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SHEEP AND GOATS IN TROPICAL AND SUBTROPICAL AGRICULTURAL SYSTEMS[1,2]

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ABSTRACT

The potential for increasing productivity of small ruminants in lesser developed countries (LDCs) is well documented. To realize this potential, however, will require that traditional farmers place more emphasis on producing for the cash market, and thus have more incentive to adopt new technology. To ensure that appropriate new technology packages are available for LDC sheep and goat producers will require a six-step research effort, repeated in each region where small ruminants are important: description of the farming system, applied research on components of the farming system, linkage with international networks for basic research and information having widespread application, multidisciplinary experiments to examine interactions among system components, on-farm validation and institutionalization of a dynamic system for technology innovations. The latter step is especially important but often overlooked. A minimum of 7 to 10 yr of sustained effort seems to be necessary for a development-oriented research program to reach a state where all six steps have been achieved. Experiences of the Small Ruminant Collaborative Research Support Program in Brazil, Indonesia, Kenya, Peru and Morocco are analyzed within the framework of this six-step model.

(Key Words: Goats, Sheep, Tropics, Subtropics, Farming Systems.)

Introduction

The untapped potential for improving the productivity of sheep and goats in lesser developed countries (LDCs) has been recognized fully only within the last decade. A landmark workshop in 1976 helped focus attention on small ruminants (Oltenacu et al., 1976; Winrock International, 1977). Reasons why this untapped potential exists, particularly within small farming systems, can be summarized into four categories: the substantial numbers that already exist; the gap between average and best observed productivities; the opportunity to increase emphasis on market-oriented incentives and the feasibility of realizing major increases with low cost inputs.

Population Numbers and Traditional Roles. In 1980, LDCs accounted for 56% of the world's estimated 1.1 billion sheep and 96% of the 460 million goats. Both absolute numbers and percent of world totals in LDCs have increased consistently since 1960 (Winrock International, 1983). Some countries of North Africa and Southwest Asia have a tradition of small ruminant husbandry at least as old as their written history.

The exact role of sheep and goats is varied, and seldom fits the North American model of sheep for meat or wool and goats for milk. In many LDCs for example, the goat is traditionally a meat animal (Mason, 1980; Devendra, 1981; Hussain et al., 1983). The sheep is mainly

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a meat animal in North and sub-Saharan Africa (Wilson, 1985), but throughout the Near East sheep are a major source of dairy products (Gordin, 1980; Devendra, 1981). Sensibly, many tropical sheep breeds do not grow wool; hair sheep, raised for meat only, are prevalent in much of tropical Africa and Latin America (Fitzhugh and Bradford, 1982).

Small ruminants may be found as an important component of mixed crop-livestock systems throughout the tropics, or of pastoral migratory or transhumant systems in Africa and South or Southwest Asia (Winrock International, 1983). Improving their productivity is undoubtedly easier within the context of mixed farming systems, due to more favorable climatic conditions, a greater variety of feed resources, and the potential for labor-intensive management.

Productivity Gap. The gap between actual and potential productivity of small ruminants in LDC farming systems can be demonstrated by comparing per animal output among regions, among controlled management situations, and among farms.

Compared with developed regions, sheep in LDCs have a reported 17% lower yearly offtake, 20% lower carcass yield, and about equal milk yield per animal (Winrock International, 1983). For goats, differences are more striking: offtake 61 vs 35%, carcass yield 6.9 vs 4.3 kg and milk yield per head 103.0 vs 12.4 kg for developed vs developing regions Such comparisons include the confounded effects of climate, breed type and management levels. In very few situations is climate likely to be the only limiting factor, as documented for dairy goats by Sands and McDowell (1978).

Controlled experimental data are available from several LDCs that demonstrate improved growth rate, reproduction, or lactation yields. To cite examples for sheep: Obst et al. (1982b) reported daily gains of 10 to 20 g for Javanese lambs fed only young fertilized napier grass, but gains of 75 or 155 g for similar lambs fed a 50/50 napier grass/rice bran pelleted diet at limited or ad libitum intake levels. In a second trial with similar lambs, daily weight gains were improved from 32 to 109 g, and dressing percent from 45 to 49, by a combination of improved diet and health practices (Chaniago et al., 1982). Improved reproductive performance of Javanese ewes was also reported (Obst et al., 1982a), with 79% lambs weaned per year under a village type management, compared with 208% under a combination of housing, feeding, weaning, and reproductive management changes.

Productivity of goats can also be improved. Laor (1982) described a package of practices that improved reproduction from .5 to 1.5 kids and meat output from 10 to 40 kg, per goat per year, in Fiji. Sharma (1982a,b) reported faster growth for kids (29 vs 18 g/d) and increased 150-d milk yield for does (68 vs 31 kg) when native goats were fed concentrates at 1% of body weight, in addition to traditional forages (Prosopsis spicegera leaves for kids, grazing native pastures for does) in a semi-arid region of India. Mishra et al. (1982) offered ad libitum forage/concentrate supplementation to free-ranging Sirohi goats in semi-arid Northwest India; final weights at 6 mo, after 3 mo on trial, were 22 kg with the supplement, 16 kg without. Crossing native Beetal goats with breeds of European origin resulted in significantly faster growth of offspring due to heterosis (Chawla and Nagpal, 1981); heterosis was also apparent in lactation performance (Bhatnagar et al., 1982; Verma and Chawla, 1982). Plane of nutrition obviously influences milk yields, as demonstrated in another study from India in which Barbari and Jamnapari does, respectively, produced 27 and 49 kg per lactation on low, and 110 and 160 kg on high planes of nutrition (Devendra, 1980).

For the third type of comparison, a measure of variability among farms must be available. Surprisingly such data are difficult to find, not from a lack of farm surveys but because many authors report only the means of their data. When such data are given with some measure of variation, as in the reports of Sands et al. (1982) of farm productivity parameters from Western Kenya, and Bell et al. (1983) and van Eys et al. (1984) of village monitoring data from West Java, it is possible to identify a potential for productivity increase simply by analysis of what the better farmers are doing that makes them better. The authors mentioned all conclude that a potential exists for the "average" farmer to improve productivity simply by copying management ideas from his more productive neighbors.

Changing Incentives. Traditional LDC farmers have many reasons for including small ruminants in mixed farming systems, such as: to convert otherwise valueless resources (crop residues, forage from marginal land) to animal products; to obtain manure for fertilizing crops; to serve as a hedge against the years when crops

or cattle will fail to yield cash income; to sell for cash when emergency or routine needs arise; for recreation, such as the fighting sheep of West Java; for slaughter or sale at times of religious festivals; or as a symbol of status and wealth (Primov, 1982; Suradisastra and Nolan, 1983; Winrock International, 1983; Campbell et al., 1984; Reynolds, 1984).

The most likely motivation for traditional farmers to improve the productivity of their small ruminants is economic: the opportunity to increase cash income. There is reason for optimism that farmers can be so motivated. For example, a study by Ismaili (1983) of mixed small farms in Morocco suggests that lamb sales earn more cash than wheat and other crops combined. Consumer demand and an adequate market structure, of course, are prerequisites. Studies by Primov (1981) in the Peruvian Andes and by Sabrani et al. (1983) in West Java both indicate that the market structure is adequate, and that demand for meat products exists, in relation to small ruminants in the two respective regions.

The economic incentive is less likely to work in many nomadic and transhumant societies where sheep or goat herders operate largely outside the money economy. Exchange of animals or their products for cash is not looked upon as an advantage by these people. Even for a sedentary situation, it was speculated by Primov (1982) that farmers whose main reason for raising goats was as a hedge against crop failure and cattle losses during years of drought, would not place high priority on improving meat output from their goats.

Low-Cost Inputs. For farmers in any situation to reorient their enterprise toward the cash market, risks must be minimized. This not only means maintaining stable market conditions, but also assuring that new technology is cost-effective. Evidence is growing, some of which is presented later, that significant productivity increases of small ruminants can be attained with low-cost inputs such as feed produced on marginal land with intensive but cheap labor. Also, the capital cost of the animals themselves (including many improved genotypes) is relatively small. They can multiply quickly due to early maturity, the possibility for prolificacy, and a relatively short gestation period.

The small body size of sheep and goats is an advantage on several counts (Winrock International, 1983). Housing cost can be minimal; animals can reach market weight in a few months; family labor can easily perform animal management and feed collection tasks; feed requirements are within the resource limitations of small farms; risk is better dispersed (the death or illness of a sheep or goat is easier to cope with than for a larger animal); and if slaughtered, the small carcass can be consumed quickly by family and neighbors.

Stimulating Permanent Productivity Improvements

The demonstrated potential for increasing the contribution of small ruminants to rural welfare in many LDCs has encouraged considerable recent activity toward that end. Winrock International (1983) has identified 80 research, development, credit and training projects with possible small ruminant components, operating in at least 46 countries. Research was the primary focus in 23 of the 80 projects.

Experience has taught that such programs will not achieve a uniform success rate. Recent analysis of development programs for LDC agriculture has suggested that the probability of success can be improved by adopting a "farming systems" approach. Various authors have described this approach, with varying terminology and a slightly different analysis of the several stages involved (Norman, 1978; Solano and Avila, 1983; Fresco, 1984).

We would like to propose our own six-step approach to development-oriented agricultural research, for small ruminants or any other commodity of importance to small or medium LDC farms, which, if followed, we believe can greatly enhance the probability for long-term success. The first five of our six steps have been listed or implied by Norman (1978), Solano and Avila (1983) and Fresco (1984), although not in exactly the same format. Step 6 is usually overlooked or left to chance, which we believe to be a serious flaw to previous analyses of the development process. Our six steps are described as follows:

1) Farm-level surveys and monitoring, planned and interpreted by a multidisciplinary team, for the purpose of better understanding existing biological and socioeconomic systems.

2) Experiment station research (applied or adaptive) on components of the biological system identified as critical for local producers. To be relevant, the planning of this research must reflect the detailed knowledge of existing systems which can come only from the type of

on-farm descriptive research described in Step 1. The geographic scope of application for Step 2 research must be defined carefully, to account for known limitations in the transfer of technology across agro-ecosystems.

3) Linkage with an international research center or network that has sufficient resources to conduct basic and applied research on system components that are common to several countries or to a wide ecological area.

4) Development and testing of packages of technology, in experiments large enough and long enough (across time) to define conclusively output levels at different levels and combinations of inputs, including interaction effects.

5) On-farm testing of technology innovations in controlled experiments planned and supervised jointly by a multidisciplinary team of research and extension personnel. This step must be completed before new ideas are released for wide dissemination.

6) Institutionalization of a dynamic system for continued monitoring and improvement of on-farm technology, with effective, permanent lines of communication among farmers, researchers, extensionists and support persons (veterinarians, bankers, marketing specialists). This step is the most critical of all if the effort expended on steps 1 to 5 is to result in permanent improvements.

Progress Toward Improving Small Ruminant Productivity in LDCs

In this section examples are cited to illustrate the six-step process toward permanent productivity increases for sheep and goats in certain areas of the tropics and subtropics. Because of our familiarity with them we have chosen examples from the five countries affiliated with the Small Ruminant Collaborative Research Support Program (SR-CRSP). The five research sites span three continents and represent five unique ecological systems. An interdisciplinary team is at work at each site, usually incorporating animal breeders, nutritionists, research veterinarians, reproductive physiologists, sociologists and economists, plus range scientists if appropriate. Host country collaboration is coordinated, respectively, through the National Research Institute for Animal Production in Indonesia; the Ministry of Agriculture and Livestock Development in Kenya; EMBRAPA's National Goat Research Center in Northeast Brazil; the National Institute for Agricultural Research and Promotion in Peru; and the Hassan II Institute of Agronomy and Veterinary Medicine in Morocco. Memoranda of Understanding between each of these institutes and the several United States institutions collaborating with them were negotiated and signed in 1980 or 1981.

1. Farm-Level Surveys and Monitoring. In each of the five countries, Step 1 survey and (or) monitoring was one of the initial activities after collaborative agreements were established. Methodologies for the one-time surveys and longer-term monitoring have been described by Gutierrez et al. (1981) for Brazil; Thomas et al. (1982) for Indonesia; Sands et al. (1982) and DeBoer et al. (1984) for Kenya; Ismaili (1983) for Morocco; and Quijandria et al. (1984) for Peru.

The Indonesia results offer the most complete example of information from on-farm monitoring. The baseline survey covered 368 mixed crop/livestock farmers in three villages (only farmers who kept sheep and(or) goats were sampled); 90 of these farms were then selected for intensive monitoring over 2 yr. From the outset, local extensionists and political authorities were involved, which was critical when cooperation was later sought for on-farm experiments. Farms were visited monthly by trained enumerators who lived in the villages. Data were collected on general management practices, flock size, reproductive performance, feeding, labor requirements and division of labor, major income-generating activities and economic returns. Feeds were sampled on each farm and analyzed for botanical and chemical composition. Liver samples from sheep carcasses were analyzed for trace minerals; fecal samples were checked for endoparasite loads.

The monitored flocks consisted of two to five mature females (van Eys et al., 1984) that were usually confined to elevated pens with slatted floors for the purpose of manure and compost collection. Fresh forage was hand-fed daily. Labor requirements for other farm activities determined the time available for gathering feed, which in turn limited the number of animals a farmer could keep. The involvement of women in small ruminant care tended to increase as farm size decreased and men were forced to seek off-farm employment (Gatenby and Wahyuni, 1985).

Low means were found for virtually all production parameters, but with a large, consistent variability among animals and among

farms within villages. Reproductive performance, for example, was about .8 lam or kid weaned per mature female per year (van Eys et al., 1984) in spite of a demonstrated high prolificacy of Javanese breeds (especially sheep; Bradford et al., 1984). Inounu et al. (1984) reported 1.5 lambs weaned per ewe per year in a research flock. Reasons for poor reproductive performance on farms included problems with estrus detection, timeliness of mating and inadvertent slaughter of pregnant ewes (Bell et al., 1983). Many farmers seemed to lack sufficient understanding of the basic principles of reproduction, which is especially important in a situation where males are not housed with females. Often, breeding males were shared among farmers under varying and sometimes complex arrangements.

Another contributor to low reproductive efficiency was high mortality in village flocks: 35% for single lambs, 52% for twins and 42% for triplets (Tiesnamurti et al., 1984). Corresponding rates of 17, 18 and 36% were obtained with similar sheep in a research flock (Inounu et al., 1984). Mortality was highest in the village where animals were allowed to graze; higher parasite loads were also noted for grazing animals.

One would expect small farmers to respond positively to suggestions for improving the reproductive performance of their small ruminants, by increasing prolificacy or reducing mortality (or both), since they could thus reduce the maintenance cost (for housing and feeding of adult females) per offspring.

Other parameters found to be low for village animals were growth rate, weaning weight and mature weight (Subandriyo, 1984; van Eys et al., 1984). A comparison of growth rates for ram lambs raised under village conditions or with improved management and feeding demonstrated a productivity gap (table 1). However, the fact that faster gains were realized by some producers (up to 139 g/d for preweaning and 121 g/d for post-weaning lambs) indicates that the gap can be narrowed.

An important reason for low growth rates may be poor feed quality, as indicated in table 1. Total feed dry matter (DM) offered to most village animals appeared to be adequate (averaging 5% of their live weight per day). Diets included a wide variety of feed sources, but mainly native grasses and crop by-products. The high level of cell wall fiber in a mixture of native grasses (70% neutral detergent fiber) at the research center severely restricted DM intakes to an average 28 g/kg live weight (Prabowo et al., 1984; Pulungan et al., 1985).

Refusal levels for village animals were generally high, contributing to compost yield and at the same time facilitating animal selectivity. However, feeds of superior quality such as tree legume foliage, sweet potato vines, bean straws and agro-industrial by-products were fed infrequently, and then usually as the sole dietary constituent. Diets varying widely day-to-day were deemed inadequate to meet production requirements. For example, possible deficiencies of phosphorus, sodium, zinc and copper were detected (Prabowo et al., 1983; 1984). Salt or mineral supplementation was not a common practice.

Crude protein concentration in native grasses seemed adequate, but other research with

TABLE 1. POSTWEANING GROWTH OF JAVANESE THIN-TAIL RAMS UNDER DIFFERENT SYSTEMS OF FEEDING AND MANAGEMENT

Type of management/feeding	Avg daily gain, g/d	Reference
Village, unimproved	31	Chaniago et al. (1984)
Village, improved management (anthelmintics + concentrate)	109	Chaniago et al. (1984)
Experiment station		
Grasses + leucaena (50%)	50	van Eys et al. (1985a)
Grasses + gliricidia (50%)	64	van Eys et al. (1985a)
Grasses + cassava leaves (40%)	59	Mathius et al. (1983)
Grasses + cassava meal (35%)	64	J. E. van Eys (unpublished)
Grasses + tahu waste (40%)	55	Pulungan et al. (1985)
Grasses + tahu waste (80%)	123	Pulungan et al. (1985)
Pelleted grass + concentrate	157	Obst et al. (1982b)

tropical grasses indicates that their protein may be poorly utilized (Flores et al., 1979; van Eys et al., 1985a). Lambs and kids on farms that used a high proportion of leguminous shrub and tree leaves or high protein agro-industrial by-products had faster gains (van Eys et al., 1984). Data in table 1 show a similar advantage from supplementation with high protein feeds.

The farm survey and monitoring results from Northeast Brazil offer a second example of useful information that could not otherwise have been available to the researchers. A baseline survey covered 127 farms, all with sheep and(or) goats, in the state of Ceara, from which a sample of 32 farms in eight municipalities was chosen for periodic followup monitoring (Gutierrez et al., 1981). It was found that virtually all farms combined goat and(or) sheep production with cattle and several crops. That the natural "caatinga" rangeland was the major feed resource was no surprise. When supplemental feed was given, the survey revealed that it went first to cattle, sometimes to sheep, but almost never to goats, which were expected to fend for themselves even during the severest dry seasons. Husbandry practices were generally limited to deworming ("at least once a year"; the recommended frequency for most years would be four doses) and rotation of breeding rams or bucks to prevent inbreeding. Animals were corraled at night; daytime grazing areas were seldom fenced. On 20% of the farms some of the goats were milked. Offtake of animals for meat was low (about 24%); 40% of the offtake was consumed on the farm, 60% was sold. Even with such low productivity, capital inputs were low enough to make the cost/return ratio more favorable for small ruminants than for other enterprises (DeBoer, 1984).

2. Experiment Station Research with System Components. Given the known limitations in transferring technology across geographic areas, the failure to include applied or adaptive research as part of a development project will considerably reduce the probability of success. The objective of this research is to define productivity responses when locally available inputs are used (local breeds, feeds, health maintenance measures and locally feasible management practices). Interactions among various components of the system must be defined: for example, differential breed responses to increments of nutrient intake. Such studies can be initiated while Step 1 is in progress, if their design is based on realistic knowledge of the target system. However, a common error (not limited to LDCs) is to carry out random pieces of adaptive research with little idea as to how the results will fit into existing production systems.

The survey and monitoring in Indonesia and Brazil, cited above, had a major impact on the respective Step 2 research programs. In Northeast Brazil, researchers noted the reluctance of farmers to invest much capital in their small ruminant enterprise, and thus decided to place more emphasis on low-cost technology options such as controlling the breeding season in order to have periods of highest nutrient requirement coincide with best grazing conditions, selectively favoring growth of the most palatable of the prevalent tree and shrub species; developing low-cost health maintenance strategies; and determining which trace minerals might be limiting to growth or reproduction. In Indonesia, researchers were encouraged by the possibility of increasing animal nutrient intake by the more rational use of locally available feed resources, and thus decided to take better advantage of the gene for prolificacy found in local breeds. (Prolificacy in Javanese Thin-tail sheep is tentatively thought to be influenced by one major gene; Bradford, 1984.) Selection is now occurring for both highly prolific and single lambing lines, while maximum profit feeding programs are being defined for both lines.

In Kenya, also, Step 2 research priorities were influenced by farm survey results. Some examples:

a) Diverting cropland to forage production on small mixed crop/livestock farms was judged not to be a feasible way to improve nutrient intake by livestock. Rather, options that would enhance forage output from existing cropping patterns were explored. An early conclusion was the value of inter-cropping sorghum 4 to 6 wk after planting maize, and ratooning the sorghum. Maize yields were not affected. Relay cropping pigeon peas with maize was also promising (Onim et al., 1984).

b) Studies of household consumption and purchasing patterns for staple foods revealed a surprisingly high degree of market orientation, as opposed to subsistence production. This finding encouraged researchers to proceed with developing a dual-purpose goat with higher milk producing ability on the assumption that milk sales could enhance income in some house-

holds, while expenditures for milk could be reduced in others (Nyaribo et al., 1984). Positive farmer attitudes about dual-purpose goats, along with a favorable economic potential, reinforced confidence that this strategy would be successful (Mukhebi et al., 1984).

c) An 80% prevalence rate of nematodal infections led to breed evaluations for Haemonchus contortus resistence (Abinanti et al., 1984).

d) As in Indonesia, the observed high reliance on native grasses and weeds from roadsides and other non-productive areas led to the nutritional evaluation of these plants. In two villages non-cultivated plant species accounted for 60% of the biomass fed to livestock. Introduction of tree legumes is also being tested (Sidahmed et al., 1985).

The survey by Ismaili (1983) in Morocco helped give direction to the applied research program in that country. Conducted in an area where sheep and wheat are the two major farming enterprises, the study revealed the extent to which sheep depend on grazing on wheat stubble as their major feed source during the normal gestation period, which also coincides with the driest part of the year. A concerted research effort was then launched to learn more about the nutritional contribution of wheat stubble and associated weeds, and the reproductive response of ewes grazing thereon.

3. International Linkages. Some problems are common to several LDCs over a wide geographic area. Few countries can afford to conduct research on all such problems, nor should they allow their limited resources to be diverted from the adaptive research that must be done locally. An active linkage with the international centers (ILCA in Ethiopia, ILRAD in Kenya, CIAT in Colombia, ICARDA in Syria) that address small ruminant production or feed resource problems; or affiliation with international networks such as those supported by FAO in Rome, CATIE in Costa Rica, the IDRC in Canada, the ACIAR in Australia, or AID in Washington; or a bilateral agreement with a university or research center in the "MDCs" (more-developed countries), can provide access to basic developments such as new vaccines, identification of and strategy for dealing with toxic substances, methodology for treating fibrous feeds, or new information about mineral or protein utilization.

Benefits of Step 3 linkages with an MDC university have been documented for the Kenya project, in dealing with the potentially serious introduction of caprine arthritis-encephalitis (McGuire, 1984), and application of an ELISA test for contagious caprine pleuropneumonia (Bari et al., 1984). In Indonesia, also, two problems were judged to be more efficiently researchable with the help of international linkages. One involved the apparent toxicity of Brachiaria brizantha to sheep; an international team comprised of Indonesian, Australian and American scientists reported their preliminary conclusion that a fungus was involved (Zahari et al., 1984). The second problem concerns the proper balance of rumen-soluble vs rumen bypass nitrogen supplementation for low-cost village diets, which is currently under investigation both at a United States campus and in Indonesia.

4. Development and Testing of Packages of Technology. The distinction between Steps 2 and 4 is that the first is primarily component research, whereas the second attempts to identify important interactions among components. Usually a multidisciplinary team (with one designated leader for day-to-day decisions) will design, monitor and interpret the results of the experiment. The design must allow sufficient animal numbers, treatments, and time for results to be conclusive; and it should also allow for economic evaluation at different input cost/product price ratios. Realistic computer simulation of biological and economic options can help the research team design the most efficient experiments.

Step 4 experiments have been initiated in Northeast Brazil, to investigate interactions among various aspects of native range management, supplementation schemes for breeding does or ewes that graze the native vegetation, calendars of reproductive management and health status. At this writing it is too early for results to have been published, although some preliminary data have been evaluated.

5. On-Farm Testing of Technology Innovations. Information is available from on-farm trials in Indonesia and Brazil; the other three sites also have such trials planned or in progress.

In Indonesia, groundwork for on-farm experimentation was laid after one year of the monitoring study. In cooperation with local extension personnel a series of monthly evening meetings was initiated in each participating village to discuss observed limitations to small ruminant productivity and to study ways for improvement. Both the ideas discussed and the

spirit of cooperation engendered at these meetings were helpful when the time came to introduce on-farm trials to the villages. Four technology options were tested in these trials: improved breeding management and control of breeding rams, anthilmetic treatment, production of legume tree foliage and supplementation with minerals and(or) urea.

Results of supplementation trials (table 2) highlight the potential for farm-level productivity improvements with small input increments. Minerals or mineral-urea mixtures were provided in molasses blocks for a period of 9 mo (van Eys et al., 1985a). Results confirmed hypotheses from monitoring data about mineral deficiencies, and demonstrated the usefulness of adding a mineral supplement to forage diets. Urea, however, had no effect on animal performance. In addition to improved weight gains from mineral supplementation, lamb and kid mortality decreased to zero in an upland village and to 3% in a lowland site.

Preliminary results are also available from 3 yr of on-farm tests in Northeast Brazil (J. U. Alves, S. Riera and W. C. Foote; personal communication). Simple management recommendations were tested on 17 farms in six municipalities, with observations on 4,000 goats. In one comparison the breeding season was restricted for 187 goats while traditional continous breeding was continued for 204 similar animals. For continuous and restricted breeding, respectively, fertility was 92 and 83%; abortion rates were 6 and 1%; prolificacy was 1.6 and 1.6; and kid mortality to 6 mo was 26 and 3%. In a second on-farm comparison, sterilizing the navel at birth lowered kid mortality to 4% (compared with 26% with no treatment). A third test, of weaning at 4 mo, resulted in too many problems for the farmer, and it was concluded that this practice needed to be re-evaluated. An on-farm trial of mineral supplementation also had to be abandoned when it became apparent that the prior step of establishing good working rapports with the farmer had not been given sufficient attention (N. Barros, personal communication).

A project recently launched in the Peruvian Andes appears to hold good promise for eventually demonstrating the value of on-farm experimentation (Quijandria et al., 1984). Farm survey data of West (1981), Martinez (1983) and McCorkle (1982) were useful in designing an integrated, multidisciplinary project in indigenous agropastoral communities. No major conclusions are yet available. In one community, however, where previously cultivated rapports were not as strong as in others, an exercise in selecting breeding stock ended poorly when the selected animals, having been placed in a separate flock, were all stolen. Community leaders logically blamed the project for the loss (after all, these animals had been clearly labeled as the "best") and canceled further participation.

6. Institutionalization of a System for Continued Monitoring and Improvement of On-Farm Technology. The final step of building permanent institutional linkages among research, extension and other critical support

TABLE 2. PRE- AND POST-WEANING WEIGHT GAINS (G/D) OF SMALL RUMINANTS IN TWO JAVANESE VILLAGES WHEN PROVIDED WITH MINERAL OR MINERAL-UREA BLOCKS[a]

Treatment	Upland		Lowland	
	Pre-weaning (<90 d)	Post-weaning (90-365 d)	Pre-weaning (<90 d)	Post-weaning (90-365 d)
Control	71[b]	40[b]	49[b]	39[b]
NaCl	92[bc]	62[bc]	56[bc]	36[b]
NaCl + $CaPO_4$	110[cd]	58[bc]	57[bc]	55[bc]
Complete mix	124[d]	75[c]	102[c]	69[c]
Complete mix + urea	102[cd]	63[c]	82[c]	48[bc]
SE	27	17	25	22

[a]Adapted from van Eys et al. (1985b).

[b,c,d]In the same column, means that do not have a common superscript differ (P<.05).

agencies, and the farmers they serve, is too often given insufficient attention. However, it must occur if the process described by Steps 1 to 5 is to become dynamic and continuous. Just an an extension organization devoid of sound technological information is useless or counter-productive, it is also true that the most appropriate technology will do no good without an institutional infrastructure to get it applied. There is no one best model to follow (although many will suggest the landgrant model as the most functional). Whatever the institutional structure, formal or informal, it must allow for continued interaction among farmers, extensionists, veterinarians, credit and marketing specialists, and researchers.

Building functional linkages and mutual confidence among these varied groups is admittedly not easy. Unlike the United States, in many countries agricultural research and extension, by tradition, are conducted by separate agencies. Of the five Small Ruminant CRSP sites, only Peru and Kenya have the two functions assigned to the same agency. That the Kenya team has been concerned about permanent linkages is evidenced by the study of Reynolds et al. (1984), who found both a positive attitude but potential problems (insufficient personnel, need for in-service training) if the extension service were to become more closely involved in a dual-purpose goat development project.

Three conditions must be met before the process of technology modernization can become dynamic and permanent. First, there must be a will on the part of appropriate national leaders to create the necessary institutional linkages. It would be helpful if this will were manifest early in the development process, so that prior steps, particularly on-farm monitoring and on-farm validation, could be organized in a way that will facilitate these permanent linkages. Secondly, Steps 1 to 5 must yield truly helpful ideas; further, producers must come to recognize how the new ideas will help them. The third and related condition is that a sense of trust and confidence must be built among all of the partners. Researchers and extensionists need to listen to the farmers and learn from their experiences; farmers, on the other hand, must have the confidence to continue trying new ideas even when some of them fail.

The time frame for all six steps to occur must be considered. The collaborative projects of the Small Ruminant CRSP have been in existence for barely 5 yr, and it is safe to say that in none of the five sites are permanent institutional linkages fully in place. From the preceding experiences, it would appear that 3 to 5 yr is the minimum necessary for on-farm monitoring and initial component research (Steps 1, 2 and 3) to yield sufficient information for the proper design of integrated system experiments and on-farm validation (Steps 4 and 5); and that an additional 2 to 3 yr is necessary for valid packages of technology to be ready for widespread application. It appears that this time requirement will be longer for more extensive herding systems (as in Northeast Brazil and the Peruvian highlands) than for intensive, mixed-farming systems (as in West Java and Western Kenya).

Thus in the very best situation, and only if other pre-conditions are met, a new program will require 5 yr as the absolute minimum to achieve Step 6. However, given normal delays and setbacks a time frame of 7 to 10 yr seems much more realistic. Too often, national and international development agencies have failed to sustain their efforts for this long, or they have failed to ensure that all components of the development process are given proper attention. It is our hope that future programs will not repeat these mistakes.

Conclusions and Recommendations

A common failure in many LDCs has been to allot scarce resources to applied research without first studying the target farming system, which often means that the wrong topics have been given attention. In each of the five countries where the SR-CRSP operates, examples are available of a beneficial redirection of applied research after examining farm survey and monitoring data.

Properly designed and conducted surveys and monitoring will help researchers in assessing current input usage, productivity levels and producer motives. The most effective survey team will be multidisciplinary, including both social and biological scientists. The survey activity will also build rapports with the farmers, facilitating later on-farm trials, and will start to cement the inter-institutional ties essential for long-term development.

Biological observations should be repeated across several seasons and production cycles, to obtain reliable estimates of variability. Socio-

economic parameters also can be better defined with repeated observation. One-time, static surveys can only help in framing the right questions for long-term monitoring; they are not reliable as sources of biological and economic coefficents, nor are they as likely to influence constructively component (Step 2) research.

Women play an active role in small ruminant management in some areas (West, 1981; Martinez, 1983; Gatenby and Wahyuni, 1985). In these situations female enumerators questioning female family members may obtain a quite different insight into the farm enterprise than male enumerators questioning male subjects. If women help make resource allocation decisions, the extension strategy must be directed at least partially toward them.

In the mixed-farming system, all components must be looked at. As pointed out by Gutierrez et al. (1981) and Primov (1982), there may be interactions among the various crop and livestock enterprises, which could represent special opportunities or constraints for improving the small ruminant component.

National research agencies in LDCs should foster channels of communication with MDC or international institutes, to ensure access to new information of possible applicability. As with the researcher-farmer linkage, communication between national and international center should flow in both directions; feedback to the international program will contribute to its own effectiveness.

On-farm experiments should initially test only those interventions which seem foolproof. Trials should be kept as simple as possible, but provide for valid statistical interpretation. The use of baseline information and continued monitoring of control farms can compensate for the confounding of farm with treatment. Supervision and record-keeping must be adequate to ensure the reliability of results. Involvement of farmers and extensionists throughout the planning and execution stages is essential. Further ideas about on-farm livestock trials are available from a recently published workshop (Nordblom et al., 1985).

A positive experience was reported from the monitoring and on-farm testing program in Indonesia (van Eys et al., 1985b) in that average flocksize increased by 59% over the 3 yr of the program. This would indicate a certain flexibility in resource allocation on these small mixed farms. It was hypothesized that continuous outside attention may cause farmers to take more pride in their small ruminant enterprise. Also, the expectation that technical assistance could lead to higher productivity may stimulate farmers to expend greater effort. Either way it is evident that closing the productivity gap comes not only from improved technical ideas, but depends also on changes in farmers' attitudes.

The experience gained over the first 5 yr of the SR-CRSP has added substantially to evidence that small ruminant productivity can be improved in the LDCs. There is evidence not only that the biological system responds to technological innovation, but that social and organizational constraints can be overcome with a purposeful long-term effort. The examples cited in this paper are only a small part of the recent literature reporting small ruminant research. The SR-CRSP, ILCA and other programs and institutions can be contacted directly by the interested reader for complete lists of their publications.

Literature Cited

Abinanti, F. P., P. Sayer, J. Bari, S. Mbwiria, J. Njanja and M. Zeglen. 1984. A small ruminant herd health survey in Western Kenya: Research data. Small Ruminant CRSP Tech. Rep. No. 25. Washington State Univ., Pullman and Min. of Agr. and Livestock Devel., Nairobi, Kenya.

Bari, J. K., S. Waghela and R. Heinonen. 1984. Comparisons of the enzyme-linked immunosorbent assay (ELISA) with complement fixation and indirect fluorescent antibody as diagnostic tests for contagious caprine pleuropneumonia in Kenya. Proc. 3rd Small Ruminant CRSP Kenya Workshop, Nairobi, p 165. Univ. of California, Davis.

Bell, M., I. Inounu and Subandriyo. 1983. Variability in reproductive performance of sheep and goats among village farms in West Java, Indonesia. Proc. Vth World Conf. on Anim. Prod., Tokyo, 2:823.

Bhatnagar, D. S., D. S. Chawla and R. C. Sharma. 1982. Effect of crossbreeding on milk production in dairy goats. Proc. 3rd Int. Conf. on Goat Prod. and Disease, Tucson AZ. p 353.

Bradford, G. E. 1984. Genetic improvement of sheep and goats for smallholder production. In: R. D. Blond (Ed.) Partners in Research. p 58. SR-CRSP, Univ. of California, Davis.

Bradford, G. E., J. F. Quirke, P. Sitorus, I. Inounu, B. Tiesnamurti, F. L. Bell and D. T. Torrell. 1984. Genetic basis of prolificacy in three Javanese sheep: A progress report. In: Sheep and Goats in Indonesia. p 131. Proc. Sci. Meet. on Small Ruminant Res., Balai Penelitian Ternak, Bogor.

Campbell, R. R., C. A. Suda and H. F. Lionberger. 1984. A social systems description of small farmers in two Western Kenya districts. Small

Ruminant CRSP Tech. Rep. No. 43. Univ. of Missouri, Columbia.

Chaniago, T. D., J. M. Obst and T. Boyes. 1982. The growth of Javanese thin-tail rams with improved feed and management. In: M. R. Jainudeen and A. R. Omar (Ed.) Animal Production and Health in the Tropics: Proc. 1st Asian-Australasian Anim. Sci. Congr., Penerbit Univ. Pertanian Malaysia, Serdang, Selangor. p 327.

Chaniago, T. D., J. M. Obst, A. Parakkasi and M. Winugroho. 1984. Growth of Indonesian sheep under village and "improved" management systems. In: Sheep and Goats in Indonesia. Proc. Sci. Meet. on Small Ruminant Res., Balai Penelitian Ternak, Bogor. p 109.

Chawla, D. S. and S. Nagpal. 1982. Role of exotic genes on growth rate of Beetal crosses. Proc. 3rd Int. Conf. on Goat Prod. and Disease. Tucson, AZ. p 550.

DeBoer, A. J. 1984. Economic analysis of small ruminant production and marketing systems. In: R. D. Blond (Ed.) Partners in Research. p 19. SR-CRSP, Univ. of California, Davis.

DeBoer, A. J., H. A. Fitzhugh, R. D. Hart, M. W. Sands, M. O. Job and S. Chema. 1984. Production of meat and milk from goats in mixed farming systems in the high potential tropics. In: J. R. Simpson and P. Evangelou (Ed.) Livestock Development in Subsaharan Africa: Constraints, Prospects, Policy. p 335. Westview Press, Boulder, CO.

Devendra, C. 1980. Milk production in goats compared to buffalo and cattle in humid tropics. J. Dairy Sci. 63:1755.

Devendra, C. 1981. Potential of sheep and goats in less developed countries. J. Anim. Sci 51:461.

Fitzhugh, H. A., and G. E. Bradford (Ed.). 1982. Hair sheep of Western Africa and the Americas: A genetic resource for the tropics. Westview Press, Boulder, CO.

Flores, J. F., T. H. Stobbs and D. J. Minson. 1979. The influence of the legume Leucaena leucocephala and formal casein on the production and composition of milk from grazing cows. J. Agr. Sci. (Camb.) 92:351.

Fresco, L. O. 1984. Issues in farming systems research. Netherlands J. Agr. Sci. 32:253.

Gatenby, R. M. and S. Wahyuni. 1985. The role of women in small ruminant production: a case study in Ciburuy, West Java. In: Efficient Animal Production for Asian Welfare. Proc. 3rd AAAP Anim. Sci. Congr., Seoul, Korea. Vol. 2.

Gordin, S. 1980. Milking animals and fermented milks of the Middle East and their contribution to man's welfare. J. Dairy Sci. 63:1031.

Gutierrez, N. A., A. J. DeBoer and J. U. Alves. 1981. Interacões de recursos e caracteristicas economicas dos criadores de ovinos e caprinos no sertão do Ceará, Nordeste do Brasil—Resultados preliminares. Bol. de Pesq. No. 3. National Goat Res. Center, EMBRAPA. Sobral CE, Brazil.

Hussain, M. Z., R. Naidu, I. Tuvuki and R. Singh. 1983. Goat production and development in Fiji. World Anim. Rev. No. 48:25.

Inounu, I., N. Thomas, P. Sitorus and M. Bell. 1984. Lambing characteristics of Javanese thintail ewes at Cicadas experiment station and under village conditions. Small Ruminant CRSP Working Paper No. 18. Balai Penelitian Ternak, Bogor, Indonesia and Univ. of California, Davis.

Ismaili, D. 1983. Caracterisation de l'élèvage ovin dans une zone bour du Tadla. 3rd Cycle Memoire, Inst. Agron. et Vet. Hassan II, Rabat, Morocco.

Laor, M. 1982. Increase of meat production in herd goats by improved management of grazing and breeding. Proc. 3rd Int. Conf. on Goat Prod. and Disease, Tucson AZ. p 299.

Martinez C., D. 1983. A comparative study of the organization, management and husbandry practices of three sheep production units in the Central Sierra of Peru. SR-CRSP Tech. Rep. No. 11. Winrock Int. Inst., Morrilton AR and National Agrarian Univ., Lima, Peru.

Mathius, I. W., J. E. van Eys, A. Djajanegara and M. Rangkuti. 1983. Effects of cassava leaf supplementation on the utilization of napier grass by sheep and goats. Proc. Vth World Conf. on Anim. Prod., Tokyo. p 401.

Mason, I. L. 1980. Sheep and goat production in the drought polygon of northeast Brazil. World Anim. Rev. No. 34:23.

McCorkle, C. M. 1982. Organizational dialectics of animal management. SR-CRSP Tech. Rep. No. 6. Univ. of Missouri, Columbia.

McGuire, T. C. 1984. Animal health constraints on small ruminant performance. In: R. D. Blond (Ed.) Partners in Research. p 113. SR-CRSP, Univ. of California, Davis.

Mishra, R. K., D. Gaur, D. Singh and R. M. Acharya. 1982. Purebred performance of Sirohi goats under range management in semi-arid region of India. Proc. 3rd Int. Conf. on Goat Prod. and Disease, Tucson, AZ. p 348.

Mukhebi, A. W., F. B. Nyaribo, R. H. Bernsten, J. E. Reynolds and A. N. Mbabu. 1984. A socio-economic evaluation of the dual purpose goat enterprise in small-scale farming systems in Western Kenya. Proc. 3rd Small Ruminant CRSP Kenya Workshop, Nairobi. Univ. of California, Davis. p 95.

Nordblom, T. L., A.K.H. Ahmed and G. R. Potts (Ed.) 1985. Research Methodology for Livestock On-Farm Trials: Proceedings of a Workshop Held at Aleppo, Syria. IDRC, Ottawa, Canada.

Norman, D. W. 1978. Farming systems research to improve the livelihood of small farmers. Amer. J. Agr. Econ. 60:813.

Nyaribo, F. B., R. H. Bernsten and A. W. Mukhebi. 1984. Inter-seasonal household food consumption patterns in Western Kenya. Proc. 3rd Small Ruminant CRSP Kenya Workshop, Nairobi. Univ. of California, Davis. p 89.

Obst, J. M., T. Boyes and T. Chaniago. 1982a. Reproductive wastage in Javanese thin-tail sheep. In: M. R. Jainudeen and A. R. Moar (Ed.) Animal Production and Health in the Tropics: Proc. 1st Asian-Australasian Anim. Sci. Congr.; Penerbit Univ. Pertanian Malaysia, Serdang, Selangor. p 425.

Obst, J. M., Z. Napitupulu and T. Boyes. 1982b. Nutritive value of elephant grass (Pennisetum purpureum) and rice bran diets for growth of tropical sheep. In: M. R. Jainudeen and A. R. Omar (Ed.) Animal Production and Health in the Tropics: Proc. 1st Asian-Australasian Anim. Sci. Congr.; Penerbit Univ. Pertanian Malaysia,

Serdang, Selangor. p 255.

Oltenacu, E. A., A. Martinez, H. A. Glimp and H. A. Fitzhugh (Ed.) 1976. Proceedings of a Workshop on the Role of Sheep and Goats in Agricultural Development. Winrock Int. Inst., Morrilton AR.

Onim, J.F.M., R. Hart, K. Otieno and H. A. Fitzhugh. 1984. Potential of intercropping forage crops with maize in Western Kenya. Proc. 3rd Small Ruminant CRSP Kenya Workshop, Nairobi. Univ. of California, Davis. p 65.

Prabowo, A., J. E. van Eys, I. W. Mathius and S. Lebdosoekojo. 1983. Trace mineral status and effect of mineral supplementation in Javanese thin tail sheep. Proc. Vth World Conf. on Anim. Prod., Tokyo. p 389.

Prabowo. A., J. E. van Eys, I. W. Mathius, M. Rangkuti and W. L. Johnson. 1984. Studies on the mineral nutrition of sheep in West Java, Indonesia. Small Ruminant CRSP Working Paper No. 40. Balai Penelitian Ternak, Bogor, Indonesia and North Carolina State Univ., Raleigh.

Primov, G. 1981. The regional structure of distribution of mutton in Cusco, Peru. Small Ruminant CRSP Tech. Rep. No. 3. Univ. of Missouri, Columbia.

Primov, G. 1982. Small ruminant production in the Sertão of Ceará, Brazil: A sociological analysis. Small Ruminant CRSP Tech. Rep. No. 15. Univ. of Missouri, Columbia and National Goat Res. Center, EMBRAPA, Sobral CE, Brazil.

Pulungan, H., J. E. van Eys and M. Rangkuti. 1985. Utilization of soybean curd sludge as a supplement for confined sheep fed low quality forage. Ilmu dan Peternakan 1:331.

Quijandria, B., C. Espinoza R. and M. Fernandez L. 1984. Small ruminant production system research and technology validation in peasant communities in the highlands of Peru. Mimeographed Rep., Small Ruminant CRSP, INIPA, Lima, Peru.

Reynolds, J. E. 1984. Seeking the "udder" truth about goats in Western Kenya: Conversations with community elders. Proc. 3rd Small Ruminant CRSP Kenya Workshop, Nairobi. Univ. of California, Davis. p 113.

Reynolds, J. E., A. N. Mbabu and M. F. Nolan. 1984. Extension services and the smallholder: a report of preliminary findings. Proc. 3rd Small Ruminant CRSP Kenya Workshop, Nairobi. Univ. of California, Davis. p 125.

Sabrani, M., S. Mawi, T. D. Soedjana and H. C. Knipscheer. 1983. A profile of sheep and goat markets in West Java, Indonesia. Small Ruminant CRSP Tech. Rep. No. 12. Winrock Int. Inst., Morrilton, AR and Balai Penelitian Ternak, Bogor, Indonesia.

Sands, M. W., H. A. Fitzhugh, R. E. McDowell and S. Chema. 1982. Mixed crop-animal systems on small farms in Western Kenya. Small Ruminant CRSP Tech. Rep. No. 17. Winrock Int. Inst., Morrilton AR; Cornell Univ., Ithaca NY and Min. of Livestock Dev., Nairobi, Kenya.

Sands, M. W. and R. E. McDowell. 1978. The potential of the goat for milk production in the tropics. Int. Agr. Mimeograph 60, Cornell Univ., Ithaca, NY.

Sharma, K. 1982a. Studies on the effect of supplementary feeding of concentrates at different levels on the milking ability of does. Proc. 3rd Int. Conf. of Goat Prod. and Disease, Tucson, AZ. p 336.

Sharma, K. 1982b. Studies on the growth rate and feed conversion efficiency of kids fed Prosopsis spicegera L with different levels of concentrates. Proc. 3rd Int. Conf. on Goat Prod. and Disease, Tucson, AZ. p 522.

Sidahmed, A. E., M. Onim, A. W. Mukhebi, R. S. Shavulimo, A. J. DeBoer and H. A. Fitzhugh. 1985. On-farm trials with dual purpose goats on small farms in Western Kenya. In: Nordblom, T. L., A.K.H. Ahmed and G. R. Potts (Ed.) 1985. Research Methodology for Livestock On-Farm Trials: Proceedings of a Workshop Held at Aleppo. Syria. p 101. IDRC, Ottawa, Canada.

Solano, R. and M. Avila. 1983. Un estudio de caso: Aplicación del enfoque de sistemas por el Convenio ICTA/CATIE en Nueva Concepción, Guatemala. In M. E. Ruiz and H. H. Li Pun (Ed.) Informe de la III Reunión de Trabajo sobre Sistemas de Producción Animal Tropical. IDRC Manuscript Rep. 90, Bogotá, Colombia. p 7.

Subandriyo. 1984. Factors affecting survival of range sheep in the United States and characterization of sheep in Indonesia. M.S. Thesis. Montana State Univ., Bozeman.

Suradisastra, K. and M. F. Nolan. 1983. Social aspects of small ruminant production: A comparative study of West Java, Indonesia. Small Ruminant CRSP Tech. Rep. No. 19. Univ. of Missouri, Columbia.

Thomas, N., W. Mathius and M. Sabrani. 1982. Small ruminant production in West Java: Methodology and initial results. In: J. C. Fine and R. Lattimore (Ed.) Livestock in Asia: Issues and Policies. IDRC, Ottawa, Canada.

Tiesnamurti, B., P. Sitorus and I. Inounu. 1984. Survival rate of Javanese thin tailed sheep in villages in West Java. In: Sheep and Goats in Indonesia. Proc. Sci. Meet. on Small Ruminant Res., Balai Penelitian Ternak, Bogor, Indonesia. p 167.

van Eys, J. E., I. W. Mathius, P. Pongsapan and W. L. Johnson. 1985a. Foliage of tropical legume trees as low level supplement to napier grass diets for growing goats. J. Anim. Sci. 61(Suppl. 1):331.

van Eys, J. E., I. W. Mathius, H. Pulungan, M. Rangkuti and W. L. Johnson. 1984. Small ruminant production in West Java: Results of one year monitoring by the nutrition village monitoring program. Small Ruminant CRSP Working Paper No. 34. Balai Penelitian Ternak, Bogor, Indonesia and North Carolina State Univ., Raleigh.

van Eys, J. E., S. Silitonga, I. W. Mathius and W. L. Johnson. 1985b. On-farm trials of mineral supplementation for small ruminants in West Java, Indonesia. In: Nordblom, T. L., A.K.H. Ahmed and G. R. Potts (Ed.) 1985. Research Methodology for Livestock On-Farm Trials: Proceedings of a Workshop Held at Aleppo, Syria. p 153. IDRC, Ottawa, Canada.

Verma, N. K. and D. S. Chawla. 1982. Heterosis of milk yield and its components in dairy goats. Proc. 3rd Int. Conf. on Goat Prod. and Disease, Tucson, AZ. p 305.

West, T. L. 1981. Alpaca production in Puno, Peru. SR-CRSP Tech. Rep. No. 4. Univ. of Missouri, Columbia.

Wilson, R. T. 1985. Livestock production in central Mali: Sheep husbandry in the traditional sector. World Anim. Rev. No. 53:8.

Winrock International. 1977. The Role of Sheep and Goats in Agricultural Development: A State of the Arts Study. Winrock Int. Inst. Morrilton, AR.

Winrock International. 1983. Sheep and Goats in Developing Countries: Their Present and Potential Role. The World Bank, Washington, DC.

Zahari, P., D. R. Stoltz, A. J. Wilson, T. B. Murdiati and J. E. van Eys. 1984. Preliminary observations of Pithomyces chartarum on Brachiaria toxicity. In: Sheep and Goats in Indonesia. Proc. Sci. Meet. on Small Ruminant Res., Balai Penelitian Ternak, Bogor, Indonesia. p 241.