost. It is clear that as long as we stick with the principles of the present teat cup construction, we do need these narrow lips at least for sealing within certain situations.

3) In one of his numerous publications PEETERS (17) points out that the action of the smooth muscles of the teat may support some parts of the local circulation. In fact there are some details within the results from DELWICHE (4) which can be interpretated in that way. DELWICHE milked in a linerless cup with conventional vacuum application, i.e. 70 % pulsation ratio, 50 kPa vacuum and 1.0 Hz pulsation frequency. During this treatment he observed unexpected modulations of the momentaneous flow rate. These modulations had an own frequency between 0.02 and 0.2 Hz. This is exactly the frequency range which many researchers observed under a wide varity of conditions for the activity of teat smooth muscles as well between as during milk removal (2, 4, 5, 9, 16, 19, 20, 21, 24). When DELWICHE changed pulsation frequency to 0.3 Hz he got two results

   - the flow modulations disappeared due to a synchronization between the activities of the smoth muscles and the pulsation

   - and the flow rate increased to the double level compared with the modulated flow situation. This second phenomen may even be the result of less congestion due to the stimulated smooth muscle activity.

But still we had been doubtful wether it would be worth while to look closer on slow pulsation frequencies because it is often quoted that calves swallow with a frequency of 2.4 Hz (22). But this revealed to be a wrong quotation which can happen when interpretations are carried over from one publication to next one. In the original paper (1) you can read that the vacuum in the mouth of the calf swings with a frequency of 2.4 Hz. But the author also reports that the calves had the tendency to look regularly for other teats in spite of uninterrupted milk flow from the artificial experimental teat. He quotes an older publication where those teat changes had been registrated. And when you calculate these figures, you got a teat change frequency of 0.04-0.15 Hz (6).

At that point we started to discuss some hypotheses about the function of teat smooth muscle acitivity during milk removal (11). All researchers (2, 8, 9, 24) agree that peristaltic teat oscillations between milk removals have the function of keeping the streak canal closed against the pressure of the already produced milk. We believe that regular oscillations with emphasis on relaxation may be mother natures own way for opening that valve. Physiologically a change in emphasize from contraction to relaxation is possible because there are both α - as well as β-receptors in the smooth muscles of the teat. Additionally these muscles belong to the adrenergic group so that even a humoral exitation may be possible (8, 17, 18, 23).

It is hoped that teat tissue congestion may not arise in such a "natural" milking procedure, which is a precondition for successful linerless milking. And linerless milking itself must be regarded as the fundamental precondition for simple and cheap automatic cluster attachment.

We even believe that a milk removal technique which is based on a maximal activation of the smooth muscles of the teat also can result in an immediate closure of the streak canal after milking in opposite to what happens in conventional milking technique (14). In that case teat dipping is not needed - which would be the utmost elegant solution for that problem within automation of the milk removal process.

In our present research we try to identify well defined pressure profiles which stimulate smooth muscle activity instead of counteracting it. We measure instantaneous flow rate according to the principles of DELWICHE. Ultrasound is reflected from gas bubbles in the moving milk probe. A frequency shift can be registrated which is analogue to the fluid speed. If the fluid tube is filled, speed and volume are correlated. Simultaneously we measure tissue impedance changes at different current frequencies in order to examine the local circulation. This measurement method was developped during the last 2.5 years at our own department (12, 13).

So far electronics are heavily involed in these complicated measurements. But we are prepared that the adoption of pressure profiles to individual cows and/or milking events may be superior to the application of standard profiles so that sofisticated control engineering may be needed for optimal processing.

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COMPUTER-TOOLS IN FARM BUILDING DESIGN AND EXTENSION WORK.

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Starting remarks.

Many have suggested that architectural- and engineering offices not using computer aids will be out of buisness within few years. This has been evident for engineering already. For structures of notable size and complexity computer analysis is always used, and design procedures are increasingly used as well. In ship, dam and bridge design this has been done on computers for more than 20 years already. With small, low cost microcomputers (and better communication) this is now happening with smaller, simpler constructions as well.

The architect has so far been less affected. However, a development is under way that will drastically change his work tools and way of working within few years.

Farm building designers is doing architectural and engineering design. Hence they have to be competitive, or be out of buisness no matter if they are private, company or official workers. The computer age gives new challenges and possibilities. The profession should use the opportunity to raise the quality of the services they can offer to a still higher level than before.

Using computer tools: For what?

Computer equipment is superior for logging, storage, retrieval, processing, and presentation of information in any form. It can be quantitative or qualitative, numeric, verbal or graphic (pictorial).

A building designer does very little but to collect, process, create, communicate and store information. Computer applications are therefore easy to find. Lack of imagination is one of the more limiting factors for this development. To take the applications in use require not only imagination and systematic approach, but a heavy load of work as well for development and introduction.

a. Input.

Commonly we find the farm development economy plan, earlier building plans, other documents, and data from the farm as the main inputs.

[1] professor dr. techn.

From the farm a map over the site area is important. If changes or extensions to existing buildings are actual, drawings containing all relevant informations are needed as well. If good enough map and drawing does not exist, they have to be established.

Data of notable volume to be used later in a computer should reside in the computer, or be registered directly without in-between paper sheets followed by keying-in and correctioning.

The economy development plan is/will be made using computer programs. Hence the data needed for building program development are stored already. It will be a typical computer task to look up the identification and location for past drawings and other documents for the same farm, or for a similar farm that could be used for comparison or as a model.

To get input for map production computer readable directly, a "total station" or a hand-held terminal is needed. The "total station" will write the surveying data (angles, distance, identification) directly into local storage by pressing a button. The cost is too high, though, for common use now and then. But a hand-held terminal will be able to receive and store data for several days of work with the tachymeter. One just key it in there rather than write in a note book. The same old tachymeter is still good, the cost is less than a tenth of a total station. Typical prices are 130-200.000 NOK for a new total station, while adding a hend-held terminal cost 10-15.000 NOK incl. program.

They both transfer their data by direct line or telephone to the computer.

b. Data preprocessing.

Economy development figures need conversion before entering a building program. Number of dairy cows/year define the average figure over the year for lactating cows. Number of cubicles, m^2 of pens and so on for all ages of animals needed to keep up such a production must be derived. Feed units or MJ have to be converted to space requirement in m^2 and m^3 for the different, actual feeds. Space needed for litter, produce, and waste must be derived. Space for auxiliary rooms and equipment must be added. All space needs should be optimized, which is a complicated task. Crop, size of stock etc. have stochastic variations over time. How much capacity above the planned average throughput is it profitable to design the building for?

We have started making computer programs that will assist the building designer in this data conversion process. There is a lot left to do.

<u>Map production</u> based on field data from a hand-held terminal (or a total station) can be fully automated (except corrections and some additional text). The computer produce a ready map (or drawing) from a plotter. A few programs of this type are in use, i.e. for road planning purpose etc.

Maps could also be produced from aerial photos. So far this is less convenient for small, scattered areas like farm building sites.

c. The design process

will be a creative process in the human mind, as it has always been. The tools used during this process will contiue to be manifold. However, before long one or more ideas for solution must come out. Paper, pencil, calculator and typewriter have been the aids for visualizion and documentation of what it looks like, use of materials and constructions. These tools are increasingly replased by computer work stations using programs for CAD (computer assisted design).

A graphic screen replace the paper sheet, a keyboard or a "mouse" replace the pencil, a plotter replace the technical drawer. The designer chose among materials and constructions already defined in various ways in the computer. Once the geometry and choice of materials and constructions are pinned, the product definition is made. Production of all needed documents, such as drawings, building description, costing etc. can then be done automatically from the program. The designer will on most steps in the process have the opportunity to make changes or additions to the pre-programmed options.

Most CAD-systems so far handle drawing production, in two or three dimensional geometry. Some will be able to picture a new building into a digitalized photo of existing surroundings. Few systems for buildings handle material type, quantity, description and cost, but a few for some types of buldings does exist. Till lately CAD systems were implemented on mainframe or mini computers, and cost a lot of money. A new generation designed for micros are now in fast development, and with a much nicer price tag. Still, they are designed for not too complex buildings. Bigger projects still need mini- or mainframe CAD systems.

d. Engineering design.

No building plan is complete without sound engineering design as well. How much the architectural concept have to be changed to include it, will vary a lot depending on degree of innovation and complexity in the concept, and on the skill and experience of the designer.

Correct working drawings, quantity lists and costing can not be done until until the engineering design is final, and is entered into the computer representation of the product.

Program modules for engineering design are integral parts of CAD systems for mechanical industry. So far no CAD system for buildings are able to handle engineering design as well. It has to be done separate, and corrections must then be entered to the other program.

For static analysis there is a vast amount of computer programs available that will ease the task for the engineer. Almost all of them use FEM-analysis and are general for a type of construction (truss,plane frame, slab etc.). Such programs are still made by civil engineers to be used by qualified personell.

The number of programs that will make an intelligent design based on the analysis is so far much more restricted. Such programs are less general, and less portable. The have to be tailored to national standards for materials, engineering design, construction requirements and so on. But a choise of programs for civil engineering design of different types of constuction members (trusses, beams, slabs, coloumns etc. made from wood, steel or reinforced concrete) are available. Other engineering jobs as heating and ventilation design can likewise be done by using computer programs.

e. Project documentation (postprocessing).

We have mentioned the creative process in architectural design, engineering design, and choice of material (integral in both). From the emergence of the concept in the designers mind till all needed documentation necessary for getting financing, grants, building permission, bids, and the construction job done, there is a large amount of work before all details are covered.

This holds for engineering design of building parts as well. It is a long way from the result of a static analysis till a ready truss drawing including all dimensions, fasteners and other details, included description, materials quality, quantities and cost.

To get full advantage of computer methods the information produced should be output from the computer in the final form for use. Hence graphic screens, drawing programs and plotters become necessary for design offices. All written documents likewise should be produced from the computer. Hence word processing programs are among those of greatest value. Exellent programs will be able to include output files from other programs as well, and to perform arithmetic operations on included data such as quantity and cost figures. Word processing programs looks more promising for the production of a description and costing document than purpose-made programs available in Norway now.

f. Job administration in the design office

is an important part of the work. It is important for filing, storage and retrieval of documents as well as for keeping record of use of time and other resources for each client, to give basis for writing the invoice. Accumulation of key data for each job gives a data base for statistics of various kinds that can be of great interest. There are purpose-made programs for such functions. More general database-programs such as DBASE-III or DATAEASE will probably give rise to more flexible and customized applications.

g. Job administration during construction.

There is so far very little specially made for the control engineer. But he will be able to use the same tools as architects, engineers and contractors.

Job administration is extremely important for the contractor. Hence many larger companies have advanced systems in use, and a lot of program systems for different type computers and size of operation do exist.

Often the construction phase involves a delivery of a prefab building or a package-deal delivery. Companies active in the prefab industry often are active users of computer technology in all the steps described above.

So far the slow budgeting process have given farm building designers and advisers on public payrolls few opportunities to follow up in the above mentioned rapid development.

h. Advisory work.

Each new building should be given a "Users guide". Very often the user does not fully understand how climatization does function and ought to be run. Using actual building data, stocking rates and local climatic data a computer program can easily simulate the building performance. Results can be plotted as easily interpreted graphs. Such information can be produced for existing buildings as well.

Results as mentioned here will allow the farmer to compare the performance with what it should be expected to be. Hence he can detect bad performance and start spotting and elimination of causes.

i. Other planning jobs for the agricultural engineer.

The above has put the building designer in focus. It is obvious that a mulitude of the same tools can be used for producing plans for roads, drainage, irrigation, and complete machine system selection. But there will be additional needs for specialized programs and data as well. That is where the skill and expert knowledge of the profession comes in. Some, but very few such programs exist, to my knowledge, in the Nordic countries.

CONCLUDING REMARKS.

The work of the agricultural engineer is rapidly becoming dependent of efficient use of computer based tools. Some of them are ready for use, and only money and time for purchase, education and training is needed to get them in use.

Others are dependent on the professional knowledge that only the trained professional have, or they have to be custom-made or customized to specific needs to be effective. It is important that the agricultural engineering institutions take initiative to and carries through this part of the software development. Otherwise each user, or software consultants without ag. engineering background will try to do this job. In both cases a lot of time and cost will be spent in making no-good software that pretends to be of quality.

To take the responsibility to make quality software for agricultural engineering applications, the institutions will need some resources which are scarce now. It may be a software engineer to complement a team, and pieces of hardware and standard software to be used in a more complete system. But mainly it will be dedicated funding of explicitly defined software development jobs. Such projects should be coordinated between several countries to get a wide variation of jobs covered with quality software within a reasonable time. A possibility of data transfer between programs is highly desirable, but requires even more coordination. That such software be made portable between different common hardware is an important requirement which too often is forgotten.

DISCUSSION, SECTION 3

John Matthews

Within the feeding topic, chairman, can we talk about identification a little more and mention that surely for fatstock a satisfactory identification system must be available right through the living animals, the meat processing phase and carcass phase. One wonders what this does when the usual process on the line for pigs is to cut the carcass in two. Something attached to one ear is left on only one half of the carcass. I think this despite that, one could arrange in the factory for the identification of both halves to be recognised by the computer, but I'm sure that one of the benefits of this is that any automatic accounting within the processing factory will half pay for the cost of the identification.

Jørgen Svendsen

I suggest that if you could get the identification system to work and you develop a feeding station for slaughter pigs, then individual electronic feeding of slaughter pigs may have some additional advantages -for example, development of housing system which are different from what we know today; mixing of different age groups of pigs; and continual changes of feed composition according to the specific needs of the animal.

Wim Rossing

By means of new techniques the prices for the identification system can be rather low. But I think that a feeding system for individual feeding of slaughter pigs will be expensive, you need a feeding unit for 10 to

20 pigs. When we go to a national system for identification the prices for this systems can go down to 10-20 SEK per transponder.

John Matthews

Could I contribute that my current thinking is that we would not identify and deal with pigs individually but in batches of 10 or 20, that is whatever is the economic batch. Now there may be some arguments that this is not good welfare. I believe it to be a more economic solution that one feeds a unit of 10 pigs the appropriate total quantity, perhaps connected with a size-sorting when the pigs are still very young so that one divides into different size-groups and thereafter treats them as a family of ten, with only one identification unit.

Egil Berge

I would like to follow the line taken up by John Matthews: That has been done all the time, and they say that if you could reduce that amount of competition between the individuals then pigs wouldn't develop differently fast and you could deliver them to the slaughterhouse all at the same time. If you keep them in one group you may computerize this. We should look for any possibility to eliminate the competition between the individuals inside such a group.

Another thing: Rather than working with complicated mixing of different qualities of food, which maybe difficult and costly, couldn't one sometimes meet individual needs by having a few stations, each giving single quality of feed? Then the computer could calculate how much every individual shall have from each station, so that it in total gets an optimum ration. Would that be another way to get at the problem? Thank you.

Wim Rossing

As the system for automatic individual dispensing of forage is rather complicated a numer of units in the cubicle house is to expensive. When you are dispensing at different places you have to store small amounts of forage at different places. This can give problems for the quality of the forage.

The dispensing unit I presented in my paper is complicated, the mixing unit however is a fairly simple one.

Michael Mayntz mentioned that there can arise some problems when you are milking the cows every time with the same milking unit. The reason for this problems is that the liner in a teatcup is always folding at the same place.

In our experiments on our experimental farm we are milking a number of cows already from september with one machine. Up till now we have had no problems. Every month we are controling the teats.

I know there have been some problems with an experiment in Kiel, but they milked all the cows, also the cows with a low yield, six times a day.

In our experiment the average milking frequency was 4 times a day, the high yielding cows up to 6 times and the low yielding cows 3 times a day.

Michael Mayntz

I agree that there are large variations concerning teat and congestion between different herds and individual cows. There is no doubt that some may be less suspectible than others. But if we want to construct equipment for commercial farms, I think it should fit to a wide variety of races and individuals. If the analysis is right that the liner movement only is needed in order to counteract teat congestion, what should be wrong with the concept not to have any congestion at all?

<u>John Matthews</u>

I wonder if many people are aware of the new so-called "hydraulic" milking systems on trial on a large scale in England at the moment where the teat canal is not closed completely during pulsations? All the signs are that milking is faster, and that there may be less risk of mastitis because of the reduction of cross infection as milk flows in and out of the teat cups. It looks a good system from an electronics man's point of view because one can visualise full pipes all the time and hence better abilities to measure conductivity or temperature. The system is still at the farm trial stage and is not commercially released yet.

<u>Michael Mayntz</u>

Excuse me, I don't want to start such a milking experts discussion, but I have some doubts according to hydraulic milking. Fundamentaly it consists of the conventional milking technique. The main difference is a gas-tight back value which is inseated in the short milk tube. But if you read all the papers about cross flow etc very carefully you see that there isn't nearly no cross infection within the same udder. The carrying over of infections material happens between cows. E.g. if you milk a cow with mastitis on left front quarter, the inner surfaces of left front liner become infected and when this milking unit is put on a new cow, you got a higher probability for new infection at her left front teat. This problem is not solved with hydraulic milking. It can only be solved with cluster - flushing between cows. Nevertheless there are many other details in the hydraulic milking system which make it an interesting development.

I just don't want to ask a question but to put a short comment. I became very glad when expression electronic stress arised, because it is really a new point of view. I think we should not restrict the electronic stress to the animal. We should not forget the farmer. It is he who has to deal with all this new equipment and he may be put under an electronic stress even worse than that one to the animal.

John Matthews

We haven't dealt with poultry and the review appears incomplete without it because we have tended to specialise in that area. Perhaps I could mention our work on electronic weighing and sorting by size of poultry which seems to work. We have to employ an electronic ejector to gently persuade the poultry off the weighperch and again when weighed to put them into the appropriate area. On welfare aspects may I mention the mechanised harvesting of broilers, where we have been able to use electronic instrumentation to measure the stress of the birds. It proved to our own satisfaction that we can make machines to generate less stress when broilers are collected from the building than is generated when they are collected manually. I think that is a different example of the use of electronics.

Jørgen Svendsen

I have a question to Mr. Rossing that has something to do with the human factor: You showed figures from a trial where you were using this pedometer on cows, and used the amount of walking as a heat detector. Why do you make these experiments? Why don't you just observe the animals to see if they are in heat? Are we not making a mistake if we start trying to make things more complicated than they are, using electronics to detect things which you can observe if you are present in the herd?

Wim Rossing

By visual observation the farmers are finding around 60-65 % of the cows which are comming in heat. Specially on the bigger farms they are missing a number of heats. It means that you are exchanging three weeks with a high productivity to a low productivity. This costs 4-6 SEK per day. So we think that it is valuable to develop sensors for detecting cows in heat.

Frode Guul-Simonsen

I have a comment or more correctly a question: Is it possible to replace the farmers eye with sensors and can you measure health by animals in the future? I really think it is not possible. In Denmark we say "farmers eye are feeding the animals". Sensors can only be a help for more correct feeding of cows and a help to take care of more animals, maybe serving over 100 cows pro person.

John Matthews

Could I just say, with respect to my ergonomics colleague present, who is speaking tomorrow, that being behind and below a cow is not necessarily the best place to observe health. I believe that for the husbandry man to be watching cows in a group and how they behave in a group outside the milking parlour is likely to be more effective than inside. As to whether we can use electronics for animal health I can only say that we have a visiting worker this summer who wishes to begin a project to use visual pattern recognition to see if we can recognise illness by the hung head or the floppy ears or other signs of dissatisfaction. I think there are many years to go, but it is interesting that people are beginning to work on the project.

Richard Matzen

I am referring to Mr. Rossing who told us about sensing milk temperature within 1/100°C. What is your experience with the reliability of the sensors in your experiment? And one more question to Mr. Matthews who mentioned the new generation of transponders. It should also be used for pigs including the treatment in slaughteries, e.g. boiling water and the flames so it will reauire quite high standards? - One has to request a standard procedure for testing of sensors reliability.

Wim Rossing

The accuracy of the sensor for measuring the temperature is + 0.1 C. In the long milktube we have problems with heat losses. The results with a sensor in the short milktube are good. The cabling from the sensor along the milktubes can give some problems. The sensor we are using is a thermistor (NTC).

Sven Andersson

I would like to ask Mr. Rossing if you have been looking at the feed-back systems for feeding animals, for example pigs and cows? I mean program for calculating the necessary quantity of feed in dependence on the daily milk yield variation?

Wim Rossing

Yes, we are calculating the amount of feed every day. The amount is based on moving average of the milk production. You can not do your calculation on the production of one day, when namely the yield is going down the cow get less food and the yield will go down again. We use for feed calculation an average of the milk production of 7 days.

SECTION 4

XVII:1 NJF-Symposium "Computers, electronics and control engineering in agriculture", Åre, Sweden, 3-5 February 1986.

THE HUMAN FACTOR ASPECT IN APPLICATION OF ELECTRONICS AND COMPUTERS IN AGRICULTURE

By Lars Sjøflot

Norwegian Institute of Agricultural Engineering

1. Aims for agricultural production and for the individual farmer

The main aims for agricultural production will be:

- production and delivery of enough food and other agricultural products with acceptable quality and low costs.

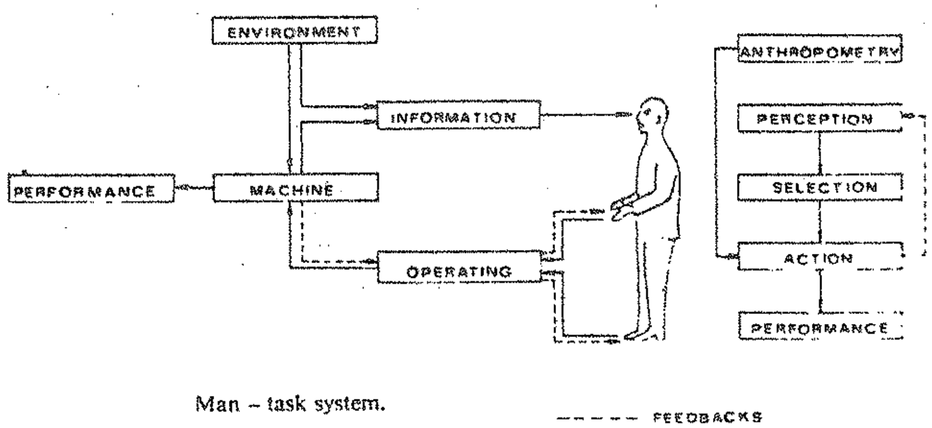
The overall aim for the individual farmer is:

- general wellbeing and meaningful life; which include
    - Good health and security
    - Optimum of stress and challenges physiologically
    - Job satisfaction through satisfying work conditions, quality and efficiency of work

Studies of the human aspect in utilization of electronics and computers must be seen in connection with these aims. Is application of electronics and computers in agriculture beneficial to man?

2. The man-task system

In studies of man at work models of man-machine or man-task systems give a good overwiew and base for analysis of principles and functions.



Man – task system.

The direct interface between man and machine/technical aids of interest for this symposium are:

- Information ⟶ perception (sensing)
- Operation ⟶ action (using hands and feet)

Between these interfaces we have in man selection and decision making; highly depending on the information input. In addition for total assessment of a man-task system we also have to consider:

Effects of environmental factors

The mental functions and emotional side in man

Man's sociological needs

The whole system's performance will highly depend on man and his ability to gain necessary information, to handle it properly and act correctly. Ergonomics is the science of man-work relations and thus quite necessary also for utilizing electronics and computers in the system.

3. Existing knowledge on human factors engineering

The clasical human factors engineering or ergonomics, just deal with the man-machine interfaces of interest for application of electronics and computers in form of instruments, indicators and other displays giving information. Also principles of control where electronics are involved were there from the beginning. Knowledge in these areas has increased considerably throughout the years since the more formal establishing of ergonomics after world war two.

To day we have good knowledge in the areas:

Design of instruments and displays
considering:
- readability and perception
- principles of effective information transmission
- logical function
- location and arrangement

Design and function of controls
considering:
- principles of control tasks; possible feedback etc.
- type and location according to force/precision requirements
- form and arrangements
- logical function

Displays and controls seen from working posture point of wiew

The superority of man or machine for different tasks

Textbooks and handbooks of ergonomics will cover the necessary principles and knowledge for specialists and designers of electronics and computer systems. In the latest years there have been a lot of projects and studies especially on ergonomics of computers and application of electronics. Results are given in special books, scientific papers and articles and also in more popular publications. It will be very important in the future that designers and others influencing on development of computers and electronics get proper education and knowledge on ergonomics.

4. Electronics and computers as aids for achieving aims for individuals in future agriculture

In general the most clear benefits of electronics and computers for individuals in future agriculture will be in situations/jobs/operations as follows:

Operating dangerous machines and installations
- by increased safety through proper warning, automatic stop etc.

Heavy and loading tasks; especially tasks requiring high precision, high working rate, bad working posture
- by using outher power sourches controlled electronically; electrohydraulics are good examples

Dangerous and "dirty" jobs in unacceptable environment for man
- by replacing man with automatic-/robotic systems

Monotonous and boring jobs or repetitive tasks
- by electronic aids, automatic and robotic systems

Jobs requiring high quality and high degree of continous attention
- by better monitoring systems and automatic control

Planning of work and production; combination of a big amount of data and considerations
- by using computers, and electronic system for collecting and storing data

Examples of some actual areas of application of electronics and computers in agriculture will be:

Tractors and combines; for avoiding accidents, increase feeling of security and satisfaction of work, improve working posture and make control and operation more easy

Equipment and technical installations; for improving job satisfaction and reducing uncertainty and stress through better monitoring, help in decision making or even automatic control

Grading and sorting of fruit, vegetables, potatoes etc.; for reducing attention stress and feeling of boredom, improving working posture and job satisfaction through higher quality and capasity of work

Milking machines; for improving working posture and reducing problems with inconvinient working hours

Monitoring and alarm systems in animal production; for having better overwiew at any time and thus better feeling of security and satisfaction.

Computers as aids in planning of work where also factors of environment, safety and ergonomics requirements can be taken into account.

The benefits for individuals of electronics and computers will highly depend of application of ergonomics in design, operational functions such as calibration, presentation and application of information, feed back in controlling systems and the operator's understanding of posibilities and limitations.

5. Problems if ergonomics and human considerations not are made

The utilization of electronics and computers might face two or three major problems. One is effects of bad system design as already pointed out. That might result in extra strain on man and none optimal system performance.

A second problem might be the general acceptance of the principles because they are new, they require new ways of thinking, they have to be learned and they have to be relyed on - to be trusted -.

A third problem can arise from the discussion of man-machine or man-techology interchange. Is it only good for man to be replaced by an automatic system or a robot? Is it really optimal to take all challenges away from an operator leaving him with only a very boring control room task where action only is needed when something goes wrong? The qestion also might be what should man do if all tasks can be done automatically? What about unemployment?

I just put up these questions. Some answers should be given every time we bring up a new equipment or a new system. If we do remember this side of human-technology relations, it will be easier to solve possible problems and to turn the development into the most positive way for mankind. In this connection it is very important to assess the total man-task system and not only the electronics or computer part of it.

6. Some wiews on needs for future research

Design. Even we have good basic knowledge of ergonomics in design and operational functions of electronic. equipment and computers, there will be a strong need for further scientific studies anddevelopment in this area. For agricultural purposes there might be a need for special instruments and electronic systems and therefore a need for special design to fit in with the practical use.

Standardization. In order to reduce confusion and errors, time and effort for learning, logical functions in comparative systems and situations should be estabilshed. For that reason some standardization is quite necessary. Establishment of standards is rather complicated and difficult. Scientific studies giving necessary results on the total working situation and practical consequences will always be a good base for standards along with reliable results on technical functions and other technical details.

Education. There will always be a need for scientific and systematizised results as a base for proper education; of designers and supervisors as well as for the practical user.

Total system view. It will be very important to have studies of how electronics and computers in the most optimal way can be a natural and integrated part of the total man-task system. In development and design there should always be people who can assess the total situation for the operator - for man -. General ergonomics is the area taking care of that. People specialized in electronics and computers should also have sufficient knowledge of ergonomics and they should work together with experts in ergonomics in order to develope the possible best man-task system. The main criteria will be the aims for the individual farmer along with the aims for agricultural production. An important part of that will be:

Impact on individuals. Effects of detail design and total system design should be studied and adjusted for by using parameters as operator's strain, safety risks, performance and feeling of satisfaction and well being.

We should always ask the question whether we are working towards the overall aims for the individual human being. Do we create and apply electronics and computers in a way that gives man more happiness, better health and safety, more feeling of well being and satisfaction by doing a good job and also giving a good economy?

SECTION 5

ALFA-LAVAL
AGRI INTERNATIONAL

Computers, electronics and control engineering'
in agriculture - NJF Symposium 1986-02-03--05.

DATA NEEDS AND DEMANDS ON PRECISION IN FEEDING AND MILKING OPERATIONS.

Bo L. Andersson, Agr.Dr

SUMMARY

The main objective of any dairy farmer is to ascertain a fair margin between income and variable costs. In a competitive situation he will have to resort to maximizing principles. In order to achieve this, it requires him:

- to have a good understanding of the production processes involved,
- to use efficient planning procedures,
- to efficiently implement plans,
- to continously monitor processes in terms of inputs, outputs and disturbances

In all these areas new technology in electronics and computer science can be of assistance.

It is emphasized in the paper, that in particular the efficient implementation of plans requires detailed information that traditionally hasn't been available to the dairy farmer. Emperical results and research studies indicate areas where mistakes generally causes substantial reduction in over all control efficiency. Such areas are:

-variation in distributed feed quantities,

-variation in individual consumption capacity (both quantity and speed) of individual animals

-variation in feed quality (moisture, energy, protein etc)

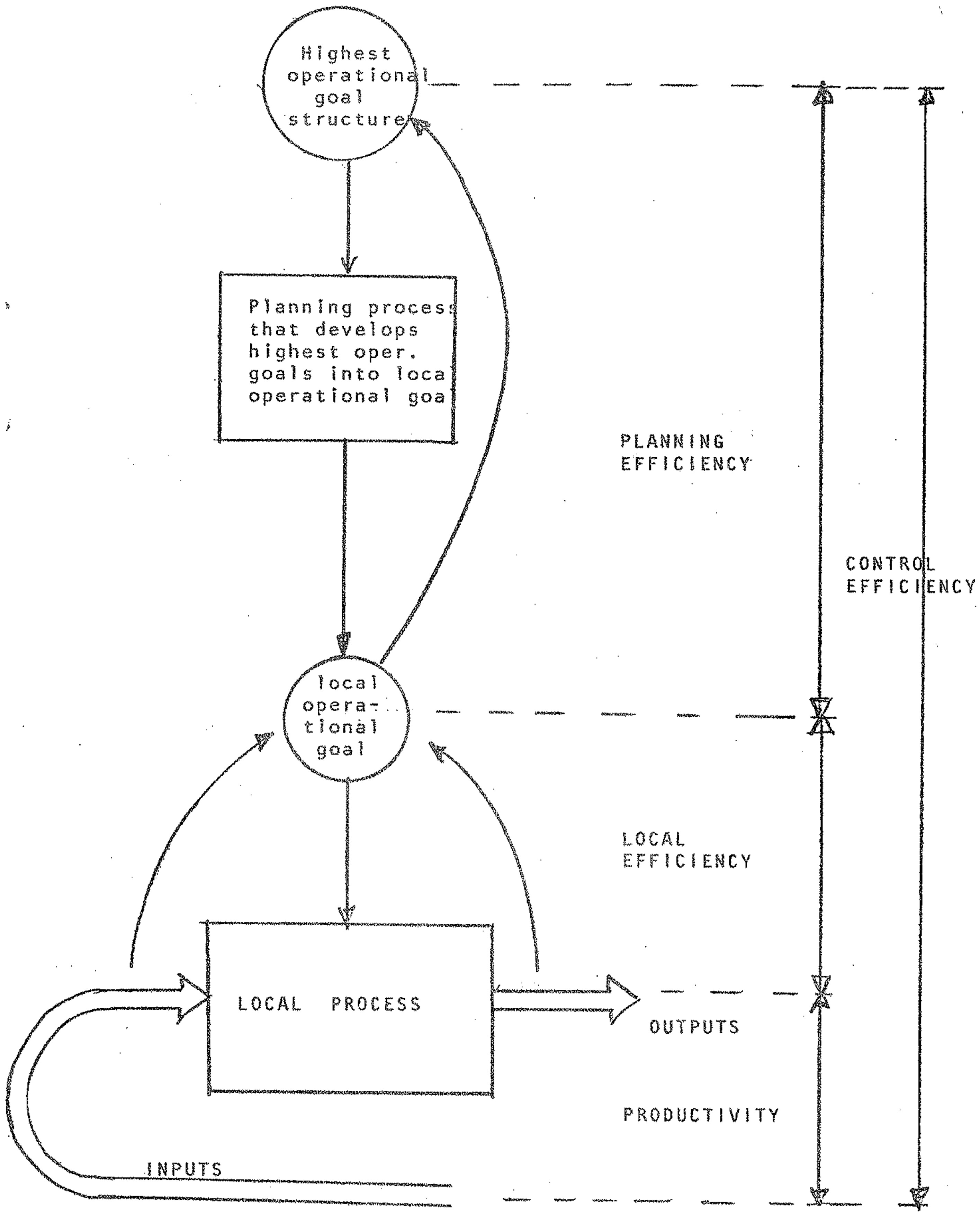
-impresize estimation of eustrus cycle

-poor detection of mastitis in early stages

-vague estimation of milk yields, etc.

In particular the absence of suitable sensors holds back further progress in many of these areas. Additionally we need further understanding of milk production as a process. Many existing decision aids (models) still treat production as stationary

FIG. 1. ELEMENTS OF CONTROL EFFICIENCY



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1986-01-21

THE 1986 SYMPOSIUM ON COMPUTERS, ELECTRONICS AND CONTROL ENGINEERING IN AGRICULTURE

DATA NEEDS IN FARM MANAGEMENT COMPUTER APPLICATIONS

by

Bo Öhlmér

1. INTRODUCTION

Examples of farm management computer applications in Sweden are:

- Investment analysis software
- Accounting systems
- Dairy cow control systems
- Dairy ration formulation
- Dairy management software package
- Sow control service
- Pig production performance control
- Pig management software package for breeding, fattening or integrated herd
- Arable management software package
- Poultry management program
- Beef management program
- Forestry management program

Some of these use main frame computers and others microcomputers which may be operated by the farmers themselves. The data needs are determined by the software application. The type of hardware used for running the software is of less importance for the data needs.

The use of this type of farm management tools and the use of information in farm management is analysed on a general base in section 2. The data needs derived from this use and the effects of automated data capture are discussed in section 3.

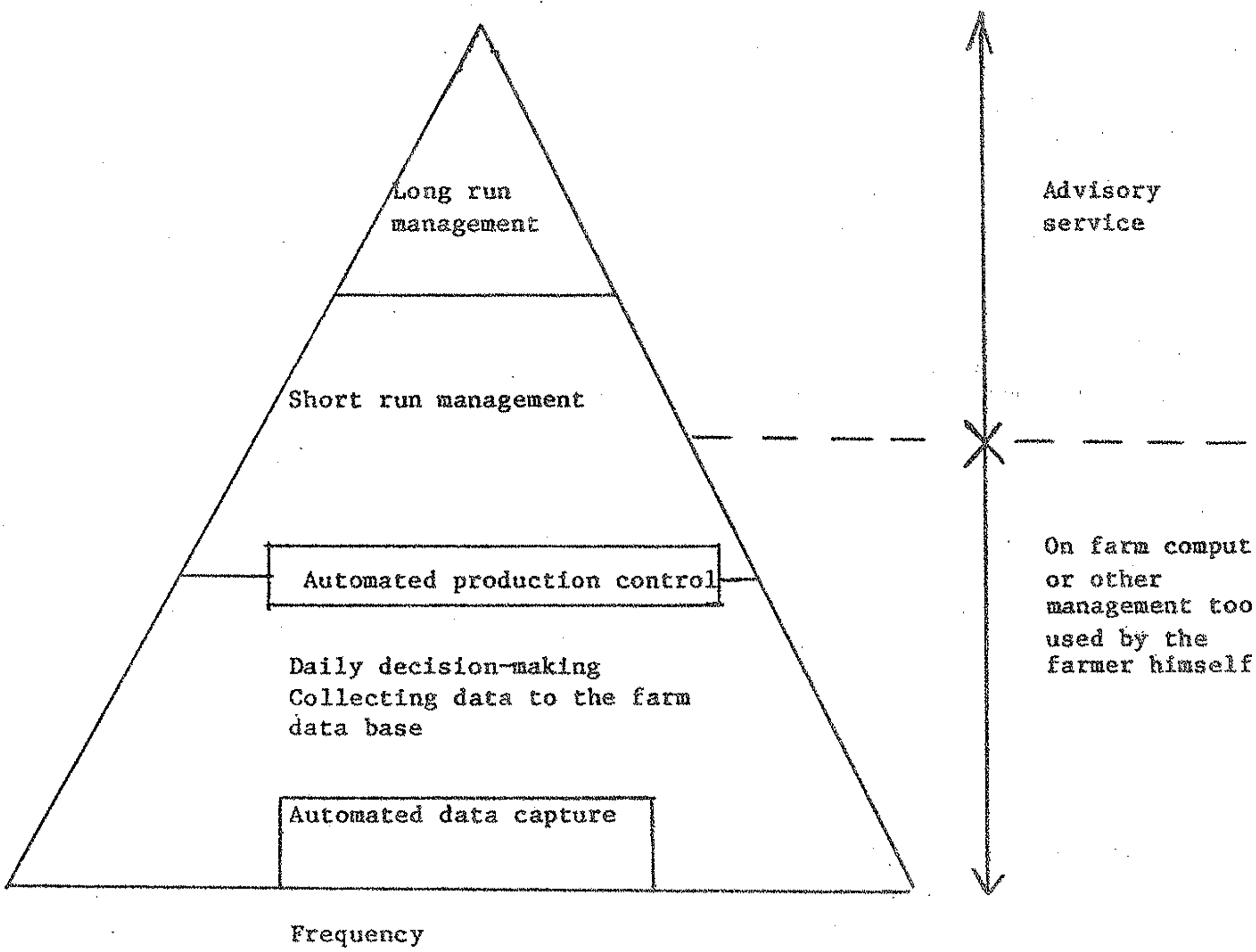
2. FARM MANAGEMENT AND USE OF INFORMATION

Some principles in farmers' needs of management tools

Farmers' management tasks can be classified according to the time horizon involved. The daily management and the short run management tasks (e.g. time planning, intensity-decisions, and combination of production means) are done so often that the management tools have to be handled by the farmers themselves. The advisers are not available every time a management tool in this class is used. The on farm computer system is a possible technique in management tools for daily and short run management.

Long run management tasks (e.g. investment decisions) are done more seldom. A single farmer needs management tools for these tasks so seldom that it is difficult for him to know how to use them. The tools may also be changed (further developed) between the times he uses them. The long run management tasks are more complex, more information from the environmental external to the farm is needed, and each task has great economical consequences. Thus farmers should consult the advisory service in this kind of tasks. The advisory service may use computerized tools for such long run tasks. The limit where a farmer should consult an adviser differs between farmers. See figure 1.

Fig 1. Principles in farmers' needs of management tools



In the daily and short run management, a farmer needs a lot of detailed data on the production. These data are gathered in the daily work and constitute the farm data base. Every farmer has some kind of a data base at his office even if he does not use computerized tools. But with the aid of a computer it is possible to handle the data more effectively so the farmer gets the right information at the right time with as little effort as possible. Devices for automated data capture may also be used in a computerized system.

In the long run management, the farm data are aggregated and analysed together with information external to the farm. The data gathering in the daily work is important for the long run management even when advisers are consulted.

The managerial process

The following functions can be distinguished in the managerial process for solving both nonrepetitive and repetitive management tasks:

a) Problem definition and tentative goal formulation

b) Information gathering from the environment

c) Information gathering from the farm including accounting

d) Analysis including planning and revision of tentative goals on the basis of new positive and/or normative knowledge as well as an improved decision rule

e) Final decision-making

f) Execution

g) Evaluation or taking responsibility to provide positive and normative feedback

These functions are presented as a flow chart in Figure 2. Function g is included in the same circle as functions b and c in Figure 2. This is because information is regarded as processed data and function g is a way of processing the data to become feedback information. After or during the execution there is a control phase. The result is measured and compared to the goals, and needed corrections are decided by repeating the process described in Figure 2. The information used in the decision making is also checked for accuracy. This is the compensation feedback loop in the cybernetic approach. This checking makes it possible to correct the standing plan and the next decision earlier than if the feedback information was based only on achieved results. This is described further by Öhlmér and Nott (1979).

Management tasks and use of information

Farmers' management tasks can be classified according to what portion of the resources are variable in the decision process, i.e. the time horizon. See figure 1.

Another dimension in the classification is what portion of the farm that is affected:

a) The firm level, which is the entire farm or more than one enterprise

b) The enterprise level, which is one enterprise or production unit within it

The concepts of the managerial process discussed earlier can be used in fulfilling management tasks in each of the classes. Cash flow planning and control is an example of decision making and control at the firm level. See table 1.

The needed information can sometimes be collected directly, as for payment routines and prices. Sometimes you have to process data to get the information, as for budget performance each month.

The importance of various decisions in an enterprise can be concluded from an analysis of how the decisions affect the gross margin of the enterprise. This is illustrated in figure 3. The information needed in each decision process can be analysed in the concepts of the managerial process, as is illustrated in table 2.

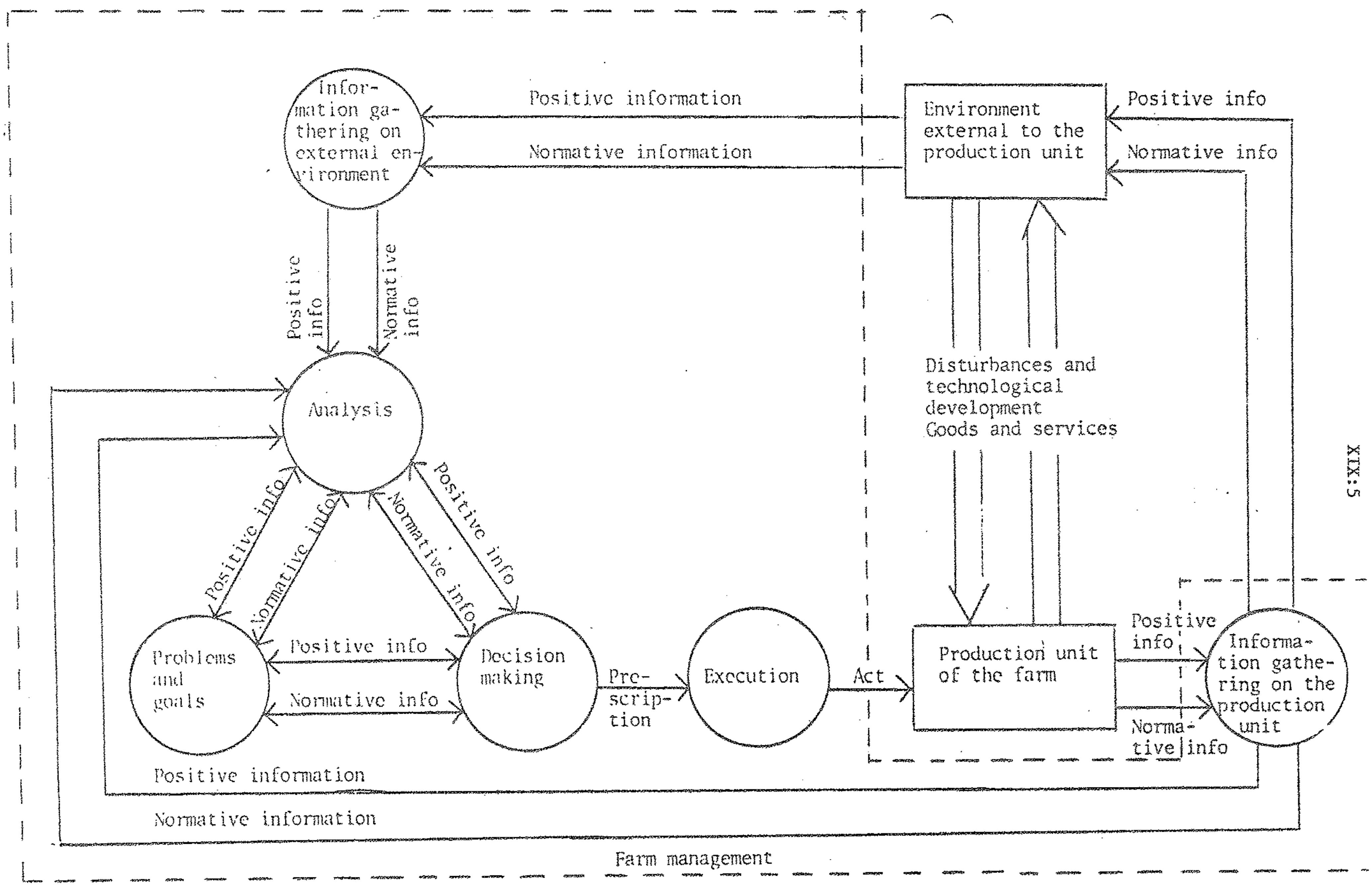
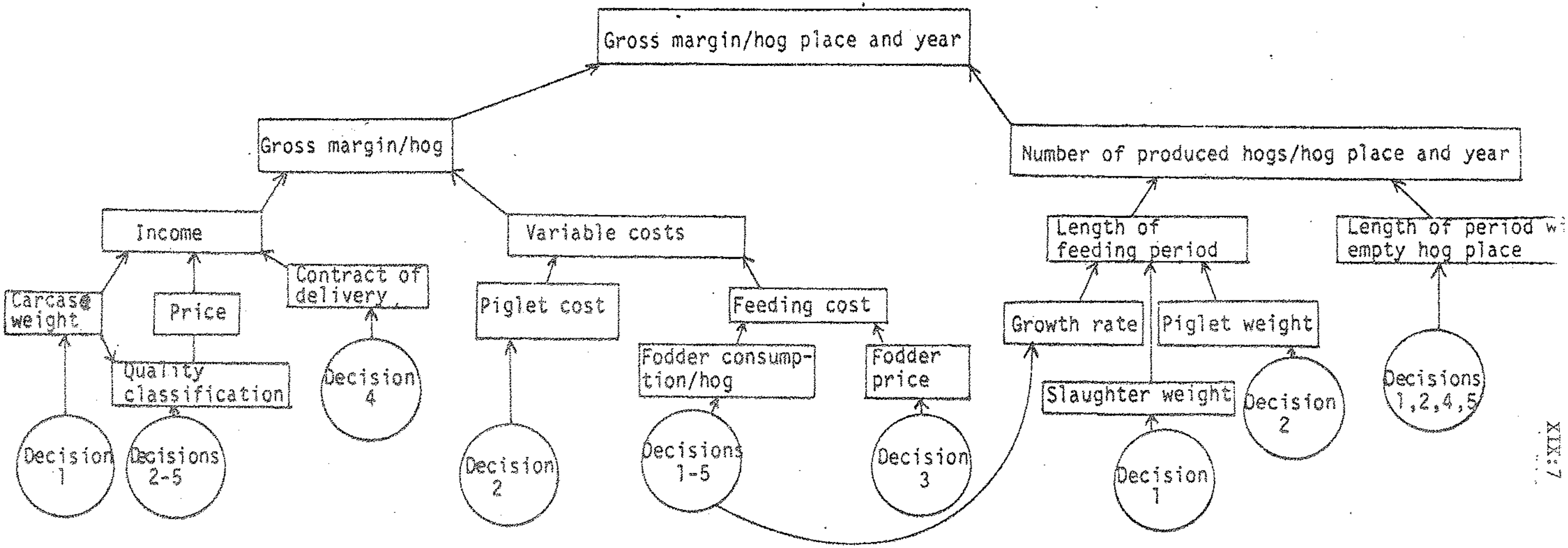


Figure 2. A model of farm management. (After Renborg and Fock, 1976, and Johnson, 1978).

Table 1. *Examples of decision making and control on the firm level*

Goals	Information from the environment	Information from the farm	Analysis	Decision rule	Disturbances	Control of performance: Info from environment	Control of performance: Info from the farm	Analysis
Decision; Cash flow planning and control								
1. Cash ≥ x Skr each month 2. High yield from capital	1. Payment routines 2. Credit possibilities 3. Prices	1. Quantity and date of bargains 2. Amount of cash 3. Budget performance former years	Make a budget and adjust it so it will be enough precautionary cash	A budget which fulfills the goal 1 is accepted	1. Varying prices 2. Varying quantities and dates of bargains 3. Outstanding taxes	1. Prices 2. Payment routines 3. Changes of the rate of discount	1. Budget performance each month	The planned budget is compared to the realized



Decision 1. Slaughter
- a. Planned slaughter weight
- b. Weighing technique
- c. Decision rule for sending the last hogs to slaughter

2. Buying piglets
- a. Genetic material
- b. When to buy?
- d. Number of piglets to buy

3. Fooder and feeding technique
- a. Fodder
- a1. Home mixture
- a11. Composition
- a12. Mixing-machines
- a13. Buy components from whom?
- a14. Storing capacity
- a2. Buying mixture
- a21. Choice of mixture
- a22. Buy from whom?
- a23. Storing capacity
- b. Feeding technique
- b1. The number of feedings/day
- b2. Machines

4. Rearing system
- a1. Batches
- a2. Continuous
- b1. Sex sorting
- b2. No sex sorting
- c. Grouping at arrival
- d. How to do with "slow-rate-growers"?
- e. Contract of delivery

5. Animal health actions
- a. Cleaning the stable
- b. Parasite control
- c. Stable climate

Figure 3. How various decisions in hog production affect the gross margin and underlying results. (Öhlmér, 1978)

Table 2. Examples of decision making and control in hog production

Goals	Information from the environment	Information from the farm	Analysis	Decision rule	Disturbances	Control of performance	
						Info from environment	Info from the farm
Decision; Buying piglets: a) Scan-piglets (= hybride), b) K-piglets (a certain quality), c) piglets from good herds, d) other piglets							
1. Higher profit 2. Hog places = x (constraint)	1. Supply (number and delivery date) of the respective piglet category 2. Prices 3. Capacity of growth rate, fodder utilization, and carcase quality	1. Growth rate of earlier categories 2. Fodder utilization of earlier categories and carcase quality 3. Number of occupied hog places	Gross margin per hog place and year is estimated through: 1. Calculus 2. Rough calculation 3. Intuitive estimation for each alternative	The alternative with the highest gross margin is chosen	1. Price changes 2. Varying growth rate capacity and fodder utilization 3. Varying supply of piglets	1. Prices 2. Supply of piglets 3. Growth rate standards 4. Fodder consumption standards	1. Growth rate 2. Fodder consumption
Decision; Determining rearing system: a) batches, b) continuous							
1. Higher profit 2. Hog places = x (constraint) 3. Labour supply = y hours/day (constraint)	1. Supply (number and date) of piglets 2. Disease frequency in each alternative 3. Growth rate and fodder utilization in each alt. 4. Demand of labour in each alt.	1. Earlier disease frequency 2. Earlier growth rate and fodder utilization 3. Earlier demand of labour	As above	As above	1. Varying environmental conditions 2. Varying growth rate	1. Standards of disease frequency 2. Growth rate standards 3. Standards of batches per year or hogs per hog place and year	1. Disease frequency 2. Growth rate 3. Number of batches per yea[r] or hogs per ho[g] place and year

(To be continued on next page)

Table 2 cont.

Goals	Information from the environment	Information from the farm	Analysis	Decision rule	Disturbances	Control of performance	
						Info from environment	Info from the farm
Decision; Choice of fodder: a) buying a complete mixture, b) coarse grain and concentrate, c) home mixture							
1. Higher profit 2. Store capacity = x (constraint) 3. Labour supply = y hours/day (constraint)	1. Selling price of coarse grain 2. Prices of alternative feeding stuffs 3. Possibility to buy from neighbours and prices 4. Growth rate and fodder utilization in each alt. 5. Demand of labour 6. Mixing costs	1. Supply of coarse grain 2. Opportunity cost of the store capacity 3. Earlier growth rate and fodder utilization 4. Earlier demand of labour	As above	As above	1. Price changes 2. Varying supply of coarse grain (quantity and quality)	1. Prices 2. Possible supply of coarse grain from neighbours and firms (quantity and quality)	1. Supply of own coarse grain (quantity and quality)

Various decision processes use the same pieces of information. All three decisions in table 2 use e.g. information on the growth rate. You can list the pieces of information and note the decision processes which use each piece. Then you can estimate the importance of each piece of information (factor). If you know the average and the standard deviation on a factor you can even make rough calculations on how much one loses if one does not consider this factor.

3. DATA NEEDS AND DATA CAPTURE

Data needs

One necessary condition for a data need is that the value of the resulting information is higher than the cost of information, i.e. the cost of data capture, storing, retrieval and processing. Furthermore in case of limited resources the marginal value of the resources needed to produce the information have to be as high as in any other use of these resources.

The farm computer applications mentioned in the introduction are only computer versions of wellknown manual routines and decisionrules. It is often so in the first applications of any new technique. Thus the data need is wellknown too, and you do not have to use any model to learn about it. When we learn more about the possibilities of the new technique we improve the decisionrules which may change the information value and thus the data needs. Use of automated data capture and new communication technique may change the cost of information and thus the data needs.

Another factor is the production system. Which precision in the prescription is it possible to implement in the production process? This precision affects the information value and thus the data needs. However, the manager himself may be the most important factor. The computer application interacts with the manager in the information system. The manager is the decisionmaker, and he has to understand the information to be able to use it. The history has shown that simpler computer applications are more used by the farmers than more advanced applications, and several studies about adoption of innovations show that the complexity affects the rate of adoption (Rogers and Shoemaker, 1971; Tully, 1968). This means that the market is small for more advanced systems. The information systems and the farm management computer applications will be developed step by step as the market grows, and the data needs will change in the same rate.

Automated data capture

Meeting the data needs through automated data capture gives:

- Faster information
- More accurate information
- Less work

Faster information means that you can make corrective actions earlier. If you have information about the slaughter weights back from the slaughter house before the next deliverance you can correct the procedure of sorting out for deliverance if needed. This increases the information value.

The information becomes normally more accurate in automated data capture than in manually reading the data and writing it on a paper. Once you have it in an electronical device it is also possible to communicate it automatically to a main frame or microcomputer. Then you do not have to reenter the data, which decreases the risk of faults. This decreases the information cost.

You get less work, because you do not have to reenter the data manually. This has effects on the costs. It means also, that you get rid of boring work. The less work makes it possible to use a higher amount of data, i.e. a more detailed information. You can use individual production unit data instead of aggregated data e.g. individual hog data instead of group data.

The effects of automated data capture are valid both for data from the farm and external data. It may be easier to realize it for external data than for internal data. The external data is already stored in a computer in most cases and can be communicated in a standardized way. However, there is no standardization of the electronical equipment used for automated data capture in the farm, which makes the communication difficult and expensive.

Conclusions

- The data needs in the farm management computer applications of today coincide with the data needs of the manual farm management methods.
- The farm management computer applications will be developed step by step as the market grows, and the data needs will change in the same rate.
- Automated data capture affects both the information value and the information cost, and may change the data needs in the future.
- There is a great need for standardization of the equipment and software for automated data capture in the farm.

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SIMULATION MODELS AND THEIR DEMANDS FOR INFORMATION OF FARM WORK PROCESSES.

by

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Agricultural University of Norway
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Paper presented at

NJF-seminar section VII

Are, Sweden 3-5 February 1986

The main objectives of agriculture.

Agriculture is an integrated part of the society and its main objectives are:

- to produce food and to ensure food supplies during crises
- to keep up settlement and employment in the country-side
- to preserve nature and environment

Research, teaching and development are engaged to help agriculture to fulfill these objectives. And great improvements have been achieved. Our animals are fed to produce maximum output, our plants are ensured best possible growing conditions to give maximum yields. At the same time the physical health of the agricultural population has been focused on to reduce health hazards.
What about the psychological health of people working in agriculture? How are their well-being and happiness? Of course, in the opinion of most people, when animals and plants are given the best treatment, the income of the farm will be maximum and hence, the farmer most happy. - May-be it is that simple, this author thinks not necessarily. If a farmer and his family have a set of produtions that requires at times 150-200 % attention and effort to keep animals and plants happy according to experts, the maximum economy may be bought too high. For people in agriculture the day to day working tasks and conditions are important. A farmer expressed it in this way: "I feel most happy when I can do a proper job in due time." What is the scientists' answer to that?

The need for production planning.

Up to the time of the second world war the changes in agriculture came slowly. New innovations in machinery and equipment were scarce, and farmers had time to adapt to new production methods and to adjust the management systems of the farms accordingly. Experiences were passed from one generation to the other and traditions ruled life of the country-side.
In the later years, however, new production methods and equipment have been introduced so rapidly that their biological and economic consequences are not fully known to most farmers when they start using them. Their present questions are: What shall I choose and what are the consequenses? The long-time inherited management systems are seldom adequate to handle these questions. Consequently quite a few farm families find themselves in a situation they did not plan for and where their health and economy are both stressed unnecessarily.
Are scientists able to take up this challenge? Can we develop systems that may assists the farmers in their planning?

Models and simulation

By definition a model is a simplified issue of reality, and simulation is experimenting with models. By using these techniques it is possible to build up alternative production systems for a given farm and to calculate the most important consequences. The decisions, however, have to be made, as always, by the farm family itself.

As the discussions in this paper will be closely connected to models and simulation, an example of an operating model for combine-harvesting is given in the following.

This model is developed as a joint project between the Norwegian Institutes of Agricultural Engineering and Farm Economics. As in all work science models time is the main factor. The model calculates in detail the required field times based upon the geometry and size of the fields, yield and harvesting conditions, working capacity of the man-machine systems, turning and unloading times, work organization and weather conditions. The calculated time requirements are then matched with figures for capital costs, machine- and operator costs, timeliness cost and economic characteristics of the family. The result of one simulation run is the total operating cost for combine harvesting on a given farm under given conditions.

The combine harvesting model is programmed on Multiplan spreadsheet for running on microcomputers, like DEC RAINBOW 100, IBM PC and compatible computers. The initial loading of data for a given farm takes less than 5 minutes, and one simulation run less than 30 seconds.

Demands for information of work in general.

The type of simulation model described in the previous chapter is very closely connected to how the actual operation is performed in real life. Therefore, very detailed and accurate information is needed for the work methods. As an example, the driving pattern before and after unloading the grain tank of the combine has been studied very carefully. This to establish the best position for the grain-trailer when it is being filled. Work methods for operations that are being practiced already, are fairly simple to establish through ordinary work studies.
Possible work methods for new, unused production systems, however, have also to be established. This task requires experience and imagination from both farmers and scientists. Quite often work-method experiments may also help the design of new farm work processes. The work science professionals are left with the challenge to put it all together in a workable model.

After work methods have been established, time-figures have to be obtained. Again all methods known from regular time-studies may be used. The great advantage compared to earlier studies is that obtaining figures to complete this type of models do not require studies of entire processes from beginning to end at the same time. From the structure of the model based on detailed work methods we know which figures are needed and to some extent also the importance of these figures. We, therefore, can make studies of selected parts of the entire process without loosing the final results. In our work on the combine-model we could, as an example, concentrate some studies on the effect of speed on working width without thinking of other parts of the harvesting.

To obtain data the use of electronics is of increasing help both in automatic registration of factors and in obtaining data that earlier were impossible to get. Working speed and width, weight of product in tank, fuel consumption and torque on p.t.o. are some examples.

Validation of these type models is intricate and difficult. A model should represent a reasonable effective way of performing a process under average conditions inside the limits of its validity. A few studies of the entire process in reality will therefore constitute a very limited basis for comparison. One way of solving this problem is to validate the figures separately and at the same time make sure that the relations in the model and the working methods correspond.

Demands for information of the farm.

The process which the model represents takes or will take place on the farm in question. It is therefore important to get all relevant data from the farm itself. For field work, the geometry, size, topography, and distance from the farmyard to the fields may all be essential inputs in a model. As an example the distance betweeen the field and the farmyard will determine if the fertilizer bags should be brought out to the field or the distributor should be filled at the storage place in the barn. For combine harvesting the availability of an extra driver with tractor and trailer may permit unloading the tank when threshing.

To be able to calculate the economic consequences of the alternative solutions we need information about the inventory, the economic situation of the family, the possibility for investments, tax situation and other factors. With models of work processes it is possible to produce a set of alternative solutions for the farm and families in question. This set of solutions, however, represents only a limited selection of all possible solutions. It is, therefore, important that the farm family takes part in this selection. Their interests, knowledge, skills and attitudes are all important factors that may have major influence on the final set of alternatives.

The combine-model - the sensitivity of some input factors.

With simulation models it is fairly easy to find the sensitivity of interesting parameters. In building models the results can be used to point out important factors that need further investigations. In using the models uncertainty may be illustrated through the possible variation of the final results.

To demonstrate these relations a set of simulations has been run on the combine-model. The basis for the calculations and the results are described in the following. (Complete documentation is given in the appendix). The simulation are based on a farm with 60 ha oats and barley, the yields are 4.5 - 5.0 tons/ha, 40 % probability for dry weather and 7 hours working day in early autumn. With a 10 feet wide combine the total cost for combining is NOK 82 600 per year, out of this cost NOK 42 400 amounts for machine cost, NOK 6 100 for operator and NOK 34 100 for timeliness cost. The total cost per hectare is NOK 1 380.

In mechanization problems most people think of the size of machine as the most important factor. In our example a smaller combine is less expensive to keep, but the timeliness cost will increase. With a bigger combine the situation is opposite. The costs for operating different sizes of combines on our farm are given in table 1 below.

Table 1
The cost for combining 60 ha grain under given conditions for 5 different sizes of combines. The differences to 10′ are given.

Combine-width	Cost in NOK				
	Machine	Opera-tor	Time-liness	Sum	Sum per ha
10′	42.400	6.100	34.100	82.600	1380
8.5′	-10000	+2100	+13100	+5200	+90
9′	-5600	+1200	+7200	+2800	+50
11′-12′	+8300	-600	-4000	+3700	+60
12′-15′	+24400	-1600	-10000	+12800	+210

The 10′ combine (Claas D48, John Deere 952, MF 20, Sampo 680 or similar) is apparently the best choice. The differences to 9′ and 11′-12′ are small, however.

Thinking of electronics it should be possible to monitor and control the threshing and cleaning functions of a combine in such a way that the operator could consentrate more on the driving and header functions. If he in this way could increase the speed by 10-20 % when threshing, how would that apply to the costs? Results are given in table 2.

Table 2
The effect of increasing forward velocity when threshing

Speed when threshing	Cost in NOK				
	Machine	Opera-tor	Time-liness	Sum	Sum per ha
Normal	42.400	6.100	34.100	82.600	1380
+ 10 %	-700	-400	-2700	-3800	-60
+ 20 %	-1300	-800	-4900	-7000	-120

A 20 % increase in speed when threshing means an annual saving in operating costs of NOK 7000 on our farm.

If it is possible to unload the grain tank of the combine when driving (without stopping), the operating costs for threshing will decrease by NOK 7900 or NOK 130 per ha. This saving will have to be compared to the possible costs of having a man with tractor and trailer driving alongside.

Farmers have to live in cooperation with the weather, and it is not much they can do about it. The effects on the cost of grain harvesting are considerable. The results of experiments with weather conditions are given in table 3 on next page.

Table 3
The effects of weather conditions on the cost of grain harvesting on our farm.

Probability of dry weather	Cost in NOK				
	Machine	Operator	Timeliness	Sum	Sum per ha
40 %	42.400	6.100	34.100	82.600	1380
60 %	0	0	-12800	-12800	-210
50 %	0	0	-7600	-7600	-130
30 %	0	0	+12800	+12800	+210
20 %	0	0	+38500	+38500	+640

These results demonstrate the importance to match combine capacity to the expected harvesting conditions.

The importance of utilizing the time, when combining is possible, may also be demonstrated through the model. One hour reduction from 7 to 6 hours effective work time increases the cost on our farm with NOK 7300 in total or NOK 120 per ha. This means that servicing the machine should take place when combining is not possible. An extra operator of the combine, makes it also possible to have meals without interupting threshing.

Conclusions.

The project under which we have developed the combine model has been running for four years. During this time the professional micro-computers have entered the market. The combination of relatively small mathematical models for farm work and the simulation of the same on micro-computers has caught great interest from farmers, advisors and adminitrators. The model demonstrated in this paper links the farm, equipment, work methods, and organization together with the economic aspects of farm production. It seems to us working in this area that this type model may contribute to a better understanding of the interacting mechanisms in farming, and, above all, focus on the human role in agricultural production.

Summary

Agriculture is an integrated part of the society, and the skill and well-being of the people working in the profession concern all of us. Modern agriculture has great potentials and many uncertainties. The experiences and traditions that ruled agriculture in former years, are no longer complete to guide farmers of today. Animal husbandry and plant sciences have become very advanced, and we know very well how to keep animals and plants healthy and happy. Also in engineering diciplines great progress have been made. What about the day to day life for the farmer and his family? Work science has a great challenge in agriculture of today.

This paper demonstrates the structure and use of a simulation model for farm work. The purpose of the model is to help designing the work-systems that go into an existing og planned production on a given farm run by a given family. The model is programmed to run on a standard 16-bits micro-computer. In this way such a model may be used widepread from the kitchen table at a farm to the desk top of an official administrator. Developing such models for farm work requires a very thorough knowledge of the work-methods that are or may be used on the farms. The relations in the model have to correspond directly to the work-methods in reality. When the structure of the model has been developed, the actual figures for the process in general have to be found. Data for the farm in question have to be filled in separately for every new case.

The model in this paper concerns combine harvesting. A series of simulations has been run for a 60 ha grain farm. The results in operating cost for the harvest show great sensitivity to weather conditions, as expected. Minor changes in the size of the combine did not alter the costs much, however. Unloading the grain tank into a trailer without stopping showed greater difference than changing from a 9′ to a 12′ combine. The simulation results stressed the importance of effective driving and of utilizing favourable weather conditions.

The type of model for farm work demonstrated in this paper seems promising as a management tool for farm work in the future.

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S K U R T R E S K I N G

Demonstrasjonsmodell
NJF-seminar i Åre, Sverige. 3-5 februar 1986

LTI/ILØ - NLVF-prosjekt:
Driftsteknisk informasjons

FORUTSETNINGER:

AREAL (ha)	60						
AREAL (daa):	600	SKURTRESKER:	4	BRUKSTID	12 år	TID/SNU	0.4 min/ga
ANTALL FELT:	6	TØMMEMETODE(S=1 F=2	1	RESTVERDI	20 %	VEDLIKEHOL	0.35 kr/h/1
KORNKOMBINASJON	4	EFFEKTIVITET(%)	100 %	REALRENTE	6 %	DRIVSTOFF	6 kr/daa
		GODT VER(%):	40 %	LØNN	60 kr/h		

RESULTATER:

TRESKERTYPE:	OVERMIDDEL	KOSTNADER/ÅR:	82600	Kostn/ha.	Kostn./år	Maskin	Arbeid	Lag.tap	Timer/år	Dager/
INVESTERING:	280500	KOSTNADER/HA:	14	14	82600	42400	6100	34100	102	42

V E K S T E R .

ART	KODE	VEKSTTID	SATID	AVLING	HL.VEKT	KG.PRIS	TRESKEEVNE	LAGELIGHET	MODNING
HVETE	1	111	0	450	80	2.94	1.10	0.39	111
HAVRE.S	2	109	0	500	50	2.13	0.90	0.28	109
HAVRE.T	3	100	0	470	51	2.13	0.90	0.31	100
BYGG.S	4	102	0	450	64	2.41	1.00	0.33	102
BYGG.T	5	92	0	420	65	2.41	1.00	0.55	92
OLJEVKST	6	110	0	200	74	4.95	0.40	0.50	110
ENGFRØ	7	82	0	40	56	24.00	0.05	0.50	82
ANNET	8	90	0	500	23	12.00	0.50	0.50	90

ARBEIDSTID

DAGER e.1.MAI	90	100	110	120	130	140
ARB.TID/DAG	2.8	2.7	2.5	2.2	1.9	1.5

S K U R T R E S K E R E

	NR	BREDDE	TANKVOL	TØMMEKAP	PRIS(1000)	TRESKEKAP
MINI	1	2.55	1730	500	152.5	4500
LITEN	2	2.70	1940	600	174.0	5350
UNDERMIDDELS	3	2.82	2100	700	208.0	6083
OVERMIDDELS	4	3.13	2596	800	255.0	7288
STOR	5	3.46	3024	900	318.0	8142
MAXI	6	4.12	4138	1000	445.0	9940
OVERMIDDELS	4	3.13	2596	800	255.0	7288

FELTER,AVLING,TIDSPUNKTER OG VÆR.

FELTAREAL (daa)	80	100	160	60	120	80
LENGDE (m)	339	506	520	294	450	368
BREDDE (m)	322	395	468	279	405	331
HJØRNER (ant.)	5	3	4	5	4	4
REL.FELTAVLING	100	105	95	100	105	95
REL SATID (dgr)	0	1	-1	0	2	0
VARONNLENGDE	1	1	2	1	2	1
VARONNSLUTT	1	2	4	5	7	8
FELTFAKTOR	615	387	684	533	592	484
KORN- NR 1	4	4	4	4	4	4
KOMBINASJON - 2	2	2	2	2	2	2
NR 3	1	1	1	1	1	1
NR 4	2	2	4	4	4	4
NR 5	2	2	2	4	4	4
NR 6	2	2	2	2	2	2
NR 7	1	1	1	1	1	1
NR 8	1	2	1	2	1	2
NR 9	4	4	4	2	2	1
NR10	4	2	4	2	4	2

B E R E G N I N G E R .

Kulturkode:	2	2	4	4	4	4
Avling:	40000	52500	68400	27000	56700	34200
Modningstidspkt	110	111	106	107	109	110
Snutid (min)	86	54	96	74	83	68
I skår (min)	732	960	1126	445	934	563
Tømming+til/fra	154	202	205	81	170	103
Sum tid	971	1216	1427	600	1187	733
TRESKING (h)	16	20	24	10	20	12
(dager)	7	8	9	4	8	5
(stopp)	134	148	115	119	128	140
(start)	128	140	106	116	120	135
Forsinkelse	21	33	5	11	15	27
Lagelighetstap	5042	10317	2538	2257	6614	7374

S K U R T R E S K E R O V E R S I K T .

FABRIKAT TYPE	SKJÆREBORD-BREDDE m	fot	KAPASITET kg/min	KAPASITET GRUPPE
BV.AKTIV 1100	2.41	8.0	73	1
CLAAS D38	2.80	9.3	92	2
JOHNDEERE 942	2.75	8.8	92	2
DR.BORG 3000	2.82	9.3	104	3
SAMPO / MF580/16	2.76	9.0	99	3
SPERRY N.H8040	3.66	12.0	126	4
SAMPO / MF680/20	3.01	10.0	120	4
CLAAS D58	3.16	10.5	132	5
JOHNDEERE 1055	3.65	12.0	144	5
SPERRY N.H8055	4.00	13.0	171	6
DR.BORG 7000S	4.48	14.8	160	6

DISCUSSION, SECTION 4 and 5

Horst Göhlich

Along our enthusiasm on electronics and control mechanism I think we shouldn't forget also the simplier things in between. That means the adaptation of the various mechanisation of the whole process. When I have seen today a picture, men grabbing the material by hand from the trailor and throwing it into the blower, I feel there are quite often certain gaps to observe which have to be considered before the next step of automation can be realized.

Frode Guul-Simonsen

My question is for Lars Sjöflot. You can measure vibration for tools, but it is also possible to make measurement of data program. You see, some program are very bad to use and some very good. It could be interesting to test a program how it is for use by the farmer.

John Matthews

Can I connect one very interesting point that Lars Sjöflot made about humans, with yesterday's discussions about animals. We tended to talk yesterday about minimum stress and I think Lars made an important point today - that for humans minimum stress is not necessarily best - we need optimum stress. Now there is also for farm livestock an optimum stress which is not minimum. I don't know if there's an answer. Perhaps it's yesterday's subject rather than today's, but it certainly has given me a new thought from this paper this morning.

Horst Göhlich

The presentations today and the day before brings me up to a general question: Are we now able to define the future type of working place of our farmer, of our people on the farm. Maybe they are not farmers anymore, maybe they are managers, but to aim the men-machine task system, and to predict the future task of the people in agriculture. I think we have to try actually to define the future working place. How will the farmer be involved in agricultural operations and what are the most suited steps for application of electronics, computers and other things. With other words, what kind of automation will likely be most accepted by the farmer and secure the progress and efficiency?

Egil Berge

I pick up the line from John Matthews once more. It is not only man that requires optimal stress. So does the animals. And boring among animals is one of the really problematic things in intensified husbandry. Chewing all day on a pipe or something else just because there is nothing else that they can do. So we shouldn't forget to plan for optimum stress for animals as well.

Coming back to the conclusions from Sjøflots lecture on optimum stress, we yesterday spoke about electronical stress. One sense of it could be the situation the farmer has in an automated production line. What if something fails? That brings me back to something else about his job and that is satisfaction. One other thing that is important to them when it comes to satisfaction and the way they feel: They feel lonesome at the farm, -working alone. Some of them think it is a stress to think about "what if something goes wrong. What if I get sick, what if I broke my leg", or something like that. But individuals feel different. Some people love to repair things that goes to pieces, others hate it. Hence a conclusion valid for anybody can not be made.

Jörgen Svendsen

We want to develop housing systems where the animals are doing well, and where they are not stressed in a negative sense of the word. In my presentation yesterday I made the point that we for years had been busy trying to solve problems related to environmental stressors in animal housing. When introducing electronics in agriculture, we should try to avoid developing systems which in a negative sense introduce "electronic stressors". I will give an example which I didn't have time to mention yesterday. This is in regards to the electronic feeding system where we have sows in relatively large groups, with reasonable space, and with plenty of straw bedding. Technically, the system seems to function quite well. However, we are starting to see the kind of abnormal behaviour in this group of animals which you usually only see in fixed and tethered sows. That means that possibly something is wrong with regards to group size, feeding technique, or for other causes which we do not really understand why. However, this may be one example of problems introduced using advanced electronic techniques.

John Matthews

I thought it might be useful from my personal experience to give some real examples where I believe I have data to show where ergonomics or electronics improved efficiency, and I have written down five. I hoped that I might find one where I had data that electronics had produced a bad result, but I'm still searching for this. On ergonomics we have the problem of noise on tractors. I am quite convinced that the measurements I have, when we reduced noise levels we increased work rates between 15 % and 20 % which is very good economics. I am equally convinced now that if we could reduce the ride vibrations on many types of field machinery we would again find that the driver was able and willing to increase the speed by 10 %. Another good example where ergonomics would pay for itself.

Now on routine work. A few years ago I made some measurements of mental workload of milkers, trying to identify the origins of stress and the symptoms of stress, and I have little doubt from the data gathered that the use of automatic cluster removal, uncoupling the man from the need to take off machine units, when at the same time considering putting on units, very much reduced the mental stress and increased the speed of working. I also have data from the grain drier control example, where this time an electronic control system, certainly on two farms on which I carried out comparisons, gave much better control and was economically justified by improving the uniformity of moisture content compared with manual control. A good example, I think is Sjøflot's list where the computer is a better performer than the man, because it can understand the algorithm. Finally perhaps, another good example of where electronics can be better is in table height control on the combine harvester. I've gathered information where the driver, given manual control of table height, would have performed better if had he left the control alone altogether. As it was, he adjusted table height control and had in fact worse uniformity of cutting height than had there been no control at all. I think it is a good example of the need for electronics.

I think these are some examples where I could provide supporting data of where the man can do better with his control, and where electronics can do better.

Anders Nygaard

I would like to put the finger on one point, and that is the word stress. Every time we use the word stress, we should add something to it. At least a plus or a minus. We talk about stress when we actually mean stimuli and I think in many cases we have to make this quite clear. We can't function without stimuli and we tend to call it stress. Please remember this. Because every time we talk about environmental stress, psychological stress and so on, we mean stimuli which is necessary to action at all. Thank you!

Lars Sjøflot

Thank you Anders! It was very good words at the right time. The relation between stress as forms of stimuli and the effect in form of strain, is not quite clear for everybody, but I will not go into that discussion now. Stimuli are what affects individuals and might be a better term than stress in many cases. And I think just as you said, here might be an answer to some of the questions and comments arised, especially by Professor Göhlich. Mr Simonsen asked a question about programs for computers, the man-task relation in soft-ware. There have been done more studies on this theme. Of course there are clear differences in the easyness of using a programme, or shall we say the optimal way of using computers. I am not able now to go into how this stress have been measured. That is rather difficult, but quite a few scientists have really tried. There are many publications on this matter. Where to find them and how they are I cannot tell. I think it was good to be reminded that also this type of relation between man and machine or task is important and that we can do something to make it easier for individuals. The question rised by John Matthews was interesting and so was the comment that we also use the word stress when we look at animals. Certainly we are seeking a kind of optimum and not just minimum. The human beings are also biological systems, so there should not really be much difference between us and the animals. We are in fact animals. Plants are also biological systems and I think we also can find quite a lot of common things with the plant biologists.

Professor Göhlich put up the important question of what we should think when we leave this seminar: how to define, how to predict and describe the future working place in agriculture and the future situation for the people. We do have to look at the whole family, the people working in agriculture and living there, and I am afraid we do not have any quite clear answer to that. We have got some pieces of the answer at this seminar and we might be able to come up with some ideas. Yesterday we saw a prediction of number of cows in Sweden in the future, and the question was raised how it was made. It was said it was not just a guess, but somewhat more, and Hilmersen developed that further here today. I think we also can do so for the future working places for man. We can base it on our present knowledge and try to look a little bit forward. I agree with Professor Göhlich; the situation will change. That is at least for sure. We have to watch the developments, especially in the technical field, and try to see trends for the future. I was happy to hear Mr. Matthews' good examples of how electronics had come in and I think all these examples are positive for man. We might also find some negative consequences for individuals, and that we should learn from and avoid in the future. So there at least we have som examples proving that electronics can be beneficial for man, and this development will continue. If we look at it in a bit bigger scale, can we now maybe allow people to devote more of their time to real professional matters and get rid om much of trivial, monotonously and boring tasks. They will then have more time for inspecting animals or just to have the good feeling walking around the animals, look at them, talk to them, go out and look at the field, look at the crop. This feeling of living close to nature and growing, developing it can be a very positive factor in farmers' life. There will be more time for creative work and also for planning. It is possible to be creative and to use your brain also when we are doing the most simple and repetitive manual work. The movements or work is in a way automatic and the brain can be used for other things. By help of electronics and computers such tasks can be fully automatizised. Then we can really feel we have the time for using the brain for other purposes, for developing things and being creative. That are the bigger lines we can see in the future. I should of course, have brought in the seven points of job satisfaction, as Mr. Hilmersen mentioned. I think, however that most of the contents of those have come through in what we have said already, and I have really no more comments to that. I feel I have got a lot from this seminar and if you other participants also have got something useful, I think the arrangement has been a success - and thanks a lot to the organizers!

SECTION 6

CONCLUDING DISCUSSION

The symposium has hitherto shown that computers, electronics and control engineering have become more and more powerful tools not only for agricultural engineering research activities but also for better efficiency in agricultural and horticultural production processes. In the concluding discussion the following question was the overall problem dealt with:

- In which way shall we continue and develop research activities and how can we make sure that knowledge from other disciplines are included? More specific, which problems - processes - equipment - sensors - control models do we have to develop?

In connection to this main question the participants also had to pay attention to these sub-questions:

- Are we using the optimum production processes?
- Are we still maximizing output?
- To what extent can other inputs, e.g. chemicals, fertilizers, feed stuffs be substituted with intelligent machinery?
- Processes of special interest for change from mechanization to automation and individual care where biological variation is treated as a production and quality potential rather than a disturbance as nowadays?

Some criteris for dealing with these questions and for giving priority to important activities may be:

- biological or genetic potentials
- scientific possibilities
- quality potential
- environmental needs
- impact on farm management
- profitability for farmer, manufacturer and society
- investment costs.

Egil Berge

I would like to suggest that investment turnover time be also considered. It comes into profitability, not only the farmers profitability but also the societies profitability in investing in new techniques. The faster the turnover time, the more interesting it is to have a new system ready for use. As to the suggestions, I think that there should be a high priority to animal production systems, and to green-house production systems. By this I mean development of new production systems. There are so many factors that now may be fundamentally changed that we really have to start at the bottom with new system development thinking. Thank you.

Ove Berkefelt

When you put the priorities on that list I think it depends on who you are. If you have a broad overview on responsibility as John Matthews you can argue like he is doing. If you have a more narrow-minded view like I have, with responsibility for electronic development or technical development, then you have of course to put the priority on the engineering possibilities. What we can do is to give the agro people the solutions to their problems. We cannot look away from that. We have a long range of technical solutions. We can do all sorts of sensors. We just have to have the agro people to tell us what they want to have done or what problems they have.

There is one thing which I would like to put on high priority also from my narrow minded view, and that is profitability. If we cannot find profitability in development projects then there will be no project, or no product at least. Because if we start a development project which is not enough analysed with respect to profitability then somebody will be very sad at the end. I wote for profitability as the highest priority and then engineering possibilities.

John Matthews

I think that within new understanding of the physics of processes or the chemistry or microbiology of processes, perhaps there are intermediate possibilities for example new methods for threshing using ultrasonics, new methods for cutting materials using lasers. There is a very large potential by the use of genetic changes to breed, plants resistant to fungus, and plant systems capable of fertilisation but I think this will all be in the longer term. I think quality is vitally important and would give that very high priority at this stage. I would want to widen the environmental needs to embrace social needs, rather than environmental ones because I think we need to include in it the welfare of animals and the welfare of workers. I would say that the three things, animal welfare, worker and farmer welfare, and preservation of country environment, are social factors. Now certainly in the United Kingdom at the moment Government is giving that the very highest priority because of pressure groups. I have the feeling that our pressure groups are perhaps rather stronger than those in some other countries. I don't know enough about the situation here. So all our programmes that would come under social factors have high Government support.

Lawson Safley Jr

I would like to make a few general comments. I would like to compliment the Scandinavian countries for their foresight in having such a conference as this. I think this type of conference could be used to good advantage in the US. It is amazing to see the similarity in the problems which you have here in Scandinavia, as we do in the United States. Everything that I have heard the last few days indicates to me that we have a tremendous opportunity for using electronics and computers to change strategies somewhat from 'crisis' farming to what I term 'time-management' farming. This would allow us to use automation as a tool to provide the farmer with a better opportunity to have what I refer to as 'quality' thinking time using the computer to actually help in making decisions. I see tomorrow's farmer as a person who is going to have a superior education. With this education and an ability to use information wisely, he will become a better manager. Mechanization and electronics will be valuable tools.

Another point is that the farmer will necessarily have to maintain better records in both animal and crop production, recognizing the uniqueness of each individual farm. I believe it will be necessary to develop software that will be specific to a particular farm. Possibly the use of simulation or linear programming will be used to help the farmer towards maximizing profit. Software can also be developed to aid in predicting the effects of different input changes given constraints relative to environmental and labour budgets. Dr. Nilsson has made the comment that if we had a generalized model for the farm that you could work possibly in reverse to determine what specific electronic components we might need in order for the farmer to be able to sit down and operate his farm as a total enterprise. It would be much better if he had a computer at his fingertips to aid in the decision process as compared to 'crisis' farming where he is going from day to day on individual activities where he might not clearly see the complete picture for his operation.

Lars Sjøflot

I find it very hard to make any priority out from the criteria put up here. They are very much linked together, and I think I follow very much John Matthews view. There is a clear need for team work and inter-disciplineary work in the future in order to utilize the real potential in all the points put forward. It was said here that engineers and people from the biological side must work together. Also experts from the human side have to go into that cooperative work to really make use of and benefit from the future potential of the area discussed at this seminar.

Hisamitsu Takai

In regard to what was said about animal production systems and feeding systems I feel that electronics in agriculture give possibilities if we use them right. We should use the electronics to improve the possibilities of treating the animals more as individuals. With the development of reliable and cheap electronic identifications systems this could be done a lot better than we do today, and that fits well into the animal production system and feeding system.

Per Almgren

Study the trends on the development of consumer tastes; their buying preferences in the next 10-15 years etc. That will have an impact on what problems we should concentrate. Quite recently, we have had a debate in Sweden, on how the animals are treated in different respects.

From the debate concerning environment we can conclude that the public opinion will demand better conditions for the animals. They will demand better quality of the product and they will also stress the importance of a good environment. That means, that we have to develop processes and sensors to keep control over different types of chemicals. We will need some sort of objective measurement methods to be able to judge quality in some respect. I have no ready answers to this problem, but I think there are some ideas that we could start with. I think we have to measure things that are correlated to quality and also think about what we mean by the word profitable. I know that in Norway some small experiments have started with a quite new approach to how the farm should be financed and how extra recources could be mobilised when needed. But that is still on a very small scale right now, with just a few farms involved. But we must keep in mind the fact, that the economic outlook may well be quite different in the future.

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