IDRC-256e

Small Ruminant Production Systems in South and Southeast Asia

Proceedings of a workshop held in Bogor, Indonesia, 6–10 October 1986

Proceedings Series

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE • CENTRE DE RECHERCHES POUR LE DÉVELOPPEMENT INTERNATIONAL
CANADA

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IDRC. Regional Office for Southeast and East Asia, Singapore SG
IDRC-256e

Small Ruminant Production Systems in South and Southeast Asia : proceedings of a workshop held in Bogor, Indonesia, 6–10 October 1986. Ottawa, Ont. IDRC, 1987. xii + 414 p. : ill.

/Animal production/, /goats/, /sheep/, /mixed farming/, /small farms/, /South Asia/, /Southeast Asia/ — /feed/, /crops/, /research methods/, /economic analysis/, /animal diseases/, /case studies/.

UDC: 636.3(5) ISBN: 0-88936-493-1

Technical Editor: W.M. Carman

A microfiche edition is available.

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Editor: C. Devendra

Cosponsored by the
International Development Research Centre
and the
Small Ruminant Collaborative Research Support Program

Abstract This publication presents the results of a meeting held in Bogor, Indonesia, 6-10 October 1986, that focused specifically on the assessment of small ruminant production systems in South and Southeast Asia. It considered the prevailing circumstances, the innovations, and the strategies that are pertinent for stimulating increased productivity from goats and sheep. The present patterns of production were examined in detail with reference to characteristics of the small farms, existing management methods, and nature and components of the production systems. These systems include extensive systems, systems combining arable cropping, and systems integrated with tree cropping. The discussion of the systems were further highlighted by country case studies, issues and policies that considered the available production resources, especially the genetic and feed resources available, constraints to production, and potential means to achieve desirable improvements. An important session was devoted to examining research methodology, strategies for development appropriate to individual systems, and a conceptual framework for on-farm economic analysis. Together, these discussions enabled a definition of research protocols and the priorities for future direction that are likely to have a major impact on productivity from small ruminants.

Résumé L'ouvrage présente les conclusions d'une réunion tenue à Bogor, en Indonésie, du 6 au 10 octobre 1986, portant sur l'évaluation des systèmes de production touchant les petits ruminants en Asie du Sud et du Sud-Est. On y a brossé un tableau de la situation actuelle, des innovations et des stratégies susceptibles d'accroître la productivité dans l'élevage de la chèvre et du mouton. On a examiné en détail les méthodes actuelles de production dans la perspective propre aux petits exploitants, les éthodes actuelles de gestion, le type de systèmes de production et leurs éléments. Il s'agit ici des systèmes extensifs, des systèmes associant la culture des terres, et des systèmes intégrant la sylviculture. Les discussions ont été étayées d'études de cas, de problèmes et de politiques émanant des divers pays et portant sur les ressources disponibles pour la production, spécialement les ressources génétiques et fourragères, les contraintes à la production, et les possibilités d'amélioration qui existent. Une importante session fut consacrée à l'examen de la méthodologie de la recherche, des stratégies de développement convenant à chaque système, et d'un cadre conceptuel pour l'analyse économique des activités sur le terrain. Toutes ces réflexions ont permis de définir des plans de recherche et d'établir les priorités qui, dans l'avenir, auront vraisemblablement un impact majeur sur la productivité liée à l'élevage des petits ruminants.

Resumen Esta publicación presenta los resultados de la reunión celebrada en Bogor, Indonesia del 6 al 10 de octubre de 1986, cuyo temp principal fue la evaluación de los pequeños sistemas de producción de rumiantes en el

Sur y Sureste asiático. En la misma se analizaron las circunstancias imperantes, las innovaciones y las estrategias pertinentes para estimular la mayor productividad del ganado caprino y ovino. Se examinaron detenidamente los patrones actuales de producción con respecto a las características de las pequeñas granjas, a los métodos de manejo existentes y a la naturaleza y componentes de los sistemas de producción. Estos sistemas incluyen sistemas extensivos, sistemas que combinan el cultivo de tierras arables y sistemas integrados con plantaciones de árboles. La discusión de estos sistemas estuvo acompanada del análysis de etudios de casos en diferentes países, así como de problemas y políticas relacionados con los recursos de producción disponibles, especialmente los recursos genéticos y alimenticios disponibles, las limitantes de la producción y los posibles medios para obtener las majoras deseadas. Una importante sesión estuvo dedicada a examinar la metodología de las investigaciones, las estrategias para el desarrollo apropiadas para cada sistema individual, y un marco conceptual para la realización de análisis económicos en las granjas. En su conjunto, estas discusiones permitieron definir los protocolos de investigación y las prioridades para el futuro, que probablemente habrán de tener importantes repercusiones sobre la productividad de los pequeños rumiantes.

CONTENTS

RESEARCH METHODOLOGY AND REQUIREMENTS FOR SMALL RUMINANT PRODUCTION SYSTEMS

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Abstract *The types of information required and methods available for studying small ruminant production systems within the context of a farming systems research approach are outlined. Emphasis is given to methods suitable for on-farm research. The major socioeconomic data required and the problems associated with their collection by survey are discussed. Specific animal-production information is required on population structure in the area being studied; then, for the farms, or villages if very small farms are involved, details are needed on population dynamics, existing productivity, health, and housing. The responses of the animal characteristics to changes in management systems are normally estimated from observational studies and on-farm experimentation, but there are severe limitations to data obtained in this way. Methods for collecting and interpreting these data are outlined and the value of systems modeling as an aid to the design of improvement programs is discussed.*

There is general agreement that farming systems research aims to take a global approach and examine all the farm enterprises acting together in the context of the socioeconomic, managerial, and physical environments. Within this framework, the small ruminant production system can be investigated as a subset as long as the interrelationships with other components are taken into account (Norman and Collinson 1985).

Farming systems research and any of its subsets rely heavily upon on-farm investigations, particularly for initial situation analysis, problem definition, strategy testing, and demonstration. The knowledge used to develop the new strategies is usually drawn from the store of existing information gained from research (both station and on-farm) and experience. In many cases, however, this will not be sufficient and there is increasing interest in the use of on-farm studies because of the hopefully greater likelihood that the information being sought will be relevant to the farming situation and the results will be achievable on other farms.

The literature on farming systems research often appears to be very general and discussions of methodology sometimes lack specific details. This is undoubtedly a result of the wide scope of any systems investigation and the limited space given to authors. It is the intention here to focus on methods for investigating small ruminant production systems, with limited attention being given to socioeconomic aspects.

INFORMATION NEEDED FOR SMALL RUMINANT SYSTEMS

The information required for investigating possible improvement strategies for small ruminant systems can be divided into two main sections: one dealing with data defining the current situation and the other dealing with likely responses to changes in any part of the system.

Socioeconomic data are required to establish the system in its "real-world" context, to allow the assessment of the external impact of any changes, and to help guard against any irrelevant or unacceptable changes being recommended. Economic data are needed to assess and integrate individual farm activities and to evaluate markets and their likely development.

Regional and individual farm population structures and management systems must be defined. This includes the distribution of breeds and types, age and sex structures, and products generated. Overall information on the feed resources available and the relationship between small ruminants and other stock also must be established.

The population dynamics and production levels of the sheep and goats kept on the individual farms are important and, ideally, are needed on an age-specific basis. Data on the health of the animals, their housing, and problems related to them should also be specified.

All this information will form the basis of a situation analysis that will often allow the main constraints to productivity (or to the achievement of farmer or institutional goals) to be identified. The formulation of strategies to overcome these constraints will then require information on the response of the various production and economic parameters to changes in the inputs or the management and structure of the population.

METHODS FOR OBTAINING AND INTERPRETING THE REQUIRED DATA

This section deals with methods suitable for acquiring relevant data in the South and Southeast Asian region, with particular emphasis on those that can be used in on-farm studies. It will be seen, however, that some essential data cannot be readily or reliably obtained from farms and it will be necessary to collect these data from research stations and other sources.

Socioeconomic Information

Practically all the information relating to socioeconomic aspects of farming and livestock production systems has been drawn from surveys of farmers from the "target" group for whom improved systems are to be developed. Considerable care is needed in the design of such surveys to ensure that the sample is representative and that the conclusions drawn will be referable to the target group and not specific to the farmers surveyed. This implies that the basic sampling method should be random and not restricted to those farmers who are accessible or most cooperative. Unfortunately, resources are usually insufficient to allow adequate random samples, so stratification is required on the basis of the main physical, agricultural, and economic classifications that exist in the target group. For example, Ashari and Petheram (1983), when surveying ruminant feeding systems in West Java, classified villages according to altitude and rainfall and the main soil and land-use types. Within such classes, villages and farmers within villages would ideally be chosen at random in sufficient numbers to ensure that the range of enterprise scale is represented. This design stage is normally based on official statistics, data maintained by local authorities, and preliminary observations of the target group and its environment. An important factor in the success of this type of survey is the involvement of people with local knowledge in the design and survey team. Indeed, Zandstra et al. (1981) maintain that farmers themselves should be involved in the whole program, particularly because on-farm research and testing of potential new systems constitute an important part of any farming systems research.

Once designed, surveys are normally conducted by interview and their success in deriving valid information depends heavily upon the skill with which the questions are framed and the tact of the interviewer. The farmers of many communities have been surveyed numerous times and their attitude to interviews can be influenced by their previous interview experience, their reluctance to discuss personal, religious, and financial matters with strangers, their trust in officials, and the time they have available to answer often lengthy and apparently repetitive questionnaires. In addition, some societies have a tradition of trying to please guests, and answers may be affected by what the individual thinks the interviewer would like to hear. Clearly, there is ample opportunity for the collection of misleading information and, if specialist help is not available from experienced sociologists and economists, it is better to restrict the scope of a survey to matters relating to the most important areas of interaction between the livestock system and its socioeconomic environment.

The main sociological information required relates to the size, sex, and age structure of each family, the education levels reached, and the religious and social functions that small ruminants fulfil. Reasons for raising sheep and goats, for ceasing to raise them, and for not expanding their numbers are also important. Economic data are needed on prices paid and received for the various inputs and products, the end uses of the animals and their products, the mix of other farm activities, land tenure, family and off-farm labour involved in small ruminant production, and the availability and cost of capital. Other important information relating to market structure, official support systems, and infrastructure development will not usually be obtained from the survey of farmers but from local administrative and regional government sources.

The collation, analysis, and interpretation of most of the sociological and managerial data obtained from surveys are often difficult. Published results tend to use broad classifications and be largely descriptive. Where summary statistics are calculated, measures of variability other than ranges are usually not provided and it is likely that the standard statistical probability statements are not appropriate. Thus, interpretation depends upon the experience and ability of the researcher and is open to more conjecture than is normal for traditional biological research. When it comes to predicting the sociological effects of changes in livestock systems, the situation is worse as there is no formal methodology for estimating reliability.

Population Structure and Available Resources

The existing structures of the sheep and goat populations in the area and on the farms being studied must be established. On a regional basis, the breeds and types used, their numerical strength and distribution, and the major feed resources and raising systems used are all relevant because they provide the framework within which the farms operate. They will also identify the source of additional stock needed, the market for the sale of breeding stock, and market competitors influencing prices received for products. This information will usually be drawn from public statistics or perhaps large-scale surveys.

It is at the individual level of information gathering in this area that on-farm research really starts. It is possible to obtain by survey some of these data and some information on animal productivity and health outlined in the following sections. However, too much reliance should not be placed on data derived in this way unless specific favourable circumstances exist and additional validation studies are carried out. In general, data on animal production structure and productivity that are drawn from surveys of intensive production systems may be reasonably accurate because of the small numbers involved and their importance to the farmer. Even in these situations, however, it is unwise to rely solely on recollections of birth dates and reproduction rates over long periods; in extensive farming systems, where larger numbers are involved, information will not be accurate. Knipscheer et al. (1984) provide an example of how survey data can be validated by checking subsamples of farmers with more intensive monitoring. Because of these difficulties, on-farm studies are needed to establish the basic population parameter; however, as they can be obtained with more detailed investigations of production, they will be discussed in the next section.

Population Dynamics and Production

This section deals with methods for on-farm assessment of the main parameters of population dynamics, growth, and productivity of small ruminants. The important aspects of estimating feed availability and intake are discussed by Coop (this volume).

Population dynamics refers to the way changes occur in the size, age, and sex structure of a population. The main parameters are age at first breeding and reproduction, death, and extraction (by the farmer) rates. For a thorough study, these rates are needed on an age-specific basis, but alternative, less accurate methods are available if the detailed information cannot be obtained. For predicting population changes and availability of surplus stock, comparing systems, and diagnosing problems, these parameters can conveniently be combined into the index, net reproductive rate, used by ecologists in population studies. Adapted for small ruminants, this can be defined as the number of potential replacement females produced by a breeding ewe or doe during her life in the population. If the net reproductive rate is greater than 1.0, the population can increase or surplus females will be available for sale; if net reproductive rate is less than 1.0, the breeding population will decrease.

In practice, it is almost impossible to estimate age-specific reproductive parameters on farms and it is extremely difficult on research stations. Data must be collected from a large number of breeding animals over many years to separate age and year effects and to ensure that the years covered represent an adequate random sample. Furthermore, the statistical procedures are complex and usually require powerful computing facilities.

Despite these problems, it is possible to make estimates of net reproductive rate where large populations are available in extensive systems or if the several farmers' flocks within a village are considered as one population in the smaller intensive systems. In the region being considered, year-round matings are normally practiced, so annual lambing or kidding percentages are difficult to calculate and cannot easily be used to estimate lifetime performance. Instead, the following data should be recorded for all females: age at first mating, age on leaving the breeding population, number of offspring produced in this time, and deaths of young females between birth and first mating. From these data, the net reproductive rate can be calculated. The natural logarithm of net reproduction rate divided by the female generation length (approximated by the average age of the breeding females) gives the coefficient of capacity to increase, from which potential changes in breeding numbers can be estimated. If desired, an annual reproduction rate can be estimated by dividing the average number of offspring produced during life by the length of time in the breeding population.

It has already been pointed out that these data should be collected from on-farm observations rather than from surveys.

Where this is done, it is often also possible to record the circumstances relating to the various events, which can greatly help in identifying problems. For example, short female generation lengths may be due to high sale and slaughter rates or unusual mortality and the strategies proposed to overcome these circumstances would be quite different. Similarly, in smallholder systems, many farmers will not own a breeding ram or buck, so females in oestrus must be taken to the male in seasons when animals are confined. Thus, efficient oestrus detection and the farmers time become important influences on reproduction, which good observational records can identify. Regular records of body weight, seasonal, and feed conditions are also important for on-farm investigations of breeding performance.

Emphasis is given to reproduction because of its basic importance in the maintenance of stable populations and the fact that it is the surplus animals that meet the farmers needs for trade and social requirements. It is also clear, however, that other aspects of productivity of individual animals are important. Growth of young animals, the body weight and, hence, meat production reached, lactating ability where milk is harvested, and, in special cases, fibre production should all be assessed. It is not as difficult to record these features and smaller samples can be used. Thus, they can readily be included in programs designed to measure the breeding performance of small ruminant populations.

Health

The relative importance of health problems in small ruminant production systems of the region is poorly documented, although much is known about the various disease and "subclinical" health conditions that can occur. On-farm research is the only way that this type of information can be obtained and there are well-established epidemiological methods available.

In general, epidemiological studies aim to investigate the prevalence and distribution of disease and identify the factors that influence its occurrence and spread. The information required for this work includes records of the incidence and attack rates, distribution through the villages and farms of the area, the immunological status of the population, the presence of vectors or intermediate hosts, types and condition of housing, and the climatic conditions before and at the time of disease. Full-scale studies require considerable resources of trained workers and laboratory support, but more simple studies can be very effective if based on observations made at local abattoirs as well as on-farm records. In either case, experienced veterinarians are required at the field level and particular attention should be paid to those aspects of nutrition, management, and housing that can be altered in redesigned production systems.

Housing

Housing of small ruminants is generally only a feature of intensive village production systems, except where animals in extensive grazing systems are herded into pens or shelters for protection at night. Little research into the design of sheep and goat housing has been reported, although much is known about the effects of climate and the immediate environment on the physiology of these animals. It is difficult to carry out scientifically acceptable on-farm research into the effects of housing on production because the experimental units are the houses being compared and not the individual animals within each house. Thus, it is almost impossible to obtain sufficient numbers for valid statistical tests, so reliance must be placed on observations of the animals' physiological condition and the interpretation of these in the light of known relationships between physiological stress, productivity, and health.

RESPONSES TO CHANGES IN MANAGEMENT SYSTEMS

So far, this paper has emphasized the acquisition of information that establishes the existing characteristics of small ruminant production systems and the animals within them. From this information, it is often possible for experienced workers to identify improvement areas and draw on the existing body of knowledge to design new systems. Where this is done, the general aim is to produce a better system but not necessarily the best possible. It is frequently found, however, that existing knowledge is not sufficient. Most livestock research with small ruminants has been done in the developed counties, where the temperate climates, the breeds and types of animals, the stresses they experience, and the farming systems are vastly different from those of South and Southeast Asia. Even then, there is little detailed information on the productivity of goats, except for aspects of lactation in dairy types. Consequently, there is a need for research on the responses of small ruminants to changes in management systems.

Most of the available research information has been derived from institutional research stations and this is often criticized as lacking relevance to real farm problems. Furthermore, this work tends to focus on isolated components of the farm system and the responses obtained are often not achieved to the same extent when applied on farms. Thus, there is considerable interest in obtaining information from the farms for which the improved systems are to be designed. While this aim is admirable, there are important problems relating to the control of animals and treatments and the scale of investigation possible that make some studies impossible; these problems must be considered when planning on-farm research.

Research that aims to quantify response to changes in management can be classed as observational studies of animals in existing different conditions or as studies of imposed treatments in designed experiments. To date, most on-farm work with animals has been of the first type.

Observational Studies

An important aim of comparing animals in different existing conditions is to predict the future response to the imposition of similar differences. It is important, however, to realize that cause and effect cannot always be implied from such studies and that there may be several explanations of the observed differences. This is particularly so where different management systems are being compared that involve different farms or even villages. In general, statistical analyses are not meaningful as the true replicates are not the individual animals within systems and the systems themselves are seldom replicated. In these cases, the various statistics give useful measures of variability within a system but do not help interpret differences between them.

Another type of study that is in this category is the analysis of relationships among characteristics of the animals within the farming systems. Relationships of productivity to body weight and perhaps condition score are especially important as they are often used to predict the likely response to management changes that have measurable effects on feed availability and quality. Again, it should be realized that the relationships identified in this way are based on existing variation in each character and the covariance may be due to special circumstances that might not be repeated when changes in body weight are caused by imposition of a new management system. This emphasizes the need for validation of predictions using independent data.

Experimental Studies

On-farm experiments can be used to derive information on components of the livestock systems that are to be designated and, ideally, they should be used to evaluate any new system being proposed. Unfortunately, there are great operational problems in anything other than very small-scale experiments, but their potential relevance and farmer involvement make it important that they be attempted. The main considerations are that objectives should be as simple as possible and consistent with the production of useful information, and that as many inputs and resulting products as possible be measured to facilitate interpretation.

Planners of on-farm experiments should recognize that it is difficult to satisfy the requirements of traditional scientific experimentation, particularly in relation to replication and statistical analyses of data. These problems can be illustrated with an example of a comparison between 2 systems with 3 replicates of 10 animals each. The statistical analysis of this design is given in Table 1. The expected values of the mean squares shows that the correct error term to use to test the difference between systems is the replicates within systems. Unfortunately, this analysis is not very powerful, with only 2 degrees of freedom, yet the experiment would be a major undertaking. In most cases, no replication of the system is made and the variance between animals within systems is used as error. This is the same as pooling the sums of squares and degrees of freedom for replicates and animals in the example. Unfortunately, this contains only a small fraction of the true between-replicate variance and does not give a valid test.

Despite these considerations, the importance of the systems data to be derived from on-farm experiments is so great that investigators should not abandon the work if replicates cannot be established. When large differences are sought, there is valuable information to be derived from a comparison of the system means and a measure of the animal variance. Interpretation of these data, however, relies heavily on the experience of the investigator. It is not assisted by an inappropriate statistical analysis.

In some cases, it is possible to design reasonably powerful experiments with small numbers by techniques such as repeating measurements in successive periods (Gill 1978). The example in Table 2 shows that care must be taken with allocating the correct error terms. Here, the experimental unit is

Table 1. Analysis of variance for comparing systems.

Source of variation	df[a]	Example[b]	E (mean squares)[c]
Systems	s-1	1	$V + aV_r + arS$
Replicates within systems	s(r-1)	2	$V + aV_r$
Animals within replicates	sr(a-1)	54	V

[a] s, number of systems; a, number of animals; r, number of replicates.
[b] s = 2; r = 3; a = 10.
[c] V, variance among animals; V_r, variance among replicates; S, mean-squared differences of systems from overall mean.

not the same as the observational unit and the latter is not independent. The overall treatment difference is not powerful, but if a meaningful hypothesis can be made about the treatment x period interaction, then a much more powerful test is possible using the residual error. For example, we might test if the weight change between seasons differs from system to system. Methods for testing specific preplan comparisons of trends within the interaction are given by Gill (1978). The main problems associated with this approach are the risk of losing animals and the assumption of a constant correlation between periods, which is unlikely over a long time, although there are methods to allow for this.

Similar considerations are also associated with the evaluation of different genotypes and systems that may use genetically superior sires. The apparently simple task of comparing animals from different strains should allow for the fact that differences in prenatal and early postnatal environments can affect productivity throughout life, making it necessary to breed and rear the animals together. Where comparisons are being made of progeny from sires of different breeds mated to females of one breed, genetic replicates are the sires, not the individual progeny, so there must be a relatively large number of sires and they should be identified. James (1975) has

Table 2. Analysis of repeated measurements.

Source of variation	df[a]	Example[b]	E (mean squares)[c]
Treatment	t-1	1	V(1 + (p-1)c) + apT
Animals within treatment (error 1)	t(a-1)	3	V(1 + (p-1)c)
Periods	p-1	11	V(1-c) + taP
Treatment x period	(t-1)(p-1)	11	V(1-c) + a(TP)
Residual (error 2)	t(a-1)(p-1)	66	V(1-c)

[a] t, number of treatments; p, number of periods; a, number of animals.

[b] t = 2; p = 12; a = 4.

[c] V, variance among animals; c, correlation between any two periods (assumed constant) = (error 1 - error 2)/(error 1 + (p-1) error 2); T, mean-squared difference of treatment from overall mean; P, mean-squared difference of period from overall mean; (TP), mean-squared difference of interaction mean from overall mean.

outlined the bias that is introduced if this is not taken into account. In addition, where the experiment involves a comparison of exotic and native stock via this type of progeny testing, heterosis and gene recombination for both direct and maternal characteristics can affect the relative performance of offspring. As part of the heterosis is lost when introductions of the exotic type cease, these effects should be measured so that estimates can be made of the expected productivity of any combination of the genotypes that might be used. Dickerson (1969) has outlined the various parameters that are needed, but, in practice, these parameters are almost impossible to obtain from on-farm studies. Consequently, value judgement must be used and apparent benefits from introducing a different genotype should be discounted.

SYSTEMS MODELING

In recent years, development in computer applications of mathematical models have been used to simulate livestock production enterprises within farming systems. In general, these integrate biological data from specific farms with known relationships to produce a dynamic model of the livestock system. If these models are sufficiently realistic and accurate, they can be used to examine the likely consequences of changes to any part of the system, so many "experiments" can quickly be conducted. On-farm tests can then be carried out to evaluate the most promising systems identified by the modeling.

Models that have been constructed for sheep indicate that growth, body weights, and lactation can be satisfactorily simulated given data on the quantity and composition of available feed and on the age, sex, physiological state, and potential mature body weight of the animals (e.g., Graham et al. 1979). More difficult problems are the modeling of reproduction changes and the simulation of pasture intake with interacting effects of the animals on vegetation in grazing systems. Realistic models for grazing sheep in temperate regions have been produced (White et al. 1983), but they have not been used for goat production systems in tropical environments.

It is unrealistic to expect that completely satisfactory models of small ruminant systems will be produced in the near future. However, work will continue in this area and the techniques used will be a valuable aid to those interested in designing improved systems, particularly where individual operations are small in scale and based largely on hand feeding of crop residues.

ACKNOWLEDGMENT

I sincerely thank the International Development Research Centre for financially supporting my participation in this workshop.

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