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PREFACE

This issue of the Bulletin arises out of the workshop on "Pastoral systems research in sub-Saharan Africa", sponsored by the International Development Research Centre (IDRC) and ILCA and held at ILCA's headquarters in Addis Ababa from 21 to 24 March 1983. The workshop was attended by 15 scientists from countries in sub-Saharan Africa, by 20 scientists from ILCA and by 3 others.

The workshop focused on the methods, techniques and processes in pastoral systems research (PSR) with particular reference to ILCA's experience in sub-Saharan Africa since 1976. Twenty presentations were made by ILCA staff members. Each group of presentations was followed by a period of discussion. A full report of the workshop has been published by ILCA; these proceedings (ILCA, 1983) contain the full text of the presentations with summaries in French, and summaries of the discussion sessions in both English and French. Copies of these proceedings can be obtained from:

Publications Section, ILCA,
P.O.Box 5689, Addis Ababa, Ethiopia.

This Bulletin focuses on a selection of the presentations made at the workshop in order to highlight ILCA's approach to pastoral systems research (PSR), the methods used in the descriptive and diagnostic stage of PSR and how the design and testing procedures are followed in practice.

The workshop presentations by ILCA staff on which this Bulletin is based are the following:

Towards a framework for livestock systems research by **C. de Haan**

Low altitude aerial surveys in pastoral systems research by **K. Milligan** and **P.N. de Leeuw**

Livestock productivity and management by **R.T. Wilson** and **P. Semenye**

Household studies in pastoral systems research by **B.E. Grandin** and **Solomon Bekure**

Livestock transactions data collection by **B.E. Grandin**

Household income and expenditure studies by **Solomon Bekure**

Labour data collection by **B.E. Grandin**

Design and testing procedures in livestock systems research: An agro-pastoral example by **R. von Kaufmann**

INTRODUCTION

ILCA's mandate region is sub-Saharan Africa, a region containing 726 million hectares of land suitable for crop and livestock production. Of this land area, 526 million hectares (62%) are suitable only for grazing. These pastoral lands are inhabited by nearly 40 million people who own around 80 million livestock units, representing about 57% of the total ruminant livestock population of Africa. Much of the emphasis of ILCA's research has therefore been on these people and their animals, first in order to understand how pastoral systems are organized and function and second to design and test improvements which will give long-term benefits to the pastoral societies involved, and which will improve livestock production in this important sphere of agriculture in Africa.

Most of ILCA's work on livestock in pastoral systems has been done by the Arid and Semi-arid Zones Programme in West and East Africa and by the Subhumid Zone Programme based in Nigeria. ILCA now has some 6 to 8 years' experience of research on pastoral systems in these different environments. This experience has led to the development of a clear research approach.

The methods which have been developed are based on the farming systems research (FSR) approach now in vogue in many areas of the world. Farming systems research seeks to describe and understand different farming systems, to identify problems and constraints to production associated with these systems, to design improvements to each system through component research, to test these improvements in the producers' environment and to monitor the adoption of the improvements throughout the system concerned. The research is carried out by teams of scientists of different disciplines and from different backgrounds so that particular facets of the system do not receive disproportionate attention.

ILCA is concerned with livestock systems which include livestock and cropping components, while most of the systems research to date has concentrated on cropping components alone. Livestock systems are in many ways much more complex than pure cropping systems, due to the greater genetic variability of livestock, the daily rather than seasonal inputs required, the multiple use of livestock and the greater influence that management can have in livestock systems.

Pastoral systems research can be considered a special case of livestock systems research. In pastoral systems there can be even greater complexity than exists in the farm situation, due to the greater mobility of people and livestock, and problems of land tenure. There is often a very limited scope for improvement. The greater complexity of pastoral systems makes a systems approach to research even more necessary; it is the system as a whole rather than its components in isolation that need to be studied.

Systems research can be thought of as being carried out in four main stages of description and diagnosis, design of improvements, testing of improvements and extension. Much of ILCA's pastoral systems research to date has concentrated on understanding different systems, on determining the problems inherent in those systems and on identifying constraints to production. ILCA can now be said to be primarily concerned with the design and testing stage.

The pastoral systems of sub-Saharan Africa are under increasing pressure, due to both the overgrazing of pastoral areas and the expansion of sedentary farming which is encroaching on traditional rangelands. These pressures have made the viability of many pastoral systems increasingly doubtful, and the solutions to the present problems may have to be thought of in terms of drastic changes in the way of life of the pastoralists concerned.

This Bulletin describes the research framework that has evolved from ILCA's experience of pastoral systems research since 1976. It outlines some of the methods used in the descriptive and diagnostic stage of research. Methods of survey both from the air and on the ground and studies of both livestock and the pastoralist households are described in some detail. The final section describes some of the design and testing procedures in pastoral systems research with examples taken from ILCA's work in the subhumid zone of Nigeria.

A FRAMEWORK FOR RESEARCH

When ILCA started its research no clear methods for livestock or pastoral systems research were available. Since then considerable time and resources have been spent on studying and understanding the complexity of livestock production systems, and on defining ways in which available technology could best be tested and introduced into a particular system. ILCA has attempted to develop a systems approach analogous to the farming systems research described by Gilbert et al (1980), Byerlee et al (1980) and Shaner et al (1982).

The objective of livestock and pastoral systems research is to generate improvements to livestock and pastoral systems which will improve the well-being of the people and increase livestock production. These improvements can be technical or socio-economic in nature.

In a pastoral area the research approach includes a description of the relationship between livestock, water resources and rangelands, studies of human labour resources and household income and expenditure, a survey of market forces, and studies of livestock management and production. From such studies, constraints to production within the pastoral system can be identified.

This information is then used to design and test relevant technology aimed at overcoming the constraints. Improvements to the system are tested in real-life situations, initially with a high degree of scientific control, and, as positive effects are noted, with increasing producer/pastoralist participation and decreasing scientific involvement.

PSR can thus be considered as having four stages. These stages and the different terms used in each are given in Table 1. It is important to note that the different stages can overlap and interact. For example, it is not necessary to complete the whole of the descriptive and diagnostic stage before any design or testing activity can take place. Continuous data analysis is essential in PSR so that a changing situation can be monitored; there should be feedback from the testing stage to the design stage.

Careful sample selection is important in enhancing the cost-effectiveness of the diagnostic and testing stages of PSR. ILCA's results in livestock systems research indicate, for example, that producer wealth, the livestock:man ratio, the role of women vs that of men and the proximity of a producer to a major road are important in determining management strategies. Such parameters determine what interventions are likely to be adopted and should therefore be considered in the sampling framework.

Pastoral systems are marked by the need for continuous inputs, in contrast to cropping systems. Studies in farming systems research tend to concentrate on the crop growing season which can be as short as a few months. Thus in a fairly short space of time it is possible to observe all the major inputs to and outputs from crop production. This is not possible with pastoral production systems, which have daily inputs and outputs, the nature of which can change dramatically in the course of a year. So if there is only limited time available, the consequences will be much more seriously felt in PSR. In the study of pastoral systems, therefore, the major seasons and their transitions must be identified and considered. If they cannot be observed, more reliance must be placed on the ability of the producer to recall and report events.

Pastoral systems are characterized by the importance of capital as a factor of production. They are also marked by long cycles of drought and post-drought recovery that are less important in annual cropping systems. More attention therefore needs to be paid to long-term cycles in PSR, first in order to view the population under study in a cyclical time frame and secondly to be able to evaluate the long-term suitability and effects of proposed interventions.

DESCRIPTIVE AND DIAGNOSTIC STAGE

The descriptive phase of PSR includes a literature review of the relevant work already done on the target pastoral system or on similar systems, and a general reconnaissance of the resources and production processes of the target region. This phase provides an indication of the nature of the constraints but not a quantitative assessment of their importance or their priority ranking. The diagnostic phase involves the analysis of data collected in the descriptive phase and the subsequent determination of the priority ranking of constraints to production within the system.

The different methods used by ILCA for describing pastoral systems include the use of low-altitude aerial surveys and ground surveys, the measurement of vegetation, vegetation trends and animal productivity, the study of diseases and nutrition and resource allocation within the producer units, anthropological investigations and the classification of marketing opportunities. This Bulletin describes the

Table 1.
THE DIFFERENT STAGES OF PASTORAL SYSTEMS RESEARCH.

Stage	Object of observations
1. Descriptive and diagnostic	Natural, livestock and human resources; production systems
	Constraints, in order of priority; research requirements; assessment of chances of overcoming constraints
2. Design researcher managed and executed	Component research; design of improvements through on-station experimentation or from existing knowledge
3. Testing researcher managed, producer executed producer managed, producer executed	Researcher and producer management of improvements; producer acceptance of improvements
4. Extension	Evaluation of technical and socio-economic impact of improvements

Source: Adapted from Shaner et al (1982) and Norman (1982).

techniques used in low-altitude aerial surveys, ground surveys of livestock management and productivity, and household studies.

One of the results which merits special attention and which has assisted in developing ILCA's overall research strategy is the finding that herd and flock management practices by individual owners is one of the most important single factors affecting productivity in pastoral and agropastoral systems. For example, Table 2 gives ratios of the production index found by Wilson (1982) in central Mali. Similar results were obtained from ILCA's work in Kenya with both cattle and small ruminants.

This finding is all the more interesting because grazing is communal to all herds or flocks, and different owners in theory have the same access to this principal resource. Individual management skills therefore may play a more important role than previously reported. Attention is now being given to identifying these skills. If causal factors and parameters can be better assessed and if through extension the management of the below-average flocks and herds can be improved then considerable productivity gains can be made.

Possible improvements are identified and designed tentatively by the systems research team during the descriptive and diagnostic stage of PSR. The identification of improvements is a team effort and not the function of any particular discipline. Producers can also play a major role in identifying improvements.

Table 2.
RATIOS OF PRODUCTION INDEX[a] OF SMALL RUMINANTS IN THE AGROPASTORAL SYSTEM OF CENTRAL MALI.

Source of variation	Ratio	Goats	Sheep
Overall mean		1.47	2.31
Parity	all parities/first	1.40	1.23
Season of birth	best/worst	1.23	1.14
System	rice/millet	1.58	1.33
Flock (millet)	best/worst	2.43	
(rice)	best/worst	5.58	

[a] Production calculated in g/year/kg metabolic weight of breeding female.

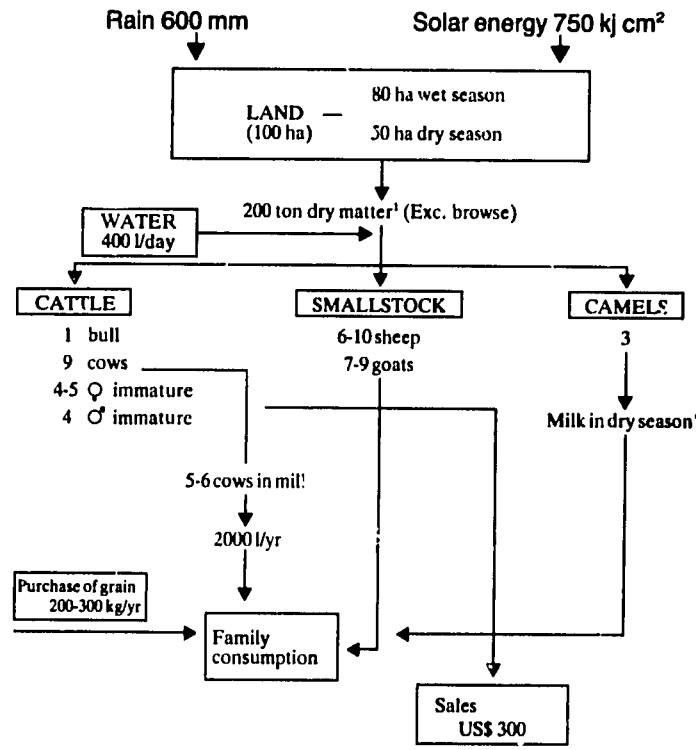
Source: Wilson (1982).

DESIGN STAGE

In the design stage of PSR the research team designs improvements based on the constraints identified in the descriptive and diagnostic stage. Research may be needed on the different components of the pastoral system. Quantitative models describing the input/output relationships at the different levels of the system may be used to assist the team in the design process. For example, the plant – animal component can be represented by ILCA's herd productivity model which is used to estimate the effect of supplementation or management strategies, such as early weaning, watering frequency and distance to water, on livestock productivity, and can therefore be used to rank the priorities for field research (Konandreas and Anderson, 1982; Konandreas et al, 1983).

A simple example of an input/output model at the producers' unit level for the Borana system in southern Ethiopia is shown in Figure 1. This example also illustrates the multi-disciplinary approach to the design of improvements. In the Borana system the herd demography study revealed significant differences in mortality between female and male calves. This is caused by a heavy reliance on milk for human subsistence which forces the Borana herdsman to allow less suckling or even to slaughter male calves so that their dams may be mated sooner. This increases

Figure 1.
INPUT/OUTPUT RELATIONSHIPS OF A BORANA LIVESTOCK PRODUCTION SYSTEM IN SOUTHERN ETHIOPIA.



[1] Food requirement of cattle and smallstock about 45 tons DM/yr.

the amount of milk available for human consumption. However, this strategy conflicts with government objectives aimed at increasing meat offtake from the Borana rangelands. An obvious way, therefore, to reduce calf mortality and to increase total offtake from the system is to increase either the total milk yield or the amount of available grain to reduce dependence on milk. The joint ILCA/Ethiopian Rangelands Development Project team is studying the feasibility of millet cultivation around the heavily manured dry-season wells, and has started work on legume introduction for dry-season supplementation.

It is generally true that in the field of animal health and animal nutrition there is a whole range of improvements which can be designed for pastoral conditions. However, in the field of range management and in the integration of forage production into pastoral systems the available body of knowledge is still extremely limited and few clear-cut solutions to the identified constraints are available. Therefore production measurements have to be made initially under controlled conditions, for example on a research station. It is therefore essential that PSR projects have access to research station facilities. The treatments in research station experiments should be defined by the biological, ecological, socio-economic and political framework determined in the descriptive and diagnostic stage.

When possible improvements have been proposed, a further feature of component research is a study of the probable impact of these improvements on the overall system. If the impact is likely to be beneficial to the system, then the improvements can be tested further.

TESTING STAGE

The testing stage is aimed at testing proposed improvements to a pastoral system under the producers' conditions. Unlike extension work, the object of the tests made at this stage is to obtain scientifically valid conclusions regarding the effect of improvements and to assess producers' acceptance of the innovations. In extension, in contrast, improvements are usually introduced without control groups i.e. without built-in scientific comparisons. Thus, in PSR the testing stage is carried out in order to make a scientifically valid comparison regarding the effect of certain treatments on a minimum required sample size. Systems research should always have a with/without comparison on a representative sample carried out simultaneously under similar environmental conditions. A before/after comparison as carried out in many development projects, will always have the confounding effect of different environmental conditions.

The testing stage can be carried out in three phases:

- researcher managed, researcher executed trials
- researcher managed, producer executed trials
- producer managed, producer executed trials.

In the first phase the trials are wholly under the control of the research team, sometimes on a research station. In the second phase the trials are conducted under the producers' conditions, and samples with and without the proposed improvement are compared. In the third phase the improvement is left wholly in the hands of the producer, while the research team monitors production with and without the treatment as before.

The easiest way of making comparisons is to use matched pairs of animals with similar characteristics in one herd or flock, in which case inputs are easily administered. If the improvements require major changes in management strategies or different organizational structures, then comparisons have to be carried out on a whole herd basis. For example in the Malian delta ILCA is testing the possibility of establishing pastoral units under traditional forms of land tenure. These units would facilitate the introduction of improved grazing schemes (ODEM/ILCA, 1983; Wilson et al, 1983). In Niger, building on traditional water rights, a promising grazing scheme developed on a government station is being tested with a small number of experimental herders' associations. Newly established water points under the control of the associations give the mechanism for testing this grazing scheme. In the Kenyan group ranches, individual ownership of certain pastures allows the testing of legume fodder banks which are aimed at overcoming dry-season nutritional stress.

EXTENSION STAGE

Once an improvement has been tested under producers' conditions with satisfactory results in producer managed, producer executed trials, it can be passed to the extension service for further implementation. This will usually be carried out in the framework of a development project.

But even at this stage it is still important to evaluate the improvement, especially as to its socio-economic impact. Ideally the project or extension structure will include a capability for technical and socio-economic evaluation. In the absence of such a structure, the national research institutes may have to take responsibility for this often politically sensitive task. The degree of involvement of an organization such as ILCA is still an open question.

The evaluation procedures should be kept simple and be focused on the specific improvement introduced. If a particular improvement is to be successful, it should produce a considerable gain in productivity and income or provide added security. The data collection system for studying the impact of an improvement can be reduced in sampling frequency and size compared to the testing stage. Information gained from the evaluation of an improvement in the extension stage can be channelled back to the descriptive and diagnostic stage of future research efforts, so that further improvements are more likely to be relevant to the current state of the pastoral system, whose characteristics may be constantly changing.

LOW-ALTITUDE AERIAL SURVEYS

One of the most useful techniques for studying pastoral areas is the use of the low-altitude aerial survey. This technique has provided a rapid, reliable and cost-effective method for assessing the numbers and distribution of livestock and people over large tracts of land as well as for gauging rangeland and water resources.

In the past, descriptions of pastoral systems had to rely on indirect methods, such as vaccination counts or tax returns, to obtain information about livestock numbers. Such methods have well-publicised errors and biases. Because counts are usually

taken only once a year, often on herds that are congregated into camps, herd distributions over space and time in relation to resources are not known. Low-altitude aerial surveys were developed initially by ecologists in East Africa to map the distribution of wild animals in national parks. Since then ILCA has explored the use of these techniques for preparing inventories of pastoral production systems. Seasonal information on vegetation and water availability combined with the observed livestock distribution patterns can give a clear understanding of resource use and can contribute substantially to the descriptive phase of FSR. Such inventories can lead to the diagnosis of specific constraints to livestock production and lead to the design of possible interventions to improve the system.

METHODS

In the low-altitude aerial survey technique a light aircraft is flown at low altitude, enabling a team of observers in the aircraft to make direct visual counts of animals, people and range resources. The aerial surveys are usually carried out using a systematic, unstratified flight pattern which ensures that every part of the study area is covered evenly and uniformly. This flight pattern makes it possible to present results immediately as distribution maps and also provides information for later stratification. Flight lines based on the 10 km UTM[1] grid provide a useful system for global reference. But sometimes flight patterns which correspond exactly to existing maps are used when ground truth work, such as livestock surveys and household studies, is carried out in the study area.

Each flight is divided into intervals down its length. This allows the entire study area to be divided into a grid pattern of fixed dimensions. All information collected can thus be related to individual grids, and the resulting maps show simple and clear distribution patterns.

The area sampled is restricted to a fixed band on either side of the aircraft. The band is determined by the projection, from the observer's eye to the ground, of two parallel rods attached to each wing strut of the aircraft. The choice of flying altitude is important: the higher the altitude the greater the sample area that can be covered and thus the greater the expected precision of the results. However animals, in particular smallstock, become increasingly difficult to see and count at higher altitudes. The altitude selected is usually between 120 and 350 m above ground. Depending on the survey design, the overall sample cover is between 5 and 20%.

INFORMATION COLLECTION AND ANALYSIS

Observers in the aircraft count and photograph the animals and dwellings seen in each grid within the sample band. Observer bias, which varies according to factors such as the effects of vegetation structure and time of day, requires careful calibration and correction. A front-seat observer is responsible for navigation and for recording ecological conditions, which would normally include:

- vegetation physiognomy;
- tree density per hectare, dead trees and indicator tree species;
- per cent grass cover, height and greenness and extent of burning;
- types of water sources; and
- proportion of farmed areas and the major crops grown.

Ecological recordings are supplemented by hand-held side-looking photography and occasionally vertical photography.

The primary objective of a rangeland resource inventory is usually to determine:

- how many? – this can be calculated from data recorded along each sample flight line.
- where? – this can readily be seen when data are presented as grid distribution maps.
- why? – relationships between animals, people and their environment can be tested by a series of multivariate analyses. Although simple correlations can be confounded by partial relationships, step-wise regressions or preferably analyses of variance or factor analyses can display the major variables in terms of their relationships to each other.

The scope of such analyses can be seen from Figure 2 which represents some of the data sets that could be collected from a typical survey. Any variable such as cattle distribution can be examined through the grid entries. The relationships between data files can be examined statistically and, as shown in Figure 2, cultivation, grass cover and distance to water all appear to influence herd distribution. In the final analysis, it is particularly important to identify the constraints to cattle herd distribution and to accord a priority rating to each file of the data set in terms of its sequential ability to explain variations in cattle herd distribution.

The total number of data files for analysis is not restricted to information collected during a flight, but can include auxiliary information such as rainfall, rangeland types, geology and administrative boundaries.

RESULTS: RESOURCE INVENTORY AND LAND STRATIFICATION

Examples are taken from ILCA's work in Nigeria, Mali, Niger and Ethiopia to illustrate some of the results from low-altitude aerial surveys and how these results can be analysed and represented.

Animal and human populations

An initial analysis of data can provide population totals for the study area, including herd and settlement sizes and densities. Table 3 shows results from the entire USAID/Niger Range and Livestock (NRL) project area (total 81 555 km^2) in the pastoral zone in the Niger Republic in West Africa, during two seasons in 1981 and 1982.

Such totals of livestock and human populations give information about likely production levels and the economy of the project area. A comparison between seasons suggests changing herding strategies. For example, the population of the Bororo cattle belonging mostly to Fulani herders was 62% greater during the wet than during the dry season, while the numbers of Azawak cattle, owned predominantly by Tuareg pastoralists, remained stable between seasons. This suggests that the Bororo herds are more mobile and may be part of a larger scale transhumant pattern extending southwards into Nigeria. In the same survey, detailed distribution analysis detected the different seasonal mobility patterns of entire and split cattle herds, of sheep and goat owners and of camel herds, as well as the areas of influx associated with livestock owned by settled cultivators.

In addition, within the NRL project area five pastoral groups were identified: three

[1] UTM = Universal Transverse Mercator projection

Table 3.
SEASONAL LIVESTOCK POPULATIONS (WITH % SE) IN THE NIGER RANGE AND LIVESTOCK (NRL) PROJECT AREA, WEST AFRICA.

Animal type	Heads				Herds			
	Total number		Stocking (ha/head)		Total number		Mean herd size	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Cattle	288 653 (12)	376 533 (16)	28	22	8 706 (10)	10 043 (12)	33	38
Bororo	152 814 (15)	246 900 (17)	54	33	4 025 (13)	5 444 (16)	38	45
Azawak	135 839 (12)	129 632 (17)	60	63	4 681 (10)	4 599 (10)	29	28
Sheep/goats	780 289 (8)	1 147 914 (11)	10	7	16 964 (8)	16 513 (10)	46	70
Camels	70 162 (9)	155 708 (32)	116	52	12 917 (9)	7 829 (13)	5	20
Donkeys	13 540 (14)	23 375 (12)	588	345	1 890 (14)	4 086 (9)	7	11

Tuareg, one WoDaabe Fulani and one Arab. The initial project preparation document assumed a target pastoral population of 50 000, whereas the low-altitude survey estimated 175 000 pastoralists.

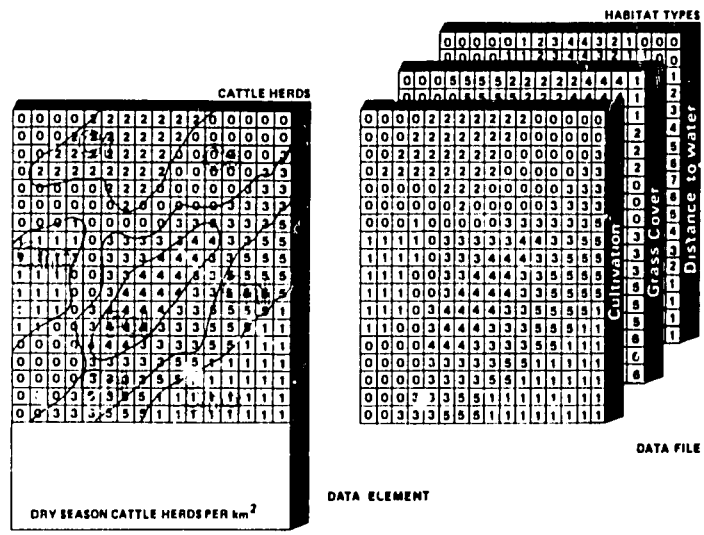
Information about the number of animals and the size of the human target group in a project area is valuable in indicating possible total regional benefits that might result from successful developmental inputs and interventions. However, distribution patterns are equally important, in that they show the regional imbalances in resource distribution and their exploitation, and can guide research and development activities into areas of human and livestock concentration. For example, the livestock and pastoralist distribution in the NRL project area showed that the WoDaaBe Fulani and tented Tuareg occupied different grazing areas. This indicated that detailed data from ground livestock surveys of sample households of these tribes would only be relevant to certain parts of the zone. Also the different transhumance patterns of the two tribal groups suggest different flexibilities in management strategies which are likely to affect their long-term development and thus the choice of interventions.

Four different methods are used to represent distribution data (Figure 3). Each grid may be shaded to represent the density it supports (choropleta symbolism). Alternatively, the individual grid information can be represented as squares or circles (whole point symbolism) where different sizes correspond to the observed densities. Finally, variations between adjacent grids can be presented on two or three dimensional contour maps.

The changes in seasonal distribution of livestock and people are a feature common to all pastoral systems. Although it is virtually impossible by aerial surveys to link these movements to specific herds without radio collaring or herd marking, movement patterns can be deduced from repeated seasonal surveys. A further follow-up through sample household interviews would establish movement histories and mobility strategies, which can assist in mapping quantified movement patterns and seasonally adjusted stocking rates.

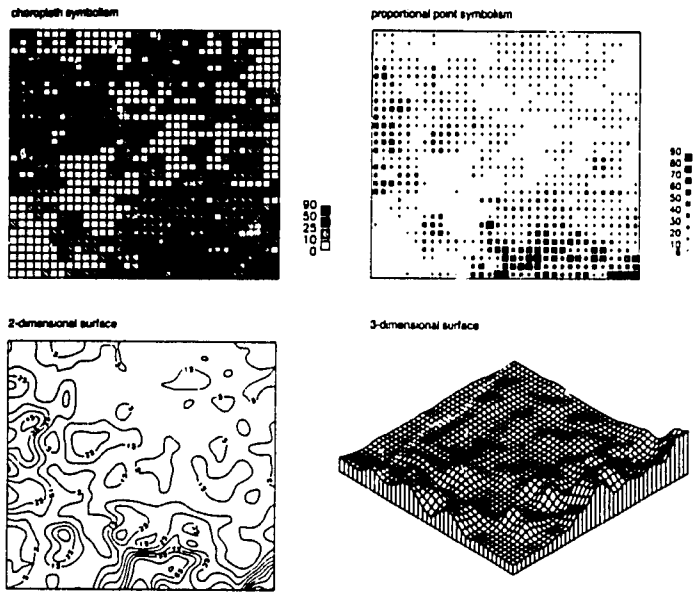
The value of an aerial survey in detecting mobility patterns can be illustrated by work in the Nigerian subhumid zone. This zone had been considered hitherto an area of mainly dry-season grazing. Because of the increasing tsetse challenge with the onset of the rains, it was assumed that most

Figure 2.
TYPICAL DATA ELEMENTS USED IN THE COMPUTER DATA HANDLING TECHNIQUE.



By coding all original information at a common format and scale, analyses (superimposing data, identifying proximity of resources and mathematical weighting) are possible with results in a 'spatial context'.

Figure 3.
METHODS OF REPRESENTING DISTRIBUTION DATA FROM AERIAL SURVEYS.



Dry-season grass distribution in a central region of the pastoral zone of Niger – May 1981
Figures shown are percentage grass cover.

herders would return to the semi-arid zone whenever surface water was again available. However, Table 4 shows that two of the four case study areas in the subhumid zone had high wet-season concentrations – exactly the reverse of what was expected.

Environmental conditions

All recorded environmental variables and their seasonal changes can be illustrated as distribution maps for the total area or specific strata. An example of seasonal changes in grass cover frequency for the upland areas surrounding the Mali delta is given in Figure 4. This change in grass cover can be explained by the level of stocking; in general, curves with a right-hand skew indicate understocking, while a left-hand skew indicates overstocking, except where there are other causes for dry matter disappearance.

Table 4.
CATTLE DENSITIES IN FOUR CASE STUDY AREAS IN THE SUBHUMID ZONE OF NIGERIA.

Case study area	Area (km^2)	Cattle density ($No./km^2$)		Mean herd size	
		Dry	Wet	Dry	Wet
Kurmin Biri	2500	17.3	4.2	51	54
Abet	2475	37.4	22.7	48	61
Mariga	2750	6.6	23.5	25	53
Lafia	3500	12.7	37.7	59	86

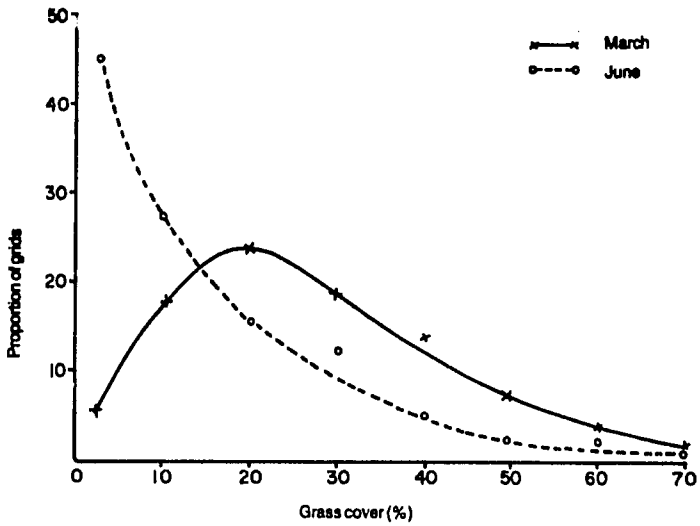
Interrelations between animals and environment

The interrelations between animals or people and the environmental parameters can provide guidelines for appropriate management interventions into the pastoral system. For example, if herds are mostly concentrated in cultivated areas, opportunities for a better integration of livestock within the cropping system can be explored. If cattle are usually concentrated in rangelands and savannas, the creation of grazing reserves or improvement of range management practices may be feasible. Similarly, direct linkages to specific variables can indicate their relative importance and assist in determining whether or not they are the constraints operating within the system.

While any set of variables can be examined it is often more valuable to study the system as a whole, considering the combined and cumulative effects of many variables on another independent variable. This approach would identify, for example, which of all the variables recorded most closely corresponds to the distribution of cattle, on the assumption that such a variable may thus be a limiting or controlling factor on cattle distribution.

This type of analysis is perhaps the most valuable to pastoral systems research, as it moves away from a basic description of the system to the diagnostic stage, hypothesising specific constraints that can be validated and tested by ground research teams. It is important to realize that results from such analyses are necessarily predictive rather than causal. For example, results could indicate that animals are usually concentrated near water, i.e. that a knowledge of water distribution allows animal distribution to be predicted. Water resources may, in fact, not be the cause of the observed animal distribution, which could be due to factors not even recorded in the survey, such as the favourable species composition near water or tribal and border conflicts. Clearly, a ground research team, equipped with the predictive hypotheses generated from an aerial survey, can quickly determine their validity.

Figure 4.
FREQUENCY DISTRIBUTION OF SEASONAL GRASS COVER LEVELS IN THE UPLAND SAHEL REGION BORDERING THE MALI DELTA.



Over large tracts of land ecological conditions usually vary considerably and so do opportunities for intervention. Thus an effective diagnosis of the principal constraints within a pastoral system will often require an initial stratification of land into major vegetation or ecological units followed by an assessment of probable constraints within each stratum, and an evaluation of whether or not particular strata are likely to respond to the proposed development.

THE LINK WITH GROUND SURVEYS

Although low-altitude aerial surveys record a large number of parameters relating to the animal and human populations as well as their environment, there are numerous parameters that cannot be recorded. For example, while the animal population size and distribution are recorded, age and sex structures are not. Similarly, baseline information about human demography, household and labour budgets and decision-making processes are not recorded, neither are environmental factors such as geology and rainfall, though these often exist in the published literature. While detailed range resource maps have been produced from intensive photo-interpretation and ground truthing, the general vegetation descriptions made during a flight will often be sufficient to indicate whether range resources are an important constraint to animal distribution and thus whether further, more detailed research is necessary.

A particularly useful advantage of low-altitude aerial survey is its ability to guide aspects of the sampling design of ground investigations (Okali and Milligan, 1980). If detailed animal production studies require a stratified sample design based on herd size, this can be derived from the results of the aerial surveys. Subsequently, aerial and ground data can be linked together and detailed results from the ground can be extrapolated to the entire study area. Similarly, if household studies are to be based on wealth strata and if the wealth characterization can be linked to factors visible from the air, such as camp size, number of granneries or cattle holdings, the basic sample frame and its locations can be determined before the ground work begins.

COSTS

In addition to their advantage as a multiple resource inventory technique, low-altitude aerial surveys are both rapid and cheap. Although survey time will depend upon sample procedures and various logistic considerations, an area of about 100 000 km² could be covered in 3 to 4 weeks and preliminary reports from the survey could be made available to ground teams 1 month later. Costs are variable. The actual flying operations themselves are usually much less expensive than the cost of the man-hours involved, and thus analysis and reporting time become important considerations. Normal 1982 costs from planning to reporting were about US$ 1.0 per km². Although costs would be higher for more intensive inventories, they usually represent a very small fraction of the budget of most large-scale pastoral development projects.

LIVESTOCK SURVEYS

Of all the elements included in integrated development plans, the livestock sub-sector has often been the weakest. The traditional reluctance of pastoralists and livestock owners in general to enumerate their animals, coupled with the mobile nature of their assets, have made accurate estimations of total animal numbers almost impossible to obtain.

The problem has been alleviated to some extent by the introduction of aerial surveys as described above. But it is not only at the population or regional level that errors have been apparent; parameters at the level of the herd and the individual animal have also been generally unknown. In the case of individual animals the estimates of production have often been based on factors derived from non-comparable situations in more developed economies, or from livestock breeding units where management for the improvement of local breeds takes place. Such management is often far removed from the real pastoral situation.

In recent years methods have been developed which give more realistic estimates of livestock parameters in traditional systems. These relate to estimates of both total livestock in a given area and individual and herd production characteristics.

By combining the two sets of data, precise figures for the total livestock output of an area can be derived with known confidence limits. It is then feasible to manipulate the data for predictive purposes, taking into account natural factors such as rainfall variability and the effects of disease and anthropogenic factors, such as responses to market stimuli and improved veterinary control.

Aerial surveys are particularly suitable to the enumeration of total animal numbers related to both time of year and location. Aerial surveys can be used to establish short-term changes in animal numbers, trends in total effective herd size and seasonal or longer-term movements. Provided a series of flights over time is flown, aerial surveys can also be used to establish the gross dynamics of an animal population in addition to the total animal numbers. But it is not possible to establish population structure or sex ratios with any accuracy. So for the establishment of population dynamics and demography as well as for individual growth rates, production parameters for meat and milk production and levels of offtake, ground surveys need to be made.

Data on livestock transactions are important in obtaining a comprehensive picture of livestock production systems. Such data are often most easily obtained during studies of pastoral households, and livestock transactions are therefore covered in more detail in the "Household studies" section of this Bulletin.

However, socio-anthropological and formal questionnaire methods, such as those used in household studies, provide insufficient data of the kind needed to establish livestock population and production parameters. There is no substitute for physical inspection and physical contact with as large a number of animals as possible. Based on this understanding, attempts were made to establish a "zootechnical" method of survey for livestock which would provide data of the kind and of the accuracy required for detailed development planning. The method was primarily designed for use with cattle, sheep and goats, but it has also been used in camel and donkey studies. This survey method, which is described below, has been used and tested in Darfur in western Sudan where livestock data were obtained from transhumant Baqqara Arabs and sedentary cultivators; in Tigre in northern Ethiopia where data were collected from short-cycle transhumant Afar in the Rift Valley and sedentary Tigrean cultivators in the Ethiopian plateau; and in West Africa during a study of agropastoral systems which used data from transhumant Fulani and sedentary Bambara cultivators in central Mali. Further studies are at present under way in Nigeria and Kenya.

Three depths of intensity of ground livestock survey are recognized:

1. the pre-survey
2. the initial survey
3. the continued survey.

The extent to which these depths of survey are carried out depends on the kind of information required and the use to which the data will be put. However, it is a prerequisite of the method that the first two stages are carried out. It may be possible to condense a continued survey with one or both of the earlier survey stages but some initial work always needs to be done.

THE PRE-SURVEY

A knowledge of the natural environment, the social groups and the general pattern of livestock distribution and ownership is fundamental to any further survey. Initial stratification can be carried out using LANDSAT imagery and, in the case of an integrated aerial/ground survey, aerial reconnaissance. But some time must be spent on the ground in all parts of the survey area. The multi-disciplinary team that conducts the survey should comprise an animal scientist, a range ecologist and an anthropologist or socio-economist. Unless one of these is thoroughly familiar with the area in question and with the local language, a guide or an interpreter will also be required; in any case the latter may be desirable for political reasons.

During this phase it should be possible to select representative areas and villages or other units for the initial survey stage. An outline of the subsequent stage should also be given to the probable participating units. If an aerial census to determine total numbers is not to form part of the subsequent survey stages, then available statistical data should also be collected at this point. In any case such data may well be useful for comparative purposes and may also help to establish household and individual ownership patterns which are studied in detail in household studies. Market and slaughterhouse figures should also be collected.

THE INITIAL SURVEY

The initial livestock survey is designed to provide data on population structure and individual animal growth rates. From these parameters it is possible to postulate individual and flock output without any additional knowledge of birth rate, death rate or actual levels of offtake. Some of these parameters may be deduced from the population structure at least as accurately as they can be extrapolated from questionnaires.

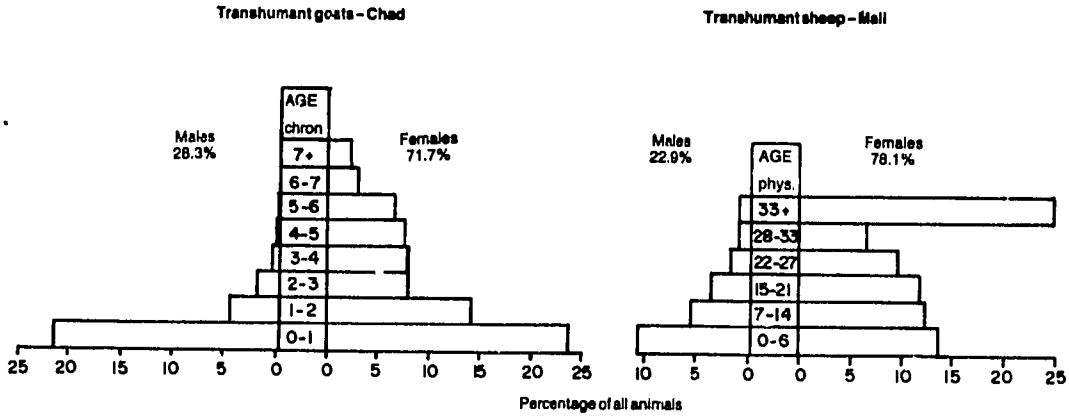
Large numbers of each animal species are required to establish realistic population means with a sufficient level of reliability. In real terms this will probably involve not less than 1000 head of each species. In fact in Darfur, data were collected in this phase for 5600 cattle, 1900 goats and 1200 sheep and in central Mali almost 10 000 smallstock were surveyed. Population classes based on dentition are likely to provide data on demography just as valuable as the data obtained using the more or less subjective ages given by most owners.

The kind of population data that can be obtained using both questionnaire and "handling and mouthing" techniques are shown in Figure 5. Figure 6 shows data for cattle at two extremes of the range of systems likely to be encountered in the traditional sector, both of these being obtained by the "handling and mouthing" technique.

Sample selection within the broader ecological/social strata established during the pre-survey phase poses some problems. A frame suitable for randomization of the sample is unlikely to exist given the differences which will probably be found in ownership patterns and flock sizes. Some subjectivity may have to be accepted after the primary stratification governing locality and group size has been adequately taken into consideration. One should aim for a representative sample. The importance of wealth effects and a rapid method for ranking producers are described by Grandin (1983).

At this stage considerable additional information on the animals may be obtained at little extra cost. This might include details of external morphology. Such physical data may have little direct relevance to the primary objectives of the study but may still provide useful comparisons, particularly as existing descriptions of African livestock, and especially those of smallstock, are generally inadequate and outdated. In some cases it is worthwhile obtaining individual reproductive histories of breeding females. It is then possible to calculate such parameters as birth rate, frequency of multiple births and parturition histories. A useful method for obtaining histories of individual animals is the progeny history technique.

Figure 5.
POPULATION DEMOGRAPHY OF SAHELIAN SMALLSTOCK.



Tables 5 and 6 illustrate the kind of information that can be compiled in this way. However, where a continued survey is envisaged, these latter parameters are probably of too tenuous a nature to be worth the investment in time required at this stage.

A complete initial survey of the type described above might be expected to take about 6 to 8 man-months occupying a time span of 4 to 6 months including full data analysis and report completion. A team composed of an animal scientist and a recorder is the minimum required for such a survey. Good results can be expected provided there is a good degree of confidence between the two, that both are aware of the descriptive shorthand being used and that both understand the main language of communication within the community being studied.

THE CONTINUED SURVEY

The continued survey is designed to provide full and reliable data over the whole range of production parameters. These include birth, death and offtake rates, individual weight gains by season and year, meat and milk production and flock or herd dynamics. Individual identification of animals is necessary, and this can be ensured by the use of coloured and numbered ear tags. Sample selections should be representative of each area. A minimum of 10 herds or flocks for each species should be surveyed with not less than 300 animals of each species being recorded initially. Very small units and atypically large ones should be avoided.

During the first visit, when each animal is identified, as much information as possible should be obtained as to its physical

Figure 6.
POPULATION DEMOGRAPHY OF CATTLE MANAGED FOR DIFFERENT PURPOSES.

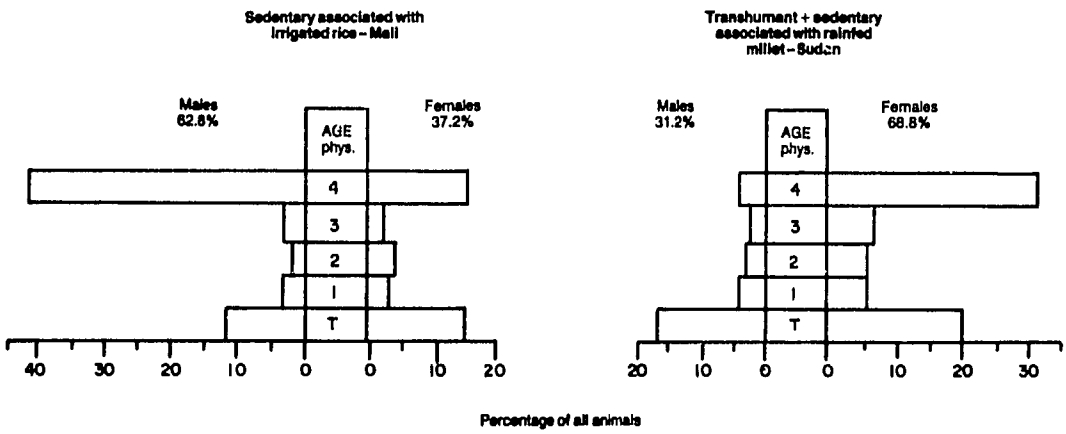


Table 5.
DATA ON KIDDING FOR 42 FLOCKS OF SEDENTARY GOATS IN THE NIONO AREA OF MALI (CALCULATED FROM INITIAL SURVEY).

Parameter	No. of pairs of incisors				Milk teeth	All goats
	4	3	2	1		
Number in sample	180	77	61	111	15	444
Type of birth:						
Triplet	8					8
Twin	203	11	4	1		219
Single	457	139	81	77	5	759
Total births	668	150	85	78	5	986
Total kids born	887	161	89	79	5	1221
Average litter size	1.33	1.07	1.05	1.01	1.00	1.24
Parturitions:						
Mean	3.71	1.95	1.39	0.70	0.33	2.22
Mode	3	2	1	1	0	1
Range	0–10	0–5	0–3	0–1	0–1	0–10

characteristics and its relationships with other animals in the unit. This information should be noted on the back of a record card with one card for each animal. Physical and family relationship data enable positive identification should ear tags become accidentally lost; family data are also useful in establishing the most prolific and productive blood lines.

Subsequent visits need to be made at fairly short intervals (2 weeks or less) in the early stages. All events in the flock or herd should be recorded on the relevant record cards. Newborn animals need to be identified, cross-referenced to their dams and weighed. Relevant details should be entered on the dam's card and on a new card for the young. A canvas sling suspended from a spring balance of the dial type is suitable for weighing smallstock and calves but some kind of crush and weighbridge is needed for cattle. A crush is also required for adult horses but a suitable sling and 200 kg dial can be used for donkeys and foals.

The main problems in the early period are associated with getting the livestock owner to appreciate the need for full reports of all events. The principal problems associated with incomings to a herd or flock are the failure to report deaths of newborn animals whose births and deaths have occurred between visits, stillbirths or abortions and the deaths of one or more siblings of multiple births.

Once some confidence in the ability of both the researcher and the owner to record and report all events has been achieved, the frequency of visits can be reduced to between 4 and 6 weeks. Longer intervals may be acceptable where there is some literacy in the group being studied and where a group member undertakes to record data.

In order to achieve worthwhile and reliable results which can be used for productive purposes or as aids to biotechnical innovations, this type of study should take a minimum of 3 years. Such a period would minimize seasonal effects in the results other than in exceptional cases. Some useful indications of production parameters will be forthcoming after the first 12 to 18 months. A programme of survey involving the three main species of domestic livestock in 30 units totalling 1000 head in one region could be expected to occupy a technician full-time, with supervisory scientific

Table 6.
NUMBER OF PARTURITIONS PER BREEDING COW FOR SEDENTARY CATTLE IN THE MOPTI AREA OF MALI (FROM INITIAL TYPE SURVEY).

Age (years)	Number of calves								Total numbers		No. of cow reproductive years
	0	1	2	3	4	5	6	7+	Cows	Calves	
0–1	197								197		
1–2	180								180		
2–3	205	1							206	1	
3–4	145	27	1						173	29	86.5
4–5	28	95	14						137	123	205.5
5–6	12	56	43	2	2				115	156	287.5
6–7	6	23	51	19	1				100	185	350.0
7–8	2	3	18	20	31				74	223	333.0
8–9		1	7	8	6	4			26	83	143.0
9–10	1		2	7	18	7	3		38	150	247.0
10+	1			1	3			1	6	23	45.0
Total	777	206	136	57	61	11	3	1	1252	974	1697.5

and analytical work including report writing, in the region of 3 man-months a year.

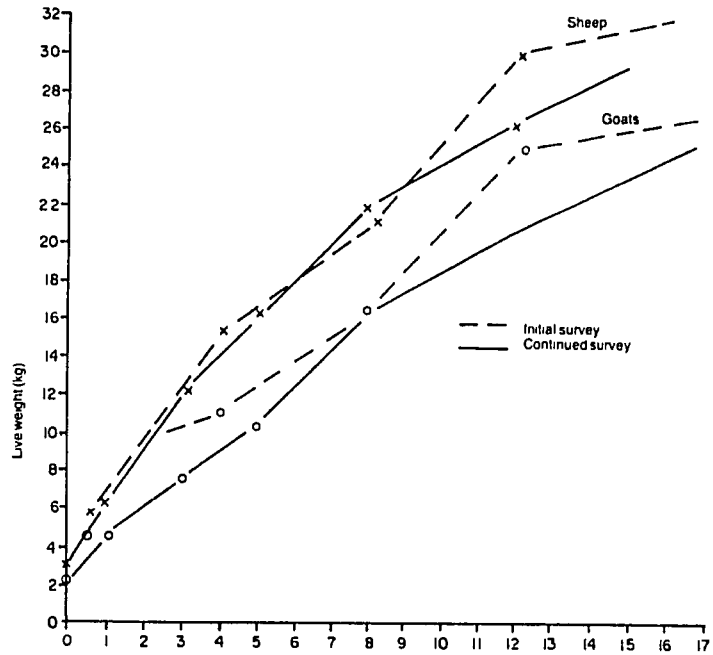
COMPARISON OF INITIAL AND CONTINUED SURVEYS

For population structure the initial survey is clearly the definitive one as much larger numbers of animals are studied. It is also clear that the initial survey can be useful in establishing generalized growth curves and mature average weights. Figure 7 shows direct comparisons for Mali for initial and continued surveys for sheep and goats from birth to 18 months of age. The main problems occur at the top end of this age range where either the ages in the initial survey were underestimated or weights were taken at a time of the year which was particularly favourable to them. What Figure 7 doesn't show, and which can only be obtained from a continued survey, is a breakdown of weights by type of birth and parity. Nor do initial surveys give seasonal weight variations. With a continued survey one can obtain weight curves by season of birth, and gain a much better idea of the variations in weight with age.

When studying reproductive traits, the initial survey will give neither the age at first parturition, the parturition interval nor the distribution of parturition intervals in relation to parity. But these can be shown by the continued survey. One of the principal drawbacks of an initial survey is the lack of any firm data on deaths and offtake. It is possible to compile some figures from population structure and individual breeding female histories (total animals born, now in flock, died, sold etc.) but these are subject to considerable errors of recall. A continued survey makes it possible to establish precise figures for these parameters.

The great advantage of the continued survey is its precision and the opportunity it provides for calculating and using statiscally significant values. The combination of various parameters such as the birth rate, death rate, weight of females and young at weaning enables one to calculate certain production indices. These are extremely useful in determining the effect of management and biological and economic factors on production.

Figure 7.
A COMPARISON OF GROWTH CURVES FOR THE SAME POPULATION WHEN ESTIMATED FROM A SINGLE SURVEY AND CALCULATED FROM LONG-TERM DATA.



HOUSEHOLD STUDIES

One important part of the descriptive and diagnostic stage of PSR consists of the recording of household level data in pastoral societies. Three major areas of such studies are the assessment of household livestock transactions (to complement the livestock surveys described above), household budgets and labour use.

As has been noted, pastoral systems are characterized by high mobility of both people and livestock which can cause problems in sample selection and long-term survey work. Many areas inhabited by pastoral societies are largely inaccessible to researchers on the ground, or are accessible only at a prohibitive cost. Given the high mobility it is often difficult to ensure that the same families can be covered throughout a long-term study. It is often more cost-effective to study more households in fewer communities.

Pastoral systems are marked by the communal sharing of major resources, and therefore focusing on the household as a unit of production is often more difficult with pastoralists than with sedentary farmers. Thus in order to understand pastoral management practices and strategies, attention must be paid to the relationships between households. PSR is aimed at increasing the productivity of pastoralists and improving their welfare. As much resource management and many inputs and outputs occur on the household level, data must be collected at this level in order to understand these important production parameters. Interventions generated by PSR have to be acceptable to and adopted by individual pastoral households. A good understanding of the perceptions, goals, strategies and decision-making of individual households is essential if researchers are to effectively design and test improvements which are acceptable at the household level.

METHODS AVAILABLE FOR COLLECTION OF DATA AT THE HOUSEHOLD LEVEL

There are general methods available in farming systems research which can be used in a PSR framework. The types of data collection techniques which might be employed can be usefully described in terms of formality and frequency.

The techniques range from informal, open-ended interviews normally done by the researcher himself to highly formalized pre-coded questionnaires which are usually administered by a trained enumerator. In terms of frequency, techniques may require single visits, limited visits or multiple visits which may be continuous throughout the study period, or may use seasonal subsamples. Multiple visit surveys themselves may vary considerably in terms of the frequency with which the data are collected from each producer.

Informal surveys

Informal surveys can play a major role in the early stages of research. They are conducted by the researchers themselves without the help of enumerators, or the use of questionnaires and random samples, and thus they are simple and qualitative. Informal surveys provide critical background information on the production system and form the basis of later, formal questionnaires. Informal surveys can elicit types of information that are impossible to collect with formal questionnaires. These include information on producer's strategies, decision-making and social aspects of the production process. Sensitive information is also more likely to be provided in informal contact with a researcher than with an enumerator. An informal survey gives the researcher the opportunity to interact directly with the producer and explore issues as they arise, rather than in a predetermined way.

However, the sample may not be truly representative in informal surveys. And as these surveys are qualitative, their validity is more likely to be questioned by decision makers and planners.

Case studies may be seen as a variant of the informal survey in which a carefully selected sample of households is chosen for intensive study, including frequent visits by the researchers themselves. Case studies are particularly valuable in providing data on the full range of production parameters for the sample households, including data on goals and decision-making which are impossible to glean from formal questionnaires. Through case studies, linkages within the pastoral system are more likely to be understood.

Formal surveys

Formal surveys rely on the administration of precisely designed questionnaires by enumerators, and have the advantage that the number of households which can be included in any study can be increased. They provide standardized and quantifiable data, although there are inherent limitations in the type of data that can be collected. While sampling errors are easily decreased through formal surveys, measurement or observation biases inevitably increase. Formal surveys also have the disadvantage of requiring considerable expenditure on training and supervising enumerators, and on coding, data preparation and analysis.

The accuracy of formal surveys depends on many factors, including the quality of the enumerators and the questionnaires, the type of data to be collected, the frequency of the visits and the cooperation of the respondents.

Enumerators and questionnaires

The use of enumerators introduces biases into the data collection. While it is impossible to eliminate this "enumerator effect", steps should be taken to minimize it through the proper selection, training and supervision of enumerators as well as by paying attention to the details of questionnaire design. The enumerators should preferably have the same ethnic background and if possible be known to the target population. This facilitates their acceptance by the latter and enhances their ability to explain the questions in terms and concepts which the respondents understand.

Great attention should be paid to developing the questionnaire, to ensure that it taps the precise information required, to phrase it so that it enhances the recall of the respondent, and to standardize it to reduce "enumerator effects". Ideally a questionnaire should be carefully translated into the language of the respondent so that questions are listed in terms and concepts that the respondent understands. The more precise the question, the more likely is the respondent to recall and relate the answer.

Data type

Not all events are equally well remembered. Events which are regular are less likely to be remembered individually, but producer estimates of their occurrence are likely to be adequate. Irregular events which occur rarely are likely to be remembered individually, but frequently occurring events will pose great difficulty in recall and will necessitate high frequencies of questioning. And information on certain events might best be gathered by observation rather than by questioning. But for most data, observation is far more time-consuming and thus more expensive than recall.

Frequency of visits and end effects

The frequency of visits depends on the type of event to be recalled and on the depth of data desired. All surveys based on recall suffer from the "end effect", i.e. the difficulty of specifying the limits of the period for which information is requested and the tendency of respondents to include events from outside this reference period. End effect problems occur with the first interview as the end point of the reference period is often unclear. Information from the first interview should usually be excluded from analysis as it is invariably over-reported. Single visit surveys in particular suffer from end effect problems unless the period can be clearly specified.

The primary role of single visit formal surveys is to quantify and verify the hunches which have emerged from the initial informal survey. They are most appropriate for collecting information on variables for which a single objective measurement will suffice. They may also be used to collect general data on a relatively small number of variables, particularly when the essential parameters of the production system are already well understood. For well remembered and registered events, single visit surveys may be able to elicit time-depth data. For non-registered events, single visit surveys rely more on the producer's ability to estimate from general experience rather than to recall actual events.

Multiple visit formal surveys have several advantages over single visit surveys. They provide time series data, are more likely to reflect actual events rather than estimations, and both the enumerator and the respondent benefit from learning. But as the frequency of visits increases, with the same amount of resources, the number of households must decrease.

Respondent cooperation and bias

Whatever the information collected, it is necessary to distinguish between the respondent's ability and his willingness to respond to a questionnaire. Ability to respond is largely a function of survey design, whether the questions are well-phrased and solicit information which it is possible for him to remember. Multiple visit surveys appear to have a learning component, so that some improvement in recall occurs, provided that it is not offset by respondent fatigue. There are likely to be some social/psychological factors which encourage inaccurate and selective reporting. These may be due to a desire for greater prestige, fear of shame or a cultural taboo on certain topics. Case studies and participant observation are particularly useful to evaluate and adjust for such reporting biases.

COLLECTION OF DATA ON LIVESTOCK TRANSACTIONS

Livestock transactions are defined as all voluntary offtake and acquisition of livestock, whether permanent or temporary. For acquisition they exclude birth, but include purchases and acquiring animals as gifts, on loan, as bride price or by any other "socially mediated" means. For offtake they exclude death but include such transactions as sales, gifts, exchanges of animals, slaughter and loans. Births and deaths of animals are covered by the livestock surveys described above (p. 11).

In investigating a pastoral production system it is critical to study all transactions which affect offtake and acquisition, whether or not they are commercial and whether or not the animal leaves the area. These data are needed to complement results such as those described in the "Livestock surveys" section of this Bulletin. Together, this information gives an understanding of how the producer manipulates his animals to fulfil both short- and long-term needs and goals.

To underline the importance of studying total transactions, Figure 8 presents data obtained on one group ranch in Kenya. It shows the mean annual value of permanent offtake for both poor and rich households. It also shows this value broken down by type of transaction: sale, exchange, gift, and slaughter for home consumption. While the actual value of transactions varied greatly between the rich and the poor households, the percentage of transaction type did not. For both groups, sales represented only slightly more than half of the transactions. Approximately 45% of the value of the transactions was through non-commercial channels. This emphasizes the need to study the full range of transactions. This information is critical not only for understanding the producer's goals in herd accumulation, but also for understanding his wider strategies.

Informal surveys can give the following important background information for understanding livestock transactions among pastoralists:

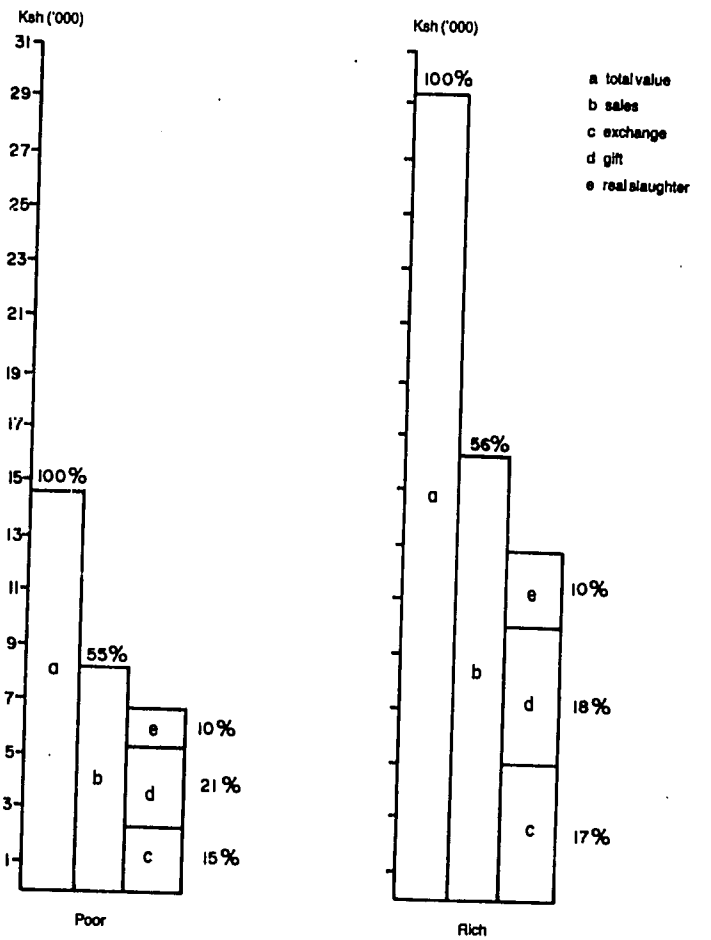
1. the general uses of livestock within the society, including both economic and social aspects;
2. the general goals of the enterprise within the economic sphere (milk/meat; commercial/subsistence);
3. the distribution of rights to animals and their products; and
4. the culturally available means of acquisition and offtake of animals.

For individual transactions, data should at least include information on the transaction type, the species, age category and sex of the animal.

HOUSEHOLD INCOME AND EXPENDITURE STUDIES

Very little is known about the economics of household level activities in pastoral production systems. But interventions are frequently proposed which call for increased cash expenditure on the part of the pastoralist. An intervention may also require increased labour input. Will there be suffi-

Figure 8.
VALUE OF PERMANENT OFFTAKE BY TRANSACTION TYPE: A MAASAI EXAMPLE FROM KENYA.



cient labour, and if so will there be sufficient food available to sustain the energy requirements of increased effort? An intervention may call for the culling of non-productive and old animals. What is the implication of this for the security of different groups of pastoral households? What needs of pastoral households can be manipulated to provide incentives for culling? It is in such contexts that information on household income and expenditure is required. And the testing of the impact of interventions also requires data on household income and expenditure.

Compared with agriculturalists, pastoralists depend more on market transactions to satisfy their subsistence needs. Work in Kenya has shown that even during the wet season the Maasai obtain up to 50% of their calorie intake from purchased food. This figure can increase up to 70% during the dry season. Household income and expenditure data are useful for determining the demand of pastoralists for purchased goods and social services and for assessing the terms of trade between pastoralists and the rest of the economy.

Collection of data

In addition to producing meat and milk for their own consumption, pastoral households engage in a variety of transactions involving livestock, livestock products, cash and other items. Animals and their products are sold to provide cash, and may be exchanged for social reasons or to increase the productivity capacity of herds and flocks. Thus in order to determine the entire household budget, income and expenditure studies should be designed in such a way as to include not only cash income and expenditure but also other important transactions. Usually the quantities of these transactions are known and their values can be determined by using prices which the items would have attracted had they been sold.

In any society the most important factor that influences patterns of household income and expenditure is the wealth status of the household. It is therefore essential that the study sample adequately represents the gradient of wealth observed in the pastoral group under study.

Types of data required

Once the sample households in the study have been determined, an initial inventory of the human and livestock populations needs to be made. An inventory of household goods also gives a clear indication of investment and consumption patterns. This information is vital for two reasons: it measures the wealth status of the sample household, and provides the basic population data for calculating per caput figures for comparative analysis.

Background information is needed on the nature of items that form the income and consumption baskets of the pastoral households to be studied, as these vary from culture to culture. A comprehensive list of these items should be established from the research worker's personal knowledge or from informal surveys involving a few pastoralists and shopkeepers in the area. The income items include:

- livestock and livestock products
- agroforestry products
- cottage industry products
- other forms of employment
- other cash inflows.

Cash expenditure items can be grouped as:

- food
- health and hygiene
- clothing
- transport
- livestock
- livestock products
- durable household goods
- others (cash outflows, such as loans given).

Information on household income is relatively easy to obtain because most of it is derived from the sales of animals which are usually remembered well. However, expenditures, especially on food items, occur so frequently in irregular amounts that recall is difficult. Thus the shorter the time span over which the respondent is requested to recall, the more accurate is the information obtained.

The frequency of collecting household income and expenditure data should depend on the nature of the research. A comparison of monthly and daily monitoring of data in Kenya showed that monthly recall accounted for 73% of the total expenditures recorded on a daily basis. If a complete understanding of the process is required then the more frequent and highly expensive methods need to be used.

LABOUR DATA COLLECTION

Labour plays a crucial role in any agricultural system. In a pastoral system where grazing and water are theoretically of free access within a resource sharing group, capital in the form of animals and labour is the essential means of production which must be acquired and managed.

As has already been noted, PSR on the whole suffers from a paucity of baseline information and understanding of dynamics within a system. This is perhaps more true of labour than of any other input to production. Anthropological studies have tended to focus on the social organization of labour while paying little attention to the actual labour demands of the system. But a proper understanding of labour as a system component must embrace both its social and technical aspects.

The energy demands of many tasks in pastoral production are much less than those needed for crop production. A myth has arisen about the idle pastoralist, because inputs in energy have been confused with inputs in time. Consequently little attention has been paid to the labour demands of pastoral production, which can be considerable.

It is necessary to understand both the labour demands of the households and the labour supply available. In the descriptive and diagnostic phase of PSR informal surveys can be used to gather information on the following aspects of labour:

1. the critical production tasks, their timing and seasonality;
2. the culturally accepted age and sex division of labour;
3. the possible recruitment pathways for labour;
4. labour demand/supply variations between households and social mechanisms for adjusting these; and
5. the constraints due to insufficiency of labour, including its effect on productivity. Ideally there should be sufficient information to make some estimation of the economic returns to labour.

Through the use of a labour profile, which details the time and amount of labour inputs into production activities by category of worker and season, it may be possible to determine whether there are labour constraints to production. It is also possible to determine what the opportunity cost of proposed interventions might be in terms of the shifting of time allocation from one activity to another.

If proposed interventions require significant changes in labour inputs or patterns, it is essential to know the answers to the following questions: Is labour available and/or can it be obtained at the required time? What would be the opportunity costs incurred with the proposed changes of labour input? Will the age/sex group normally responsible for a task or group of tasks be willing or able to undertake a proposed intervention?

In determining labour criteria it is important to collect data at the household

level as households vary significantly in both labour needs and availability. Numerous methods can be used for gathering such information.

Critical task analysis

In critical task analysis the investigator, through observations and interviews, develops a list of the most important tasks and the approximate amount of time they require. This may be done by direct observation, paralleling the work study approach used in farm management studies. This technique was used by Swift (1979) working with the Tuareg in Mali.

The technique provides useful and interesting data in a cost-effective way. It suffers from the limitation that only general descriptions of major tasks are dealt with, and no information is provided on the actual inputs of labour by various workers nor on variations in allocation of labour which might be related to season, skill or wealth.

Extensive recall methods

Recall techniques involve interviewing workers and asking them how much time they have spent on a certain activity over a specified period. These techniques can range in intensity from seasonal to daily interviews. In designing such a study for labour data the two most important decisions are the frequency of the visits and who should be interviewed.

If detailed information is required, twice-weekly recall is probably as necessary with pastoralists as it is with farmers. This is the frequency used by Swift (1982) in Mali, but high frequencies can lead to respondent and enumerator fatigue. The decision on whom to interview depends on both the breadth of data required and the cultural practices in the area under study. The herd owner at least should be interviewed; he would probably be able to say which people looked after each group of animals for the previous few days, and in what major management tasks they were engaged. The investigator must be particularly wary of biased answers: for instance the herd owner may not know an answer or it may not want to admit the fact, or the household may have non-conventional labour input patterns to which the herd owner may not want to admit. If each worker is interviewed separately accuracy is significantly increased, but so are the costs of the survey.

Data from both limited visits and extensive recall methods may enable the investigator to determine labour bottlenecks. But these methods have several drawbacks due to the fact that they may tap only the major inputs into productive, and possible domestic, activities. As many small inputs and other activities can often be missed, it is not possible to calculate returns on labour in pastoralism. The researcher will thus be unable to understand what activities would have to be foregone if labour-intensive innovations were suggested.

The time allocation technique

Because of these difficulties associated with the critical task and recall methods, the ILCA team in a study of the Maasai in Kenya used a data collection technique called "time allocation". This method relies on randomly timed visits to a household during which descriptions of the activities of all its members are recorded. These records produce a series of verbal snapshots which can be sufficient in number to provide a thorough description of the activities by age, sex, season etc. The time devoted to a particular task is calculated from the percentage of all observations of that task.

The requirements of the time allocation technique are the following:

1. A census of the sample households is needed to give the name, age and sex of each worker in the household.
2. Enumerators must stay near the homesteads so that all the important hours of the day are covered. The technique is therefore difficult with highly nomadic populations in which encampments or households split seasonally.
3. Access to a computer will simplify analysis, as the number of records is large.

The technique has one disadvantage: it is not adequate for specifying the time spent on certain activities away from the home. But its advantages are numerous:

1. It covers all potential workers.
2. It is not subject to problems of recall.
3. There is little respondent fatigue; in fact almost any person in the household can be interviewed.
4. Apart from a household census, little pre-survey information is required.
5. The technique covers the complete range of tasks, whereas the critical task technique depends on the specification of just the few most important tasks.
6. It is possible to record multiple, simultaneous activities with the technique.
7. If the sample size is sufficient, households can be compared according to their labour supply, wealth, neighbourhood or any other factor which may affect labour input.

DESIGN AND TESTING PROCEDURES

The descriptive diagnostic stage of PSR has by its very nature occupied ILCA research programmes for much of the first few years of their existence. Having built a strong foundation on which to base technical improvements, the next stage in the process of PSR is to design improvements aimed at alleviating the constraints to production identified in the first stage.

One of the research programmes of ILCA that is at the stage of testing improvements to a pastoral system is the Subhumid Zone Programme based in Nigeria. The system concerned includes the Fulani pastoralists, who should strictly be termed agropastoralists since the formerly nomadic Fulani cattlemen are now settling and becoming mixed crop – livestock producers. It is likely that many of Africa's present pastoral systems will have to incorporate some form of settled agriculture if the societies they support are to survive, and the Fulani of northern Nigeria therefore represent a good example for considering the future development of pastoral systems.

In designing and testing improved technology for pastoral systems, PSR teams should freely use the research results and experiences of other research and development organizations. They may also need to call on other institutions to carry out back-up work. National research institutes can help overcome problems that require detailed on-station experimentation, if this is appropriate, and development agencies

are essential to PSR as vehicles for testing the proposed interventions and procedures. Where possible, trials of proposed improvements should first be tested in trials managed and executed by researchers to ensure the inherent value of the improvement under controlled conditions. Next, trials managed by researchers and executed by producers should be carried out in the field to test the value of the improvement under field or range conditions and to assess its adaptability. The final test of an improvement should be made in trials which are both managed and executed by the producer himself. Such trials should be monitored by the researcher and the effect of the improvement should be assessed by comparison with producers in the same system who have not adopted the improvement.

DESIGNING IMPROVED TECHNOLOGY

Once the main constraints to production and potential intervention points have been identified, and the objective of the PSR design stage has been defined, the programmes of individual researchers need to be carefully focused and coordinated to enable them to work together as a team.

In the design stage it is important to appraise present and past techniques as far as these are documented or known. This is possibly more difficult in livestock research because there is often little contact between research stations and pastoralists. However, when considering alternative ideas generated from within, the team should go back to the local scientists and extension workers for comment and advice.

The team must also take into account not only the present circumstances but also immediate, past and future trends. If it does not it will test interventions that may no longer be relevant by the time they are proven.

Case example

The importance of close association with other research and development institutions can be seen from the experience of ILCA's Subhumid Zone Programme in Nigeria. The programme is closely associated with the National Animal Production Research Institute (NAPRI) of Ahmadu Bello University. NAPRI has been conducting research on animal production in Nigeria for about 30 years and has a wealth of results, information and scientific expertise on which ILCA has relied heavily. The programme is also linked to the Livestock Project Unit (LPU) of the Federal Livestock Department, which is responsible for implementing a World Bank assisted livestock development project. The staff of the LPU provide an audience from the development community which is necessary in the selection of priorities and for the rapid adoption of interventions. The association with LPU enables ILCA to assess the uptake, effectiveness and persistence of its innovations in real life.

An example of this three-way cooperation can be taken from the nutrition trials conducted in the PSR programme. The feed rations were calculated from data on feed requirements, and nutritional values of forage and agro-industrial byproducts were determined earlier by NAPRI scientists. Carefully controlled, researcher managed trials confirmed the expected improvement in performance, and many of the Fulani then realized the value of controlled feeding. Through farmer managed trials the LPU then incorporated ILCA's findings into a pilot smallholder dairy scheme which is now being actively promoted.

Another clear feature of the ILCA programme in Nigeria is its multidisciplinary nature. One focus of the research was on the alleviation of malnutrition in domestic ruminants with forage agronomy at the hub. Social scientists helped make it possible to grow forages by determining how pastoralists could obtain the right to use and fence fallow land belonging to arable farmers. The veterinarian first concentrated on internal parasites in young stock, as it was reasoned that with cattle continuously returning to the same spot the worm burden was likely to build up. Later it was argued by other scientists in the team that the establishment of fodder banks might be more profitable if they were used by more productive animals such as crossbred dairy cows. These animals were known to be more prone to diseases, and the veterinarian therefore started studying disease incidence in a small number of experimental crossbred animals attached to Fulani herds using fodder banks.

Research has also been carried out with an awareness of the immediate future trends in Nigerian agriculture. For example there is a trend towards larger cultivated areas and greater stock numbers. Both these factors weaken the relative bargaining position of the pastoralists, and result in more competition between them for less grazing. In these circumstances it would be unwise to concentrate wholly on forage production, and the team is devoting considerable resources towards crop – livestock interactions. This involves research into crop residue production, storage and utilization as well as growing food crops in fodder banks by judicious rotation or by transplanting into rows hoe-cut through a stylo.

TESTING IMPROVED TECHNOLOGY

Testing innovations raises more serious problems in PSR than in farming systems research. Some of these problems are due to factors such as mobility, which have already been mentioned. Others relate to the difficulty of simulating pastoral conditions on research stations.

As described in the first section of this Bulletin, in the testing of improved technology researchers first conduct their own experiments to find out whether the technology works under controlled conditions. They repeat the experiment, firstly with the producers' participation and secondly under his control to see if the producers have the technological resources to cope with the innovation and to verify that it works in their circumstances. Finally the researcher takes a back seat and observes whether or not the producers actually adopt the innovation. If it is not adopted, or is adopted only with drastic alterations, the innovation must be dropped or returned to the drawing board for further adaptation.

When innovations are too uncertain and risky to try on producers' fields or in producers' herds, or require examination under strictly controlled conditions, they should be tested in fields and herds wholly controlled by scientists. These trials may be carried out at national research institutes or on sites controlled by the PSR team, but great care must be taken in extrapolating the results.

Once the PSR team has designed an intervention and completed successful on-station trials it can set a hypothesis that the intervention will be beneficial to livestock production in the selected district or region. The next phase of the PSR cycle is to let the pastoralists try out the intervention under the guidance of the PSR team, in researcher managed, producer executed trials. This is where PSR starts to diverge most sharply from normal research station experimentation. It is the point where data collection becomes extremely problematic because of the mobility of the stock and their large unit sizes. Moreover, because of the long generation intervals it is absolutely essential that records are kept of the

same animals for a number of years. The sample size has, therefore, to be large enough to cope with losses and dropouts over a long period.

Sample size is also determined by the needs to have enough producers involved to eliminate the effects of differences between individuals.The effect of individual abilities, ambitions and circumstances is likely to be stronger in livestock production than in crop production because of the daily need for decisions over the herd and the competition between herders for favourable grazing. At the same time, PSR can easily become too unwieldy and costly. For instance, a sample of only 20 herds may involve over 1000 animals. Sampling is also constrained by the need to work with pastoralists who are willing to cooperate almost on a first come, first served basis. There are too few herds within serviceable areas and too much communication between pastoralists for the team to pick and choose between them.

The Subhumid Zone Programme team overcame these conflicting demands in the early researcher managed phase by keeping control animals in every herd. For example, only half the eligible animals from any one herd would be included in any trial. The owners were amenable to this because they preferred to have half the animals better off rather than none at all. This technique could not, however, be continued in later trials because once the producers saw the benefits they employed the innovation on the control animals at their own expense.

The frequency of data collection is perhaps the most contentious in this stage of the PSR cycle. In the researcher managed, producer executed phase scientific and technical understanding and explanation is still required, but the researcher must allow for the producer's independence. Thus the frequency of recording must take into account the producer's natural reluctance to reveal sensitive information such as sales prices.

And the more sensitive the topic or the more aware the producer is of the official, correct or expected answer the less accurate is his memory. To combat these factors it is often better to observe the event rather than to ask about it.

Local children were employed by the team in Nigeria as enumerators to record milk offtake, deaths, sales etc. on a daily basis. However, difficulties did arise in data processing because the team had no in-house computer and attempted to run all its data once a year on the computer at headquarters. This meant that the researchers had no way of testing the suitability or reliability of the collected data.

The programme found it necessary to study the grazing behaviour of pastoral herds as a means of determining the type and quality of feed available to the cattle throughout the year. This was intended as a 1-year study, but the extent of burning and time spent grazing on burn-regrowth had not been anticipated and was only appreciated after regrowth had been a significant part of the diet for a few weeks. The study therefore had to be continued for a second year. The herd productivity recording started at the outset of the project, but it is still continuing because after 3 years there are too few data on calving intervals and age at first calving. More time is therefore needed for the team to acquire data on such basic parameters as age and weight at first calving in traditionally managed herds, let alone what effect improved nutrition may have on these parameters.

Once the producers have successfully executed the procedures, or implemented the interventions under PSR guidance, the trials can move into the final phase of the PSR cycle. The PSR team members must then stand back and become passive observers so that they can test whether their brain child can survive without them. The team needs to know if the intervention is adopted at all and at what rate, how closely the producers adhere to the original design, what modifications they introduce, how successful the intervention is in terms of the goals it was designed to achieve, how persistent it is and what side effects it has.

The final stage of PSR can only be accomplished in cooperation with extension and development agencies. It is essential therefore that the team develops a sufficiently close relationship with an agency that will allow it access to the necessary data both of extension inputs and that from the participating producers. The frequency of data collection can be much less than in earlier stages because it is no longer necessary to try and explain what is happening at the micro level. It is the macro effect on farm or herd output and profitability that is important.

The good relationship ILCA has in Nigeria with the Federal Livestock Department and the Kaduna State Ministry of Animal and Forest Resources provides ideal facilities for this phase of the PSR cycle. Indeed the only problem is that some innovations are being adopted before ILCA would normally be ready to move on from the researcher managed phase. By working through the Livestock Service in Nigeria, ILCA hopes to have in 1984 in effect a network of testing sites spread throughout the subhumid zone. These will provide ideal conditions because they will be created under differing circumstances and well away from the present sites in Kaduna State where ILCA's own influence cannot be eliminated.

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