Needs for research and development in Livestock Recording Systems (LRS) in transition and developing countries

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Summary

One of the constrains of the Livestock Recording System (LRS) is related to structural problems in the livestock sector and its institutions. Within different production systems, the necessity of standardising LRS is stressed; the more developed is the country the higher are the inputs for producing meat with the desired quality. In transition countries production systems are different and contacts among the various elements of the productive chain are less tight; this is due to the stage of development of the national economy and the physical and institutional infrastructure.

An efficient LRS should satisfy the information needs, ensure the interest of the owners by providing a co-operative environment, incorporate various stakeholders and fix an operational and financial dimension.

The various interdependency of LS and LRS purposes are shortly described and information linkages for decision-making and programme implementation are summarised. In order to facilitate transition countries in their modernisation process, the various elements involved in the recording process are analysed, i.e. sampling procedures to get representative data and phenotypic information, minimal information standards to reach affordable objectives, setting breeding goals, establish an identification system to overcome owners resistance and evaluate performance assessment

Introduction

To date LRS are widely recognised as part of information systems in the agricultural sector with the objective to improve the efficiency of the livestock system and farm operation. LRS do pursue different purposes such as improvement of animal performance, herd and farm management, product quality and sector policy. Decisions at all levels do require analysable information to meet the objective of improving

productivity and efficiency. Thus, under more intensive production conditions of market oriented Livestock Systems (LS), LRS are essential and highly effective tools in system development (Flamant, 1998; James, 1998; Meyn *et al.*, 2001).

Despite the proven benefits of LRS and the ever advancing effectiveness, the application of LRS in regions with evolving economies and less intensive livestock systems remains a problem and an issue of major concern to Researchers and Developers.

Majors problems seem to be associated with
a) low awareness of potential benefits of recording to livestock owners, the Research and Development (R+D) sector and policy makers,
b) problems of finding the right organisation for animal recording and of attaining due participation,
c) lack or insufficient technical know-how to implement and utilise recording, and
d) lack of or non-sustainable funding to cover the cost of LRS (Trivedi, 1998).

This paper attempts to contribute to the identification of R+D with a focus on LRS in different LS, its purposes, organisational needs, recording methods and cost effectiveness.

Assessment of needs in LRS

One of the dilemmas of LRS in evolving livestock systems is related to structural problems in the livestock sector and its institutions. Disciplinary boundaries and institutional barriers between relevant agents involved in policy making, development of concepts and implementation of tasks in livestock policy analysis, farm management improvement and service, breeding policy and program implementation, veterinary services often restrain the definition of shared objectives and purposes related to LRS. Moreover the linkage between Research and Development agents and their staff, and the participation of livestock owners is far from being optimal.

Thus, the pursuance of partial objectives and the definition of self-centred needs can contribute to the rather unsatisfactory experiences of LRS (Flamant, 1998).

The system context for LRS

The identification of objectives, purposes, tasks of LRS, and implementation requires a close association with the livestock system it is supposed to serve. Different systems demand different objectives and purposes, and as such require different tasks, approaches and recording methods.

Livestock systems (LS) undergo a dynamic development in relation to the macro economic conditions and changes in factor costs. Three such stages are described and compiled in table 1. At a stage of low market contact and high capital cost LS tend to be diversified, rely on household resources and have the major objective to attain food security, contribute to family insurance, and reduce risk. Improvement options are limited due to the scarcity of input factors, the prevailing production risk, and limited output options.

Under conditions of increasing market linkages and external inputs the livestock enterprise reduces the number of functions and objectives it serves in the system, and tends to specialise. First decisions for reducing diversity have to be made and the livestock system is gradually oriented to market opportunities. Options for improving livestock performance and management initially depend on the availability and cost of inputs, but increasingly on skills and information. Proximity to supporting infrastructure, institutional support and secure market opportunities foster this system development and the need for improving system efficiency.

A growing market demand for specific livestock products and the associated demands for product quality together with the need to increase labour and land productivity will lead towards a more specialised livestock system with a growing input of capital for yield increasing and labour saving technologies. Growing external inputs (investments) increase production risks and demand all measures to maintain and improve productivity and efficiency.

Many livestock systems in developing countries are still part of the described low external input system, and only in growing national economies or in urban/peri-urban locations do they enter the semi-intensive or even the specialised type of system.

In transition countries with restructuring economic sectors and where smallholder systems have been reinstalled, livestock systems are diverse, too, and have only limited market contact. Factors contributing to the diversity of systems are:

a) the stage of development of the national economy, influencing the demand for products, and factor costs for labour and capital,
b) the physical and institutional infrastructure and its effectiveness (transport, information access, extension and other services)
c) the recent history in Central and Eastern European Countries (CEEC) regarding the restructuring in the farming sector but also the existing traditional structure of agricultural enterprises (number and size of small farms) in some CEE countries

It is obvious that the objectives and purposes of LRS will depend on the economic stage of the livestock system as outlined in table 1.

Table 1. Interdependency of livestock systems and LRS purposes.

Purpose of LRS	Type of livestock systems: Low external input, high diversity, limited market contact	Intermediate system	Highly specialized system, high external input, market dependent
Livestock policy decision making	high	high	high
Market related information:			
• Supply forecast	low	growing	high
• Product quality assurance / public health	low	growing	high
Farm / herd management improvement	low	growing	high
Livestock performance assessment:			
• Characterisation of AnGR	high	reduced	low
• Breed / population comparison	low	growing	high
• Breed improvement	possible	possible	possible
• Product quality	low	intermediate	high

In low external input systems hardly any technical purpose exists, while issues of relevance to the sector policy, which may include relevant decisions for facilitating sector development, should be rated high. Other relevant purposes at this stage are linked to global political issues such as Animal Genetic Resources (AnGR) characterisation or estimating the value of local livestock populations as an important step in shaping a national breeding policy.

Only in fully market oriented, specialised, high external input systems the full set of purposes is pursuable in LRS.

Organisation and purpose of LRS

The organisational frame of any LRS is defined by the purpose it is supposed to fulfil and should satisfy the following principles:

a) satisfy the information needs required by its stakeholders,
b) ensure the interest of livestock owners by providing a participatory environment and feedback of relevant information or services,

c) include different institutional stakeholders and define the operational dimension, financial requirement and funding sources

Considering the diversity of purposes and system needs and the corresponding range of involved stakeholders, LRS essentially have different organisational and operational structures, partners and funding modalities.

LRS for the sole purpose of providing information to policy makers and markets or for characterising AnGR will involve livestock owners and public sector institutions such as Ministry of Agriculture, Marketing Agencies, and Agricultural Research and Extension Centres and Universities. The purpose is almost entirely directed to provide a public good and may be fulfilled by intermittent recordings. Thus, the LRS should be organised and operated by the public institutions with a "Community based participation of breeders" and the respective feedback of information.

In highly specialised intensive systems with its multitude of purposes for different interest groups / stakeholders livestock recording systems

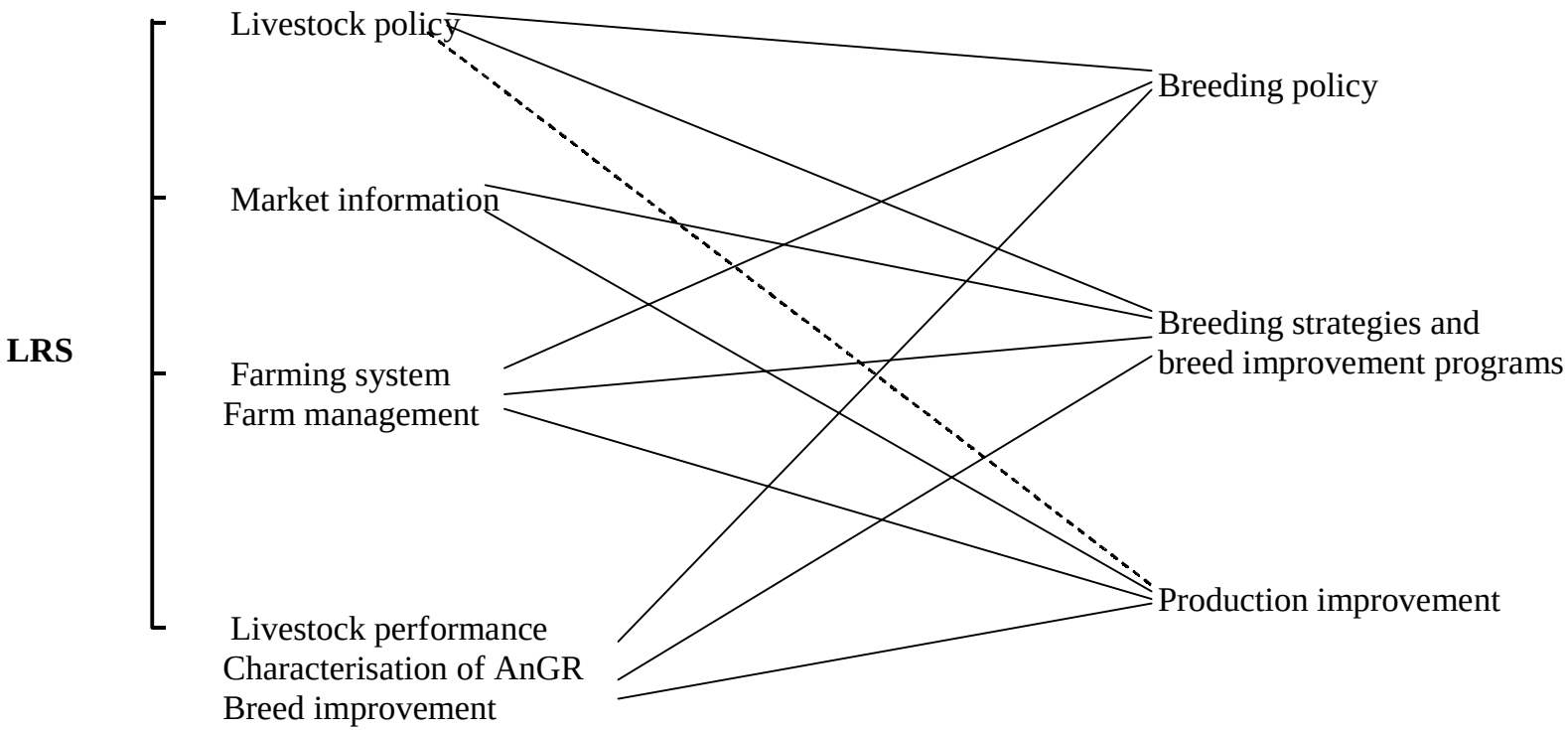
a) need to collect information at various frequencies of various components of the production system (from production to consumption),
b) have a special purpose for performance and productivity enhancement (breeding, management),
c) provide public and private goods of relevance to the public sector,
d) and are of an increasing economic importance to the livestock producer.

The organisational challenges are directed towards the involvement of stakeholders (esp. farmers) in planning of LRS, in the establishment of cost effective LRS, in implementing effective utilisation concepts for collected information and efficient feedback mechanisms for information sharing and service provision.

The dynamic changes of purposes and organisation requirements indicate the need to establish a LRS organisation strategy for a given country, which is concerned with the following five generic problems of organisation development (Schreyögg, 1999):

1. structure of purposes (type, time of occurrence),
2. integration of stakeholders / partners (individual farmers / farmer association, public and private organisations),
3. political and legal environment for organisations,
4. decision making structure and instruments,
5. management instrument to foster changes as required by a system circumstances.

Figure 1. Information linkages for decisions and program implementation.



Information linkage

Different purposes of LRS by different stakeholders tend to lead to independent information systems covering specific aspects of the same livestock systems. Pollot (1998) summarises types of recording systems found in a livestock industry and raises the issue of missing linkages between purpose groups such as genetic resource improvement, enterprise management, farming system research, government policy, and various other schemes. Missing linkages often are a result of uncoordinated implementation of recording by different agents for different purposes but targeting the same system and livestock farmer. This situation may be understandable during the initial phase of a LRS with distinct differences between purposes (e.g. livestock and market policy versus AnGR characterisation) and interested agents. However, soon during the further development of a LRS with consolidated purposes, linkage problems are costly and affect the cost effectiveness of information collection and the appropriate analysis.

A simple example shall illustrate the need for linkage (Figure 1). The formulation of a sustainable breeding policy in a country requires information about the biological base of its AnGR, the ecological and economic environment under which these AnGR are kept and utilised (farming system), the current and perspective market linkage, and the policy framework provided for the livestock sector. Consequently, the respective institutions mandated for each purpose need to co-ordinate their tasks, the establishment of a common LRS, and to ensure the common use of information.

Another example may be very familiar to breeders concerned with breed improvement programs based on selection within breeds either at farm level or at population level. Breeding goals can only be established after knowing the economic importance of traits in a foreseeable market situation, and selection processes based on performance recording do require a careful assessment of production and management system related factors in order to attain a useful accuracy in performance comparison.

Extension services with the aim to improve the production efficiency do also require a full set of information if the service provided is to be effective.

Approaches in information collection

Many countries with either no LRS or only partial recording structures and linkage problems between sets of purposes of LRS require a strategy to evolve a functional LRS to fit changing purposes, technical means and financial abilities.

A strategy for a stepwise approach in establishing a LRS, in securing relevant partnerships and linkages, and for obtaining information in relation to needs and purposes should consider

- sampling concepts and successive steps in Livestock System Analysis (LSA) and LRS
- minimal information standards,
- and purpose oriented information requirements for performance assessment

Sampling

A situation in which it is not feasible to develop a LRS with wide coverage in a livestock sector calls for systematic approaches to obtain reliable information from a much smaller sample taken from the total.

Three major approaches prevail:

a) getting representative information on livestock system typologies, on the importance of AnGR and their average productivity, and on current management practices,
b) getting information for phenotypic characterisation of breeds, for analysing variability in management and performance among farms and among animals within farm,
c) identifying breed and trait preferences, and selection opportunities.

General methodologies for successive steps used in livestock system analysis but also in breed characterisation studies are discussed by Matheron and Planchenault (1992), Rey and Fitzhugh (1994), and Flamant (1998) and are composed of

Table 2. Sample size calculation to define a minimal data structure in animal performance recording.

$$LSD = [2 (t_0 + t_1)^2 (\delta^2_s / i + \delta^2_a / ij + \delta^2_e / ijk)]^{1/2}$$

where

LSD	=	the least significant difference (in units of SD)
t_0	=	the t value for probability 0.05
t_1	=	the t value for probability Z (1 -0.90) or 0.20
δ^2_s	=	the relative variance between sires (1 / 4 h^2)
δ^2_a	=	the relative variance between sires (3 / 4 h^2)
δ^2_e	=	the relative variance within animals
i	=	the number of sires
j	=	the number of dams or progeny per sire
k	=	the number of replicates per animal

after: Bruns, 1992.

1. Diagnostic surveys of the LS using secondary data, informal and formal once-off surveys, which cover a stratified random sample per region (macro level).
2. Establishment of a regional typology of systems, identification of types and functions of livestock populations, listing of production constraints and resources (macro level).
3. Repeated diagnostic surveys based on stratified sampling procedures to obtain representative information on farm and household characteristics, farm resource endowment, structure of the livestock enterprise, and phenotypic characterisation of breeds (meta level). The sample size is a function of the variability among farms, the variability among animals within farms, and the breeding structure within farms, esp. the number of sires being used per year. The minimum number of farms should not be less than 40 for any regional livestock system at the meta level (Baker, 1992).
4. The final step in this sampling approach is concerned with detailed animal related information for phenotypic and genetic description of breeds. The sampling should follow a stratified random sampling procedure assuring a broad genetic sample from as many farms as possible. A minimum set of 200 breeding females and 10 males per breed are required for detecting breed differences of approximately 10 % of the mean. For estimating genetic parameters, at least 20 sires, each mated to at least 20 females are required (Baker, 1992; Bruns, 1992). The sample size calculation demands information as outlined in table 2 (micro level).

This stepwise approach with its macro, meta and micro survey levels will provide valuable information for all purposes of a LRS and establishes sufficient opportunities for developing a “standard” all encompassing LRS.

Minimal information standard

Information acquisition is a costly exercise, especially in cases where repeated measurements are required to obtain a complete and accurate assessment base. Utmost care is therefore required to only record and collect data essential for the given purpose. A clear distinction needs to be made between a “scientific” and a purpose oriented LRS approach to information collection and analysis.

Standard sets of essential information linked to specific purposes and required answers need to be established with carefully considering the need, practicability in obtaining information, costs involved, accuracy, and alternative means of getting the essential information (auxiliary traits). Some data sets of LRS are compiled in table 3 mainly covering the farming

system, the production system and livestock performance assessment. For each data set the question has to be solved regarding the necessity of information, measurement methods, repeatability, accuracy, necessary frequency of data recording and predictability for estimating the aspired information.

Particular problems are associated with data sets which require time series information (milk, eggs) but also with those information based on continuous input and output events. The minimal information requirement for a farm model to calculate gross margins or profit functions, as shown in table 4, provides a simple dimension of the problem for obtaining such data in farming systems in less organised economic environments. The tasks at hand are related to the application of sampling methods, re-call, once-off and structured repeated surveys/recordings, supported by the use of general market data (prices for output and input components).

The appropriate assessment of feeding systems and budgets can also be of concern since precise direct recording systems are very time consuming and costly. The assessment of feed resources available on the farm demands cost efficient, alternative methods such as applied by Abdinasir (2000) for a smallholder dairy system. Farmers' information on land use and types of crops grown, together with empirical information on grain-straw yield rations for each crop grown are used together with the farmers' re-call information on grain yield to predict straw yield. A similar procedure is used for predicting forage availability and yield.

Livestock performance information

Setting breeding goals

In all livestock systems animals are kept for defined but varying purposes. These purposes may involve a large number of traits (multi-purpose) or only special traits (single purpose). The utilisation of performance traits then often depends on the expression of a number of biological functions or traits, which even in a single purpose situation demands the consideration of several traits. Thus, one of the first decisions to be made is the definition of a breeding goal/objective and the traits involved in expressing the genetic merit. The definition of a breeding goal is a decision to be made by the owner of the breeding population, and as James (1998) argues, often tends to be arbitrary and only in recent times breeding goals have been defined in a structured way based on considerable information about trait variability and production functions.

In many situations with an imperfect information base the widely accepted approach to define breeding goals from production functions is not feasible. Attempts are therefore required to assist breeders in making decisions on breeding goals through a set of stepwise methods responding to the sources of available information:

a) initial information on existing arbitrary or customary breeding objectives can be obtained through the application of a "community based participation matrix ranking" of preferred functions, traits, selection criteria and breeding decisions as proposed for and applied in less developed livestock systems by Steglich and Peters (2001)
b) information from farming system surveys (samples) about production costs, performance indicators, performance variability, estimates, combined with population parameters (obtained from literature) and breeders' perceptions of the importance of traits allow a first economical assessment of breeding goals as suggested by Kosgey *et al.* (2001) for small ruminant systems in communal grazing conditions,
c) information from a meta and micro study using a genetically connected stratified sample as described by Bruns (1992) will allow population parameter estimation for the population in question. Together with

Table 3. Data sets in LRS and the need for minimum information standards

1. Production environment

   Location, climate
   Farming systems, production systems
   Feed resources and feeding system / budget
   Management system

2. Identification data

   Individual animal identification system
   Animal bio data (birth data, breed, sex, litter type, etc.)
   Pedigree data

3. Performance related information
   3.1. Functional traits
      Fertility: oestrus and conception occurrence post partum, conception efficiency
      Health: udder, legs, feet occurrence of other diseases and disease resistance
      Reproductive wastage: prenatal and perinatal losses
      Milkability: milking ease, animal behaviour milk, let down
      Physical traits: linear body measurements
   3.2. Production traits
      Milk: yield, contents, quality
      Growth: weight gain, lean, meat quality, feed conversion
      Egg: clutch size, clutch number, egg mass, egg quality
      Fecundity: litter size, rearing rate
   3.3. Productivity and production efficiency
      Biological production efficiency
      Economic production efficiency

Table 4. Minimal Farm Model for Gross Margin/Profit Function Calculation.

- Gross margin calculation (Dairy)
  - Gross output (volume, price)
    - Milk, calves, cull cows, manure
  - Variable costs (volume, price)
    - Replacement
    - Type: farm grown, purchased
    - Feed (nutrient requirements)
    - Operational cost
  - Resource requirements
    - Labour (hours, type)
    - Capital requirement for current assets
    - Capital requirement for fixed assets
- Required information
  - Type of animal (breed, live weight)
  - Housing system (type, cost, durability / depreciation)
  - Herd size (replacer)
  - Labour input
  - Production parameters (e.g. milk yield, calving interval)
  - Input parameter (e.g. nutrient demands, type of feed)
  - Prices of marketable outputs and inputs
- Purpose
  - to assess the economic performance and competitiveness of the production enterprise
  - to quantify resource requirements
  - to provide a basis for farm planning
  - to calculate efficiency measures for the farm
  - to assist definition of economically based breeding objecting

economic production information from the farming system analysis (stratified sample) it is then possible to apply a first structured definition of a breeding goal.

However, the establishment of a cost-benefit analysis for various traits requires extensive investigation to obtain reliable information on population parameters, cost structure and product values. Together with a good understanding of present and future market impacts on product prices and production costs it is only then possible to define a breeding goal with some degree of accuracy.

However, even at this stage one has to be careful not to rely only on production function equations but to carefully relate estimates to the reality of production systems and breeders' perceptions. This might be especially important in multi-purpose livestock systems in situations with considerable uncertainties about natural and economic production conditions, and with rather high natural disease challenges.

Groen *et al*. (1997) rightfully point out in the report of an EAAP working group dealing with economic values in dairy cattle breeding, that one of the basic draw backs of objective methods to define breeding goals based on modelling with economic values is the use of historical prices and production data, while breeding is future oriented. This has to be kept in mind when positive approaches (data evaluation) or normative approaches (data simulation) are applied for profit function or bio-economical models to derive breeding objectives.

Non-objective methods do not derive economic values by direct calculation of influences of improvement on the increase in efficiency of the production system. They may be more appropriate for livestock systems in which production conditions are constrained by factor limitations (health, feed, management complexity). As outlined by Groen *et al*. (1997) these methods assign economic values in order to achieve a distinct genetic gain and are useful to examine the limits for genetic improvement.

Identification

A clear and sustainable identification system of animals of a population subjected to performance recording and selection is proclaimed as one of the essentials of a breeding scheme. While it is acceptable that repeated recording of individual performances does require an individual and durable identification, purposes such as performance characterisation or productivity assessments in stratified samples may need to be pursued without a comprehensive system of identification.

In any given situation it is essential to assess identification needs and possibilities for a number of reasons:

a) Livestock owners may resist the identification and registration of their animals in situations where taxes are imposed on livestock, or where customary believes counteract any infliction on an animal (ear tag, branding, tattoos, ear carves).
b) Traditional ways to identify animals within the herd may exist, which are sufficient for once-off performance assessments based on owners' descriptions and even repeated recording as part of a farming system survey to characterise populations.
c) Temporary identification systems using paint markings or strings (leg, neck, horn) may overcome traditional identification constraints and fulfil all demands for individual repeated recordings. This method may be used in schemes where best animals are identified based on owners' records and which are subsequently subjected to a comparative performance recording for ranking purposes and the start of a breeding nucleus.

However, a master plan for a comprehensive identification system which involves such factors as geographic location, country, region, county, village, breed code for pure breeds or crossbreds, breeder code, and individual animal registration number could and should be established as soon as repeated recording and systematic selection programs are commencing. Even if these action do not encompass the whole population, but are employed on a stratified sample as part of an initial farming system survey, as part of a stratified population sample for specific characterisation and population parameter estimation, or as part of a sample recording scheme involving pre-selected animals, the partial application of a identification master plan will be more efficient than separate and uncoordinated ways of identifying animals (Crettenand, 1999).
In many CEE countries such a scheme is already established. It may not always involve all smallholder livestock owners but can be extended to fit the future needs (Vares *et al*., 2001).

In Europe standards for identification and registration of animals are set by the EU, and CEE candidate countries need to fully apply the binding rules (Hodges, 1999).

Performance assessment

The application of intensive recording schemes as evolved and used in intensive and high performance systems of industrial countries may not be the appropriate solution in less developed situations. The record of failures of such over-ambitious LRS is unfortunately large and has raised the claim to search for alternative appropriate approaches (Trivedi, 1998; Vares *et al*., 1999).

Direct recording of performance traits or their associated auxiliary traits has been well established for intensive LRS for dairy, beef, and others (Simianer *et al*., 2001; Vares *et al*., 2001; Vares *et al*., 1999). Given the high level of system development, large uniformity of production and

management systems, most of these LRS fulfil the requirements of practicability and accuracy, with regard to precision of measuring instruments, measurement methods, and recording method, and are sufficiently able to identify and measure systematic influencing factors for correction of performance data (James, 1998). The remaining problem is however, to reduce the cost of recording in times of dwindling public support for recording. In many LRS attempts are under way to test the impact of reduced recording frequencies on the accuracy of production, or to incorporate technological innovations to improve performance recording by livestock owners (B control methods). Organisational complexity and high costs are of special concern in attempts to record repeated quality traits, such as milk fat and protein or somatic cell count, which require sampling techniques, shipment to laboratories and rather costly analytical procedures.

Problems in LRS are much more aggravated in livestock systems with a lower productivity and, thus, a higher cost-sensitivity in recording. The livestock production process in these systems tends to be restrained by a number of factors such as:

- larger fluctuations in natural conditions with impact on fodder quality and quantity,
- lower external input of feed stuffs and thus instable feeding system,
- larger differences in management techniques and skills,
- high phenotypic performance variability complicating the assessment of time bound yields.

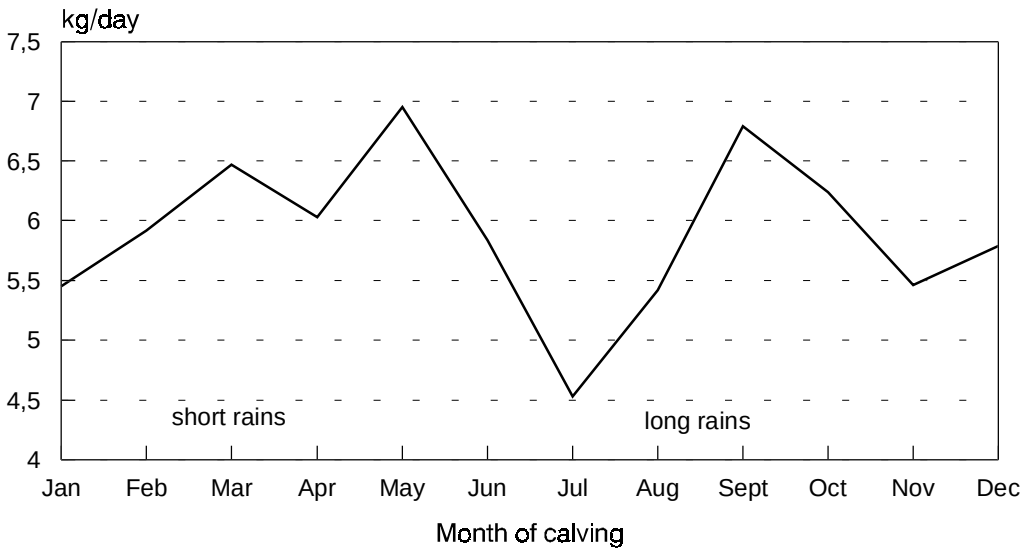


Figure 2. Lactation pattern of Friesian-crossbred cows in the Ethiopian Highlands, after Varvikko, 1991.

These situations do require a high frequency of recording to attain the esteemed accuracy which often is not feasible due to the associated costs. A typical lactation curve of crossbred dairy cows obtained under "improved" small holder dairy conditions in the Ethiopian highland proves the recording problem.

What alternative approaches could be considered in recording?

a) The first step would involve the establishment of an animal history with owner involvement to quantify performance, and to possibly

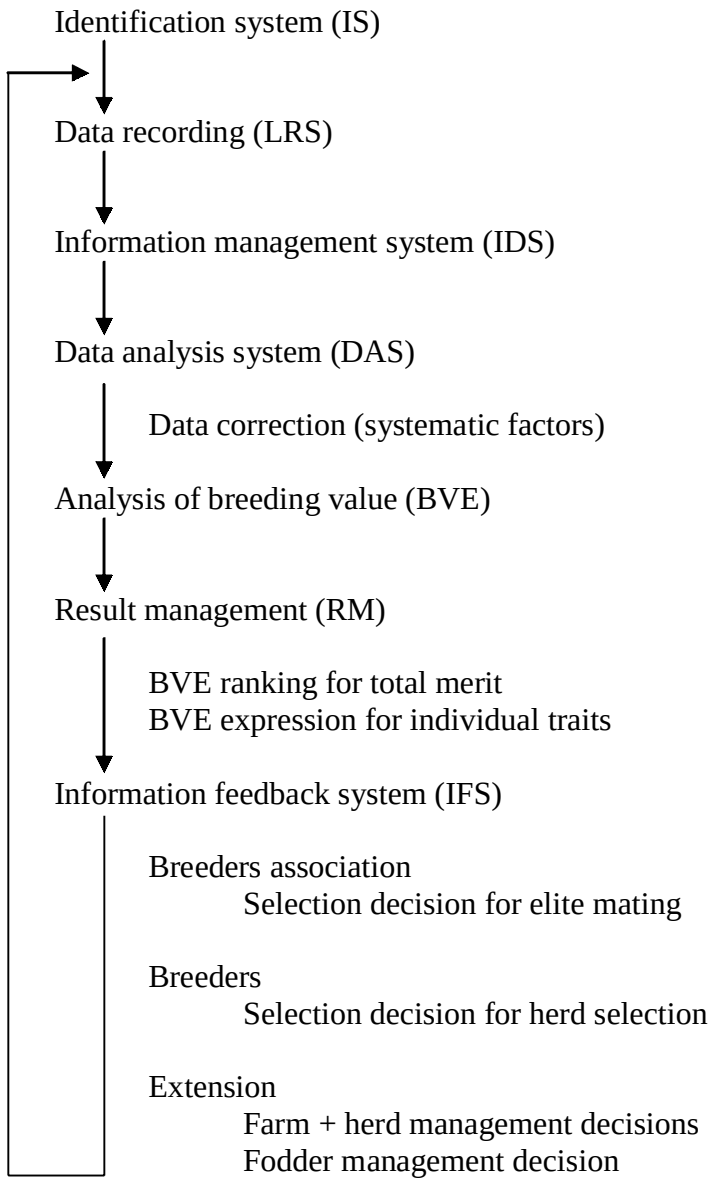


Figure 3. Organisation of information and results in LRS.

apply a matrix ranking for traits among animals. Animal performance histories are established for the following traits

- fertility (calving/lambing intervals and frequency, litter size at weaning),
- milk yield estimates (yield during 1st, 2nd and 3rd part of the lactation period), lactation length,
- weaning rate and weight score,
- functional traits,
- incidence of illness and diseases,

b) A second step involves the application of individual performance recording of sample animals (stratified positive performer sample) following a set of methods which may include:

- official repeated recording by enumerators
- alternative recording by enumerators and livestock owners
- owner recording of traits according to an agreed measurement technique and frequency pattern (daily for milk) with infrequent "visits" by enumerators to provide additional services and to "test" records

After the establishment of full sets of records further regression calculations of different measurement frequencies estimating the true performance should be made to simplify the recording process.

Data organisation and management demands

Livestock recording is known to be a rather complex undertaking which demands a stringent organisation and management scheme to be successful.

The different tasks and steps involved from the identification system to the information feed back system, as illustrated in figure 3, are highly interlinked and interdependent. Success of a LRS depends on the functionality of every step / task and, thus, a concerted organisational effort with stringent task co-ordination and process control is essential for reaching the objectives of performance recording in livestock systems. Responsibility for task implementation, methods to be used, information flow processes, result management and feedback systems have to be determined, administrated, managed, put to financial analysis, and constantly improved. Another typical area where research for development provides a prosperous collaborative working base for scientists, extension specialists, policy makers and breeders.

Conclusion

Livestock recording systems are complex actions with the final aim to improve the efficiency of the livestock sector. Purposes, approaches and the composition of tasks vary according to the system circumstances. A systematic analytical planning approach seems advisable to combine stakeholders, to specify objectives, opportunities, problems and perspectives. Major challenges in organising efficient LRS in developing

countries are associated with the low degree of attainable information and the high cost sensitivity, and in European transition countries with the coexistence of large scale and small scale livestock systems.

LRS should be established with a clear understanding of sustainable standards following a stepwise process guided by a conceptional master plan. This process needs to be concerned with purposes, tasks, interdependencies, linkages between stakeholders, methods, processes, information flows and the respective responsibilities and accountabilities of all institutions and individuals involved.

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