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SWINE PRODUCTION SYSTEMS

AN EXPLORATORY ANALYSIS OF RESEARCH PROBLEMS AND ALTERNATIVES IN SELECTED COUNTRIES OF TROPICAL LATIN AMERICA

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1. Introduction

1.01 Numerous documents have pointed out the importance of swine activities in tropical Latin America, not only with regard to consumption but also to production. In terms of consumption, pork represents from 25 to 30% of total meat consumption, second in importance to beef (60%). In terms of production, two functions are performed at the small and intermediate levels of production in tropical Latin America. The first is that of providing income on the basis of low-cost opportunity resources such as family labor, crop residues and other farm byproducts. The second function is that of capitalizing such resources by selling what is produced (i.e., the pigs) in order to balance the farm cash flow (Schuh, 1977).

1.02 The apparent inefficiency of productivity at the Latin American level stands out: Whereas the swine population in Latin America represents approximately 11% of the world total, pork production in the region accounts for only 4.6% of the world total (CIAT, 1978). The overall extraction rate is less than half of the world total and less than one third of that obtained in the developed countries.

Swine: Population, production and average productivity in selected areas

Parameters	World total	Developed countries	Latin America
Swine population (millions of heads)	674	171	71
Animals slaughtered (millions of heads)	630	246	31
Production (millions of tons)	42	17	2
Extraction rate (percentage)	94	144	44

Source: FAO, Anuario de Producción, Vol. 29, 1975; cited in CIAT, 1978

1.03 This inefficiency of productivity is greater in the tropical zones and is commonly associated with and attributed to the fact that the majority of production is derived from small and intermediate operations, which use native breeds.

1.04 At the same time, low physical productivity has been attributed to a group of interrelated factors, among which the following are repeatedly mentioned: the lack of governmental support for swine production, omission from integrated rural development programs, the absence of extension services for small- and medium-sized producers, the reduced number of specialized

professionals and technicians, the limited availability of conventional feedstuffs, deficient animal health programs, inadequate marketing systems, the limited processing of pork, and the lack of financial backing for production activities. From this long list of limiting production factors, the availability of adequate feed for efficient nutrition has been repeatedly mentioned as one of the most critical or limiting factors at the farm level (CIAT, 1978).

1.05 If we accept the initial diagnosis of low physical productivity and the working hypothesis that this is principally due to nutritional deficiencies, questions such as the following should be asked: (1) Are these nutritional deficiencies found in all production systems or just at the small-farm level? (2) Are these deficiencies fundamentally energetic or protein in nature, or a combination of the two? (3) Can these limitations be eliminated through generalized research, or does each system require specific solutions? (4) What role do the international centers have in conducting the research required? What are the advantages of their doing this in comparison to the national institutions?

The absence of primary sources of information that would make it possible to answer these and other related questions motivated the carrying out of this study in an attempt to find solutions.

2. Objectives of the study

2.01 The main objective of this study was to explore the working hypothesis that the low physical productivity of swine production in tropical Latin America is due primarily to deficient nutrition and management; and if this were the case, to analyze whether this problem could be solved by means of research and training programs, and if so, of what type.

2.02 The specific objectives of this study were to:

a) Evaluate pork production and consumption trends in the tropical Latin American countries in order to make a diagnosis of the industry's problems in general.

b) Select countries with swine production problems and identify their principal production systems in order to determine similarities and differences in the factors contributing to low productivity, as well as possible solutions.

c) Provide qualitative and quantitative information that would make it possible to undertake an exploratory analysis of the possibilities of eliminating existent limitations through research and the degree of general applicability of these solutions.

2.03 In synthesis, the purpose of this work is to characterize the principal swine production systems, to identify the causes of low physical productivity and to evaluate the possible corrective technological measures required to increase production and productivity.

3. Methodology

3.01 The method that has been used is fundamentally analytical (observation-analysis-synthesis). On the basis of the statistical information available and previous knowledge of existing production systems, countries with different degrees of swine production problems were selected. Surveys were made of producers in these countries in order to characterize the different production systems and identify their principal limiting factors.

3.02 (Selection of countries). Of the 22 countries for which there was statistical information available, 5 were selected with different degrees of swine production problems (Table I.19): Bolivia, Colombia, Ecuador, Guatemala and Paraguay.

a) Four of these countries figure among the 10 with the lowest per capital protein consumption (especially animal protein), whereas one (Paraguay) is among the 3 that apparently have the highest consumption. In the five countries selected, it has been estimated that the demand for pork grew at a faster rate than production during the period from 1960 to 1975.

b) Three of these countries are among the 10 least efficient in terms of production per head of stock, whereas two of them (Paraguay and Colombia) are among the 3 apparently most efficient in general terms. One of them (Guatemala) has the lowest per capita swine production; another (Paraguay) has the highest; whereas the rest have values that are very close to the intermediate values for tropical Latin America.

c) With reference to the type of ecology characterizing the swine production zones, in Guatemala the majority of swine production is located in the mountainous region; in Paraguay all swine activities are found in the plains region, whereas in the 3 remaining countries, production is found distributed in diverse zones and climates (tropical, subtropical and temperate).

3.03 (Size of the sample). Table 1 gives data on the number of farms surveyed per country, the type of production system (breeding or fattening) and stratification according to herd size. Because of the fact that the structure of the swine population existing in the different countries was not known prior to the study, the size of the sample and the zones surveyed in each case vary from one country to another, in accordance with the following factors: (a) the amount of time available and the possibilities of receiving collaboration and support from national institutions in conducting this survey and (b) the knowledge and experience acquired previously by personnel

from said institutions and from CIAT. The exception was Paraguay, where the existence of a previous survey (Annex VI) made it possible to reduce the size of the sample significantly. In total some 1900 producers were interviewed, and 1582 questionnaires were acceptable for processing.

3.04 (Stratification of the sample). Prior to conducting the survey, tentative strata were established according to the size of the reproductive herd (sows) on the breeding farms and the number of pigs on farms with fattening operations. This stratification was made in accordance with the tentative hypothesis that the level of nutrition and management, as well as productive efficiency, is associated with herd size. This stratification was done previously in order to obtain a minimum number of observations for each of the strata. This was not possible in all cases because of the following: (1) the lack of representativeness of a stratum in particular, (2) difficulties in locating producers belonging to a particular stratum, or (3) both of these factors.

3.05 (Representativity of the sample). It should be noted that the figures obtained correspond only to the sample and vary from one country to another; therefore, they cannot be extrapolated to the population of swine producers. Nevertheless, the sample can be considered representative of a given stratum by country, region or production systems, whichever be the case.

3.06 (Organization of the paper). This paper is presented in two parts: (1) the present text which includes the objectives, methodology and principal results in summary form and (2) annexes containing the macrostatistical report (Annex I), the countries report (Annexes II to VI), the results of the survey made of ex-CIAT trainees (Annex VII) and an annex (VIII) containing the questionnaire utilized, the code system and the form in which the primary information is available to interested parties and institutions.

3.07 The study of each country (Annexes II-VI) includes a delimitation of the principal producing regions. Then an evaluation is made of the agroclimatic conditions and the production characteristics for each region, as well as of all information related to the potential development of swine production in that region. An analysis is then made of the swine production systems, with emphasis on the technological characteristics in relation to management patterns or requirements (reproductive, sanitary, nutritional) considered essential for adequate production. The most deficient technological aspects are determined for each productive system, and an attempt is made to individualize those that merit further research, trying to evaluate to what extent these aspects are general; that is to say, with an ample spatial range of application.

3.08 Finally, an analysis is made as to what extent past or ongoing research has taken care of the problems detected, and conclusions are made with regard to potential courses of action. In other words, an attempt is made to analyze the latent demand for technology (de Janvry & Martinez, 1972),

to compare it with supply, and then to determine the inadequacy of its coverage. This will make it possible to suggest additional areas requiring research.

4. The general panorama

4.01 (Demand and production trends). In Latin America as a whole, as well as in the tropical subregion, it has been estimated that pork production and demand have been growing at approximately the same rate (Table 2); however, this is basically due to what occurs in Brazil and Mexico, which account for almost 70% of the swine population in the region.

4.02 The situation in terms of demand and production trends varies notably from one country to another (Tables 2 and I.8, Annex I). In Central America production is growing at the same pace as demand; nevertheless, in countries such as El Salvador and Honduras, production has stagnated or decreased. On the other hand, in Nicaragua and Costa Rica it is growing at a slower rate than population. The situation is somewhat similar in the Caribbean countries: while production in the subregion as a whole has stagnated, it grows at the same rate as demand in Jamaica, but decreases notably in Haiti.

4.03 In the five countries studied herein, production tends to increase at a rate of 2.6% annually, which is slightly less than the estimated population growth rate, but much less than the estimated annual growth rate of demand (4.6%). Once again, the situation varies from one country to another (Table 3).

4.04 (Per capita swine production). Average per capita pork production in Latin America (5-7 kg/year) is low in comparison to the average level in the United States (25-29 kg/year, Table I-3). Nevertheless, this level varies among countries: Paraguay stands out for its high per capita production (19-20 kg/year) and Guatemala for its low level (1-2 kg/year). In general the lowest values are found in the Central American and Caribbean countries.

4.05 The participation of pork in relation to total meat consumption averages around 20%, ranging from as low as 6% in Uruguay to as high as 40% in the Caribbean countries.

4.06 (Productivity). Estimated extraction rates (number of slaughtered pigs/stock) and meat production per animal confirm the apparent inefficiency of production in general and of the tropical subregion in particular (1.02), which produces one fourth to one fifth of the volume of meat production per head of stock obtained in the United States (Tables I.4 and I.5). It should be pointed out that during the period from 1960 to 1976, the extraction rates for animals, pork and carcass yield of the slaughtered pigs suggest that there has been no substantial improvement in swine productivity.

4.07 (International trade). The export of pigs and pork meat in Latin America is of little importance with regard to its volume, being carried out principally in the Central American and Caribbean countries. This implies that the countries in the region depend almost exclusively on domestic pork production to meet their requirements. Except for a few countries in Central America and the Caribbean, production and consumption are practically synonymous terms.

4.08 Production of the principal energetic and protein sources to be used in animal production are concentrated in Brazil, Mexico and Colombia, 3 of the 4 major Latin American countries producing pork. The production growth rate of energetic and protein sources in the period from 1970-75 was slow, with the exception of soybean meal production, which grew 5.6 times. It should be pointed out that more than half of the soybean production in the region is exported either directly or as meal. In the tropical region maize accounted for 44% of the energy and 30% of the protein produced in the region; these percentages vary from country to country (Guatemala 71 and 60%, Paraguay 26 and 21%, respectively, Tables I.16 and I.17).

4.09 (Per capita production of energy and protein sources). The United States produces 3.6 times the energy per person produced in Latin America and 8 times that produced on the average by the countries included in this report. The differences in production are even greater in the case of protein for animal nutrition (4.0 and 11.1 times, respectively, Annex I, 6.06).

4.10 On the basis of production figures for animal feedstuffs, protein/energy ratios for the different areas of Latin America were calculated, indicating that in relative terms the tropical region is deficient in protein production for animal feedstuffs. That is to say, there is a double production deficit: an absolute deficit (energy and protein sources) and a relative deficit (protein sources). Both of these deficits are concentrated in the case of the countries dealt with in this report(Table I.16).

4.11 In spite of the fact that the deficit of protein production for both animal and human nutrition seems to be accentuated, tropical Latin America is a net importer of grains (principally energy sources) to be used in animal production but an exporter of protein sources. A possible explanation of this phenomenon, is that at low nutritional levels, energy requirements become more important than protein requirements. According to this hypothesis, energy is imported and protein is exported because energy requirements are met first before thinking about balancing a diet efficiently.

4.12 Another possible explanation lies in the importance of maize in human diets in the Andean countries, which implies that the figures analyzed overestimate the energy (vs. protein) available for animal nutrition. In other words, humans will balance their diets with other protein sources (animal and/or vegetable) that are not taken into account in the foregoing figures; whereas the animals would be given more balanced diets than implied

by the protein/energy relationships mentioned previously. This would explain, in part, the importing of energetic sources and the exporting of protein sources referred to previously. In any case the proportion of these figures would seem to indicate that it is probably a combination of the two hypotheses.

4.13 In summary, in terms of apparent per capita production and consumption, as well as in terms of production growth in comparison to demand for pork, the countries in the most disadvantageous conditions are found in the Caribbean, Central America and the Andean region; but the situation varies considerably from one country to another. The estimated indices suggest that during the 1960-76 period, there was no apparent improvement in swine productivity. Estimated physical productivity of the swine herd in the tropical countries is from one foruth to one fifth of that estimated for the United States. Said productivity is attributed to the low availability of feedstuffs (absolute deficit) and the relatively low availability of protein (relative protein deficit vs. calories) available for swine nutrition.

5. Swine production systems

5.01 An attempt is made to characterize in brief the swine production operations represented within the overall farm system in the sample and to identify the factors limiting to productivity.

5.02 It should be pointed out that of the 1582 questionnaires processed for the 5 countries, approximately 73% correspond to what could be called small farms, 19% to intermediate operations and only 8% to large enterprises. The percentage of the swine population surveyed (number of pigs) had an almost inverse distribution; nevertheless, this should not be interpreted as being representative of the swine population at the national or regional levels since this sample was not weighted by expansion factors.

Stratification of the sample in the five countries, according to the size of the pig herd

	Small[a/]	Intermediate[b/]	Large[c/]	Total
	--------- percentages			----------
Number of farms surveyed	73	19	8	100
Number of pigs on farms surveyed	11	17	72	100
Number of cattle on farms surveyed	31	46	23	100

a/ ≤ 9 fattening pigs or ≤ 4 breeding sows
b/ 10-49 fattening pigs or 5-19 breeding sows
c/ ≥50 fattening pigs or ≥ 20 breeding sows

5.03 (Tentative classification of swine production systems). Although all attempts to generalize may result in the loss of validity or specificity, the principal swine production systems have been classified on the basis of the integration of the swine activity with the other farm and marketing activities:

1) Commercial enterprises: Although very few in number, they represent approximately 10 to 30% of the stock, depending on the country. Almost all feed inputs are purchased, generally in the form of complete balanced feedstuffs. The level of swine technology is quite high.

2) Semi-integrated enterprises: This system is somewhat more frequent than the preceding type; the majority of the feedstuffs, especially the energetic sources, are produced directly on the farm or in the region; but protein, mineral and vitamin supplements are purchased.

   In both systems (1 and 2) the final product (the live animal or the carcass) is sold to meat processing plants or slaughterhouses in the big cities).

3) Intermediate integrated operations: Almost all feed inputs are produced on the farm; a very limited amount of supplements are purchased, but there is general use of vermifuges and vaccines. The swine production activity is fully integrated with the overall farm system, the agricultural system and the regional market. In those places where there are regional development programs, this system forms an integral part, the objective of production being the partial supply or pork for the zone and on-farm consumption.

4) Small integrated operations: These are the most generalized and widespread in the tropical regions. Kitchen scraps or crop residues are used to feed the pigs, and practically no additional inputs are purchased, except for the occasional use of vaccines and vermifuges.

   In these last two systems (3 and 4), swine production performs the double function of utilizing low-cost opportunity resources and capitalizing them in order to balance farm cash flow (1.01).

   Table 4 gives a qualitative summary of the most relevant characteristics of these systems and includes a few examples from the regions where they were found in the survey.

5.04 (Diversification vs. specialization). There is a general tendency towards diversification of production at the small-farm level and towards specialization in large operations. With the exception of Bolivia, where no clear association between swine production systems and size is found, in the rest of the countries there is an association, to a greater or lesser extent, between herd size and specialization in said activity. Table 5 shows the existent swine and cattle population by country and strata of production. The same information is given in Table 6, but expressed in terms of number of swine per cattle in existence; it can be seen that in Bolivia, Ecuador, Paraguay and, to a lesser extent, in Colombia, the average cattle population is more important than that of swine in the smaller operations. This is further evidence of the degree of diversification found on the small farm and of the

integration (and dependence) of the swine operation with the rest of the farm system in general.

5.05 (Integration and size). On the small farms (4) the swine activities are fully integrated with other agricultural activities. In general, low-cost opportunity family labor (wife and children) is used, and almost all the feedstuffs supplied are produced on the farm itself; very little or nothing is purchased. Low cost-opportunity feedstuffs are generally supplied, whether these be kitchen scraps, crop residues or products of low commercial value due to the lack of market, bulkiness and/or distance to the centers of consumption. In general the swine production system is of an extensive, unconfined type, in which the pigs are kept in simple sheltered and shaded areas.

Similarly, on the intermediate-size farms (3) swine operations are usually closely integrated with agricultural production on the farm, from where they obtain the majority of the feedstuffs, although in some cases inputs such as protein and mineral supplements, vermifuges and/or vaccines are purchased.

5.06 In the sample of significant number of small farms acquired a limited number of pigs for fattening purposes in order to take advantage of their seasonal harvest byproducts. In addition a number of farms were found that had breeding sows but no boars; the service of a male, usually of an improved breed, were hired from neighboring farmers. This service is usually paid for in kind (baby pigs).

5.07 (Relationship of herd size and nutrition-feeding). As herd size increases, the quantity (in terms of energy) and quality (protein/energy ratio) of the feedstuffs supplied increases. Bolivia and, to a certain extent, Ecuador appear to follow this general principle to a lesser degree. In Tables 7 through 11, the information on nutrition and feeding for the five countries covered in this report is summarized. The energy supplied is expressed in terms of Mcal/AU; the protein, in terms of g/AU. These figures do not, of course, include the feed obtained in grazing or browsing when the animals are unconfined. It can be seen that in Colombia and Guatemala (Tables 8 and 10), as well as in Paraguay (Table 11), that as herd size increases, the supply (in addition to browsing) in quantitative terms (energy) and in qualitative terms (protein/energy ratio) improves. Moreover, it can be seen that as herd size increases, so does the degree of pig confinement. (see respective annexes).

5.08 In Bolivia and Ecuador (Tables 7 and 9) there is no clear association between herd size and the quantitative and qualitative supply of feedstuffs. In Bolivia, the differences among the production systems are more closely related to the producing region, agricultural production, the distance to centers of consumption and religion (Mennonite colonies). In Ecuador, although there is a greater association between regions and systems, the lack of a definite trend is most likely due to the fact that the industry is in the process of expanding and is therefore not yet stabilized.

5.09 (Interactions among limiting factors). The analysis of the information compiled on swine production in the 5 countries surveyed confirms that the most important factors limiting to swine productivity are inefficient feeding and management, but that they are closely related to others such as the breeds utilized and especially to aspects of an economic nature, such as the opportunity cost of available resources and feedstuffs produced on the farm and overall limitations of the farm for expanding the production of said feedstuffs.

5.10 (The interaction between management systems and breed). In general there is a high degree of association between herd size and system in terms of the degree of pig confinement. At the level of large enterprises, the confinement production system predominates, whereas the grazing systems predominate among the small farms (see for example Table II.14, Annex II). It is particularly interesting to note that at the small and intermediate producer levels, evidence indicates that the "improved production systems" do not appear to be significantly better than the "traditional systems" at the farm level, at least in the case of Paraguay.

5.11 In Table 12 some parameters selected for this country are presented. It can be seen that in both breeding strata, feeding improves considerably in both quantitative terms (energy) and qualitative terms (protein/energy) when going from the traditional to the improved system. Nevertheless, physical productivity in terms of piglets/sow/year improves but in a less than proportional manner. Meat production per Mcal supplied decreases to one half; and in terms of protein supplied, it decreases one third. This can be explained in terms of the interaction between breeds and management systems, as will be seen later.

5.12 In Figure 1 expected weight gain curves are presented as a function of feed supplied to unconfined (A), semiconfined (B) and confined (C) pigs and the possible effect of the adaptation of native breeds to the environment and to the system. The curves represented by the dotted lines correspond to pure breeds; those with the solid lines, to native and criollo breeds. The underlying hypothesis of this figure is that in grazing systems (without confinement) the creole animals (A) are more efficient converters than the pure breeds (A') at the level of feasible feeding (p) on small- and intermediate-sized farms. The evidence available on the limited supply of feedstuffs for unconfined tends to support this hypothesis. Moreover, available evidence (Kleemann, 1977) tends to confirm the shapes of the weight gained curves C and C' in confined system. This may be due, in part, to the fact that creole pigs tend to accumulate more fat, which requires more feed per unit of weight produced. Moreover, it should be kept in mind that the creole pig is preferred in the rural sector for the quantity of fat produced.

5.13 It should be noted that the daily weight gain obtainable in systems C' is superior to the maximum obtainable (A') in the grazing or unconfined system A. The question then arises as to why the producer does not choose

to do one of the following: (1) keep fewer pigs or (2) expand production by feeding the pigs better and reducing the sale of his agricultural products on the market. The information obtained from the survey makes it possible to formulate a possible explanation for the first question: the producer does not reduce the number of pigs because he is aware that the problem is not only the quantity of feedstuffs versus the number of pigs, but also quality (protein/energy ration) since the use of a balanced diet is implied, to which he does not have access. The answer to the second question must be found in economic considerations such as relative prices, risk, availability and opportunity costs of resources and products, and cash flow.

5.14 The means values obtained for Paraguay (Table 12) can be explained by means of Figure 2, in which curve A assimilates the traditional system and curve C, the improved one. The higher values of meat per feed unit obtained for both strata in the traditional systems are represented in the slope of mean productivity ($\alpha > \beta > \gamma$). It is also possible that the case illustrated in Figure 3 may occur although this is less probable, given the relative magnitude of the figures in question (Table 1).

5.15 The term productivity in the graphic example refers to weight gain only; however, the response could be different when measured in terms of reproductive yield. The survey data suggest that the parameter most susceptible to being affected is total annual productivity (number of litters/sow/year; number of weaned pigs/sow/year). As can be seen in Table 12, both the number of pigs born, as well as weaned per litter does not differ significantly from one system to another. The number of litters per sow per year does, however, depend on the system, especially on the continuous availability (nonseasonal) of feedstuffs. The solution with regard to continuity in the availability of balanced feedstuffs depend on the perishable nature of the products used in each system. Factors such as profitability and/or availability on the market can limit the purchase of feedstuffs to balance seasonal deficits.

6. Production-limiting factors and research alternatives

6.01 The swine production systems identified in the countries in this study present, on the one hand, the very diversified family or subfamily farm, integrated with the market, destined basically to make use of low-cost feedstuffs or natural resources; and on the other hand, commercial operations that use inputs purchase on the market and specialized wage labor in which swine production constitutes the principal or sole activity. Between these two extremes, there are a considerable number of intermediate alternatives that integrate the particular characteristics of one or the other, with different levels of intensity.

In this broad spectrum of systems, the limiting factors vary from one place to another; but in general they can be summed up as follows:

a) It is commonly found that the quantity of feed supplied is quantitatively inferior to that which should be theoretically given to the pigs for obtaining a good level of production. Energetic requirements are in the range of 13 to 14 Mcal/AU/day, whereas in the majority of the countries studied, especially in the smaller production strata, the ranges utilized vary from 4 to 9 Mcal/AU/day.

b) In addition to the insufficient supply of energy, protein deficiency is manifest; the g prot/Mcal ratio varies from 25 to 30, when it should be on the order of 40 to 45.

c) Swine productivity (low extraction rates, reduced number of pigs/sow/year, late slaughter age, high mortality rates, etc.) is generally inefficient from a physical point of view, but this does not necessarily imply poor economic results.

d) Given the existing limitations and the relative availability of feed resources, especially at the small and intermediate levels, the improvement of the physical efficiency rates per unit of time would imply a reduction in the efficiency of production per unit of energy employed, to a point where it would not be economically advantageous for the producer.

e) The quality of the final products and its use constitutes another factor limiting the greater transference of technology. Native pigs accumulate more fat than the improved races, and in rural zones their yield is often judged and evaluated in terms of quantity of lard produced.

f) It is not known whether the performance of improved races is superior to that of the native or creole breeds under suboptimal feeding conditions (according to existing patterns). The evaluation of the performance of improved races is normally done under optimal feeding and management conditions.

g) Animal health problems constitute another important factor limiting to the increase of productivity in traditional systems.

h) The overall economic aspects, particularly with regard to feeding, constitute the most important factor limiting the employment of intensive swine production technology, especially at the small- and medium-sized farms levels.

6.02 (Research alternatives). The study of swine production in the 5 countries surveyed has made it possible to identify with a fair degree of precision some of the limiting factors responsible for low swine productivity. Nevertheless, because of the exploratory nature of this survey, even more information is required in order to elaborate more specific research programs designed to solve the problems at the level of each region and country. The research areas or alternatives from one country to another can vary; but on the whole, the principal areas that would merit priority treatment would be the following:

a) A deeper knowledge of the characteristics of the most relevant production systems. It is necessary to obtain more knowledge of these systems in aspects such as the availability of and access to production factors including management capacity for incorporating new

technology; the opportunity cost of their resources; the role of swine activities whithin the enterprises and their interdependence on the rest of the farm system. The lack of knowledge on these aspects would explain, in part, the apparent non-adaptation of "improved" technology, expecially in production systems for small farmers.

b) The development and adaptation of technology applicable to the small production strata. The methodology for evaluating new technology from a physical standpoint (e.g., the evaluation of pig performance in grazing systems), as well as from an economical standpoint (impact on income, opportunity cost of resources, available feedstuffs, etc.), is a basic prerequisite.

c) In view of the fact that feed quantity and quality constitute one of the most important limiting factors and taking into consideration the characteristics of the predominant swine operation, especially in the tropical zones, the development of feeding programs adaptable to said conditions is advisable. Research on the use of forage legumes for grazing systems; research on the production of high-quality protein grains (maize and sorghum with a high lysine content and good storage qualities) that would permit the reduction of protein source requirements; the integration of a feeding program based on roots and tubers supplemented with grazing and/or whey or other protein sources; the storage or processing of highly perishable agricultural products (waste bananas, roots and tubers) would make it possible to improve the limiting factor of seasonality of production and the protein deficit in the diet; constitute a few areas of research that could contribute possible solutions to the aforementioned limiting factors.

d) Greater knowledge on swine genetics under the conditions of the predominant operations is required. The indiscriminate replacement of native breeds by improved races does not appear recommendable under the management and economical conditions and feed restrictions existing on the farm.

7. Conclusions

7.01 The average physical productivity of the swine herd in tropical Latin American countries is low - from one fourth to one fifth of the estimated for the United States. The information available at the macro level makes it possible to attribute this low physical productivity to the reduced availability of feedstuffs (absolute deficit) and the relatively limited availability of protein sources (relative protein deficit vs. calories) for swine nutrition.

7.02 This survey made it possible to identify diverse production systems systems which differ fundamentally in the degree of integration of swine production with the rest of the farm activities and in the degree of integration with the input and product markets. On the one hand, there are the generally

large and growing commercial enterprises, which are intrinsically linked to the market, provide an adequate level of nutrition, and achieve a physical productivity close to that observed in the developed countries. This type of enterprise does not play an important role in the countries included in the sample, except in Colombia and to a lesser extent in Ecuador. With the exception of this apparently unrepresentative system, the main production systems identified are closely linked to the overall farm system of which they form a part and on which they depend.

7.03 It is therefore highly recommendable to study swine production as an integral part of the different systems, which in the majority of cases are specific to each country, region and/or swine herd size.

7.04 The information obtained at the farm level makes it possible to confirm the low physical productivity estimated at the macro level, which can be attributed to a deficit of feed supply, fundamentaly qualitative in nature (protein/energy ratio and digestibility of the same). Nevertheless, the magnifitude, as well as the specific nature of the problem (and therefore the possible solution), varies from country to country, from region to region and many times, from farm to farm in association with size.

7.05 Research on the following "systems components" would make it possible to eliminate some of the most important limitations that are generally found throughout the principal systems identified.

a) The development of grains with high-quality protein (maize and sorghum with a high lysine content) and good storage qualities, adaptable to the conditions of the producer (lowland tropics and Andean region).

b) The development and adaptation of grain legumes (soybeans, cowpeas, peanuts), combined with the development of a on-farm simple, processing technology to reduce or eliminate antimetabolites, adaptable to producer conditions.

c) The development and adaptation of forage legumes compatible with conditions of the lowland tropics to be used in grazing and semiconfinement systems.

d) The evaluation of performance of native breeds and crossbreds under the subfeeding conditions prevalent in the existent swine system.

7.06 An additional component is the training of professionals to strenghen swine research and development programs at the regional level, explicity taking into consideration that the swine operation is an integral component of the overall farm system.

Table 1. Number of farms surveyed by country, orientation and size according to number of sows and number of fattening pigs a/

Country	Breeding farms (number of sows)				Fattening farms (number of pigs)				Total
	1-4	5-19	20-49	>50	1-5	6-9	10-49	>50	
	number of farmers interviewed								
Bolivia	32	75	15	1	1	3	10	3	140
Colombia	300	40	18	26	255	44	23	38	744
Ecuador	185	52	10	6	25	22	5	3	308
Guatemala	90	1	1	3	22	2	-	-	119
Paraguay	175 b/	86 b/	1	1	5	-	2	1	271
Total									
- number	782	254	45	37	308	71	40	45	1582
- percentage	(49.4)	(16.1)	(2.8)	(2.3)	(19.5)	(4.5)	(2.5)	(2.8)	(100.0)

a/ Swine production survey, CIAT, 1979.

b/ Expanded subsample; see Annex VI.

Table 2. Swine: selected statistics for Latin America. 1970-74.

Region and country	Stock	Slaughter volume	Output per capita	Pork as percentage of total red meat production[a]	Output per head in stock	Growth rate[b] of Demand	Growth rate[b] of Production[c]
	--- percentage ---		kg	percentage	kg/head/year	--- percentage ---	
Tropical Latin America	91	83	6	26	24	4.4	4.2
Brazil	50	38	7	26	20	4.1	4.1
Mexico	16	22	7	31	34	4.6	7.0
Selected countries[d]	12	14	5	23	30	4.6	2.6
Others[e]	6	5	4	-	-	-	-
Central America	4	3	3	15	19	4.7	2.2
Caribbean	3	1	3	38	11	3.5	-0.2
Temperate Latin America	9	17	8	9	47	2.3	2.7
Latin America	100	100	7	20	26	4.1	4.1

a/ 1972-1976
b/ 1960-1974
c/ All rates significantly different from zero at $P < 0.01$
d/ Includes: Colombia, Ecuador, Peru, Bolivia, and Paraguay
e/ Rest of Tropical Latin American countries

Source: Annex 1, Tables I.1, I.2, I.3, I.7 and I.8

Table 3. Swine: statistics for selected countries of Latin America. 1970-74 a/

Region and country	Stock	Slaughter volume	Output per capita	Pork as percentage of total meat production b/	Output per head in stock	Growth rate c/ of Demand	Growth rate c/ of Production
	--- percentage ---		kg	percentage	kg/head/year	--- percentage ---	
Selected countries d/	12.0	14.0	5	23	30	4.6	2.6*** e/
Bolivia	1.5	1.1	4	18	19	4.5	2.0***
Colombia	3.3	5.1	4	17	40	4.3	3.1***
Ecuador	3.1	2.1	6	37	18	6.7	4.6***
Paraguay	1.1	2.6	19	34	63	3.6	2.4*
Perú	2.8	2.7	3	30	25	4.5	1.0**
Guatemala	1.3	0.6	2	12	11	4.6	1.0
Latin America	100.0	100.0	7	20	26	4.1	4.1***

a/ Source: Annex I, Tables I.1, I.2, I.3, I.7, and I.8

b/ 1972-1976

c/ 1960-1974

d/ Includes: Bolivia, Colombia, Ecuador, Paraguay and Peru only

e/ *(P< 0.1) ; **(P< 0.05) ; ***(P< 0.01)

Table 4. Most relevant characteristics of the swine production systems in the countries surveyed.

System a/	Integration with farm or other activities	Integration with the market			Regions where found (examples)
		Purchased inputs	Sale of products	Family consumption	
1. Commercial	+	++++	++++	o	Valle, Antioquia (Colombia) Guayas (Ecuador)
2. Semi-integrated	+++	++	+++	+	Santa Cruz, northern and eastern regions (Bolivia) Guayas, Los Ríos (Ecuador) Risaralda, Quindío and Valle (Colombia)
3. Intermediate integrated	++++	+	++	++	Eastern Region (Paraguay) Chuquisaca (Bolivia) Andean Region (Ecuador)
4. Small integrated	++++	o	++++	o	Northern Coast and southern region (Colombia) Andean Region (Ecuador) Northern Region (Guatemala)
		o	++	++	Mennonites (Bolivia)

a/ Integration is defined as the interrelationship with the rest of the farm system.

Table 5. Total stock of swine and cattle on farms surveyed, by country and herd size a/

Country	Breeding farms (number of sows) 1-4	5-19	20-49	>50	Fattening farms (number of pigs) 1-5	6-9	10-49	>50	Total
	No. of head								
Bolivia:									
-swine	612	4475	2405	99	4	27	252	337	8211
-cattle	1199	3639	3172	0	15	60	398	682	9165
Colombia:									
-swine	2553	2672	4016	17132	516	391	691	17022	44993
-cattle	1245	513	285	463	343	250	379	1572	5050
Ecuador:									
-swine	2152	2462	1196	4596	142	280	234	388	11450
-cattle	3602	3326	532	0	197	220	64	0	7941
Guatemala:									
-swine	477	18	126	10917	45	15	0	0	11598
-cattle	108	7	0	70	6	0	0	0	191
Paraguay:									
-swine	2065	3001	232	668	12	0	55	90	6123
-cattle	1631	4817	12	0	29	0	0	4	6493
Total									
-swine	7859	12628	7975	33412	719	713	1232	17837	82375
-cattle	7785	12302	4001	533	590	530	841	2258	28840

a/ Source: Swine Production Survey, CIAT-1979.

Table 6. Number of swine per head of cattle in stock, by country and herd size.

Country	Breeding farms (number of sows)				Fattening farms (number of pigs)				Total average
	1-4	5-19	20-49	>50	1-5	6-9	10-49	>50	
	swine/cattle								
Bolivia	0.5	1.2	0.8	-	0.3	0.4	0.6	0.5	0.9
Colombia	2.1	5.2	14.1	37.0	1.5	1.6	1.8	10.8	8.9
Ecuador	0.6	0.7	2.3	-	0.7	1.3	3.7	-	1.4
Guatemala	4.4	2.6	-	156.0	7.5	-	-	-	60.7
Paraguay	1.3	0.6	19.3	-	0.4	-	-	22.5	0.9

Source: Table 5

Table 7. Bolivia: calories and protein supplied per animal unit (AU), averages by region and by herd size. a/

Region and strata		n	Mcal/AU	g prot/AU	g prot/Mcal
Region:					
1. Chuquisaca		40	6.0	165	27.4
2. Santa Cruz Norte		25	7.6	257	33.7
3. Santa Cruz Oeste		25	7.1	218	30.6
4. Santa Cruz Sur		50	10.1	286	28.4
Size:					
Breeding farms -	No. sows				
1.	1-4	32	11.2	313	28.1
2.	4-19	75	7.9	235	29.6
3.	20-49	15	5.4	153	28.4
4.	>50	1	8.1	292	36.3

a/ Source: Swine Production Survey, CIAT-1979.

Table 8. Colombia: calories and protein supplied per animal unit (AU), averages by region and by herd size. a/

Region and strata		n	Mcal/AU	g prot/AU	g prot/Mcal
Region:					
1. Antioquia		144	6.7	282	42.0
2. Caldas + Risaralda		73	6.3	264	41.5
4. Cauca		96	8.1	295	36.3
5. Córdoba + Sucre		163	6.7	253	37.9
6. Nariño		141	7.8	334	42.6
7. Valle del Cauca		127	8.5	375	44.2
Size:					
Breeding farms - No. sows					
1.	1-4	300	7.7	285	37.0
2.	5-19	40	8.9	360	40.2
3.	20-49	18	10.1	412	41.0
4.	> 50	26	7.9	355	44.7
Fattening farms - No. pigs					
5.	1-5	255	7.1	279	39.6
6.	6-9	44	7.9	31	40.0
7.	10-49	23	7.8	322	41.6
8	> 50	38	6.6	275	42.0

a/ Source: Swine Production Survey, CIAT-1979.

Table 9. Ecuador: calories and protein supplied per animal unit (AU), averages by region and by herd size. a/

Region and strata		n	Mcal/AU	g prot/AU	g prot/Mcal
Region:					
1. Chimborazo		26	-	-	-
2. El Oro		39	6.2	136	21.8
3. Esmeraldas		28	10.3	233	22.6
4. Guayas		25	5.8	274	47.5
5. Loja		43	4.3	125	29.1
6. Los Ríos		22	8.3	375	45.2
7. Manabí		42	8.0	210	26.2
8. Pichincha 1		49	3.9	156	39.6
9. Pichincha 2		34	13.2	471	35.7
Size:					
Breeding farms - No. sows					
1.	1-4	185	5.9	173	29.2
2.	5-19	52	6.3	259	41.3
3.	20-49	10	7.4	288	39.1
4.	> 50	6	6.5	238	36.8
Fattening farms - No. pigs					
5.	1-5	25	9.9	256	26.0
6.	6-9	22	4.9	126	25.7
7.	10-49	5	5.0	136	26.9
8.	> 50	3	5.2	121	23.0

a/ Source: Swine Production Survey, CIAT-1979.

Table 10. Guatemala: calories and protein supplied per animal unit (AU), averages by herd size. a/

Strata		n	Mcal/AU	g prot/AU	g prot/Mcal
Size:					
Breeding farms - No. sows					
1.	1-4	90	4.4	123	28.0
2.	4-19	1	3.8	94	25.0
3.	20-49	1	5.8	246	42.4
4.	>50	3	6.4	289	45.0
Fattening farms - No. pigs					
5.	1-5	22	4.6	149	32.6
6.	6-9	2	7.0	182	26.0
7.	10-49	-	-	-	-
8.	>50	-	-	-	-

a/ Source: Swine Production Survey, CIAT-1979.

Table 11. Paraguay: calories and protein supplied per animal unit (AU), averages by region and by herd size. a/

Region and strata		n	Mcal/AU	g prot/AU	g prot/Mcal
Region:					
1. Alto Paraná		66	10.4	359	34.4
2. Central		144	5.4	157	29.2
3. Concepción-San Pedro		61	8.0	219	27.2
Size:					
Breeding farms - No. sows					
1.	1-4	175	5.2	128	24.6
2.	5-19	86	8.6	247	28.7
3.	20-49	1	9.3	406	43.7
4.	> 50	1	16.5	687	41.8
Fattening farms - No. pigs					
5.	1-9 b/	5	4.1	86	21.0
7.	10-49	2	6.0	219	36.8
8.	> 50	1	5.7	220	38.8

a/ Source: Swine Production Survey, CIAT-1979.

b/ Stratum 5 is equivalent to strata 5 + 6 (1 to 9 growing and fattening pigs).

Table 12. Paraguay: estimated values of selected parameters on small farms, traditional and improved systems.

Parameter	Fattening (No. of pigs) 1-9	Breeding (number of sows) 1-4			5-19		
	Traditional	Traditional	Improved	Average[a/]	Traditional	Improved	Average[a/]
Mcal/AU/day	4	5	12	5	8	12	9
g protein/AU/day	86	116	422	128	221	402	247
g protein/Mcal	21	24	34	25	27	34	30
Meat production:							
kg year/Mcal/day	17	10	5	9	8	4	7
kg year/g protein/day	0.8	0.4	0.1	0.4	0.3	0.1	0.2
Piglets:							
Born/litter		6.6	6.9	6.6	6.9	7.4	7.0
Weaned/litter		5.2	5.6	5.2	5.2	6.1	5.3
Litter/sow/year		1.1	1.3	1.1	0.9	1.2	0.9
Weaned/sow/year		5.7	7.1	5.8	4.9	7.2	5.0

a/ Weighted average according to the representativity of the system.

Source: Tables VI.15 and VI.18.

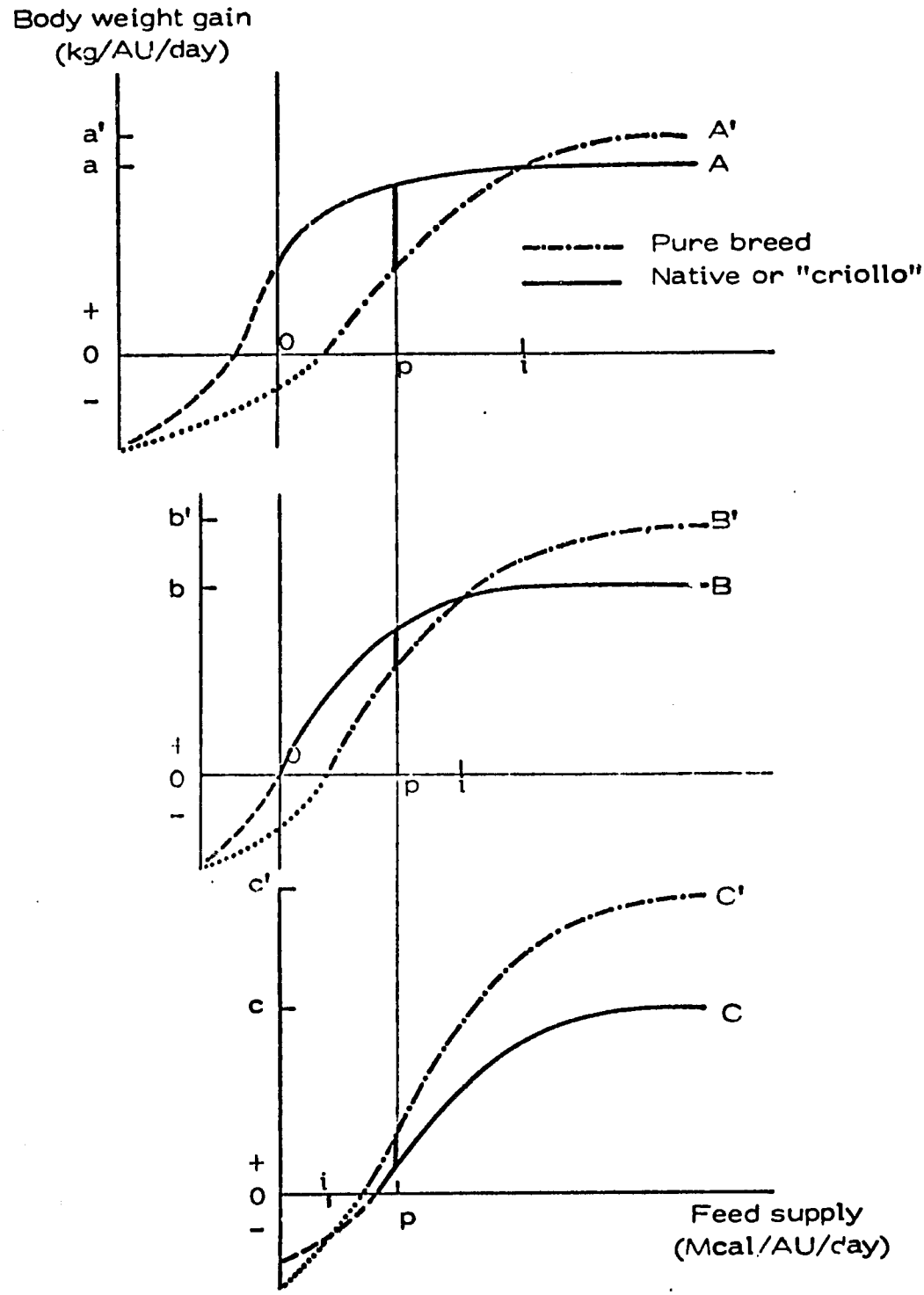

Figure 1. Weight gain curves as a function of feed supply in free (A), semiconfined (B) and confined (C) swine production systems, and possible breed adaptation effects.

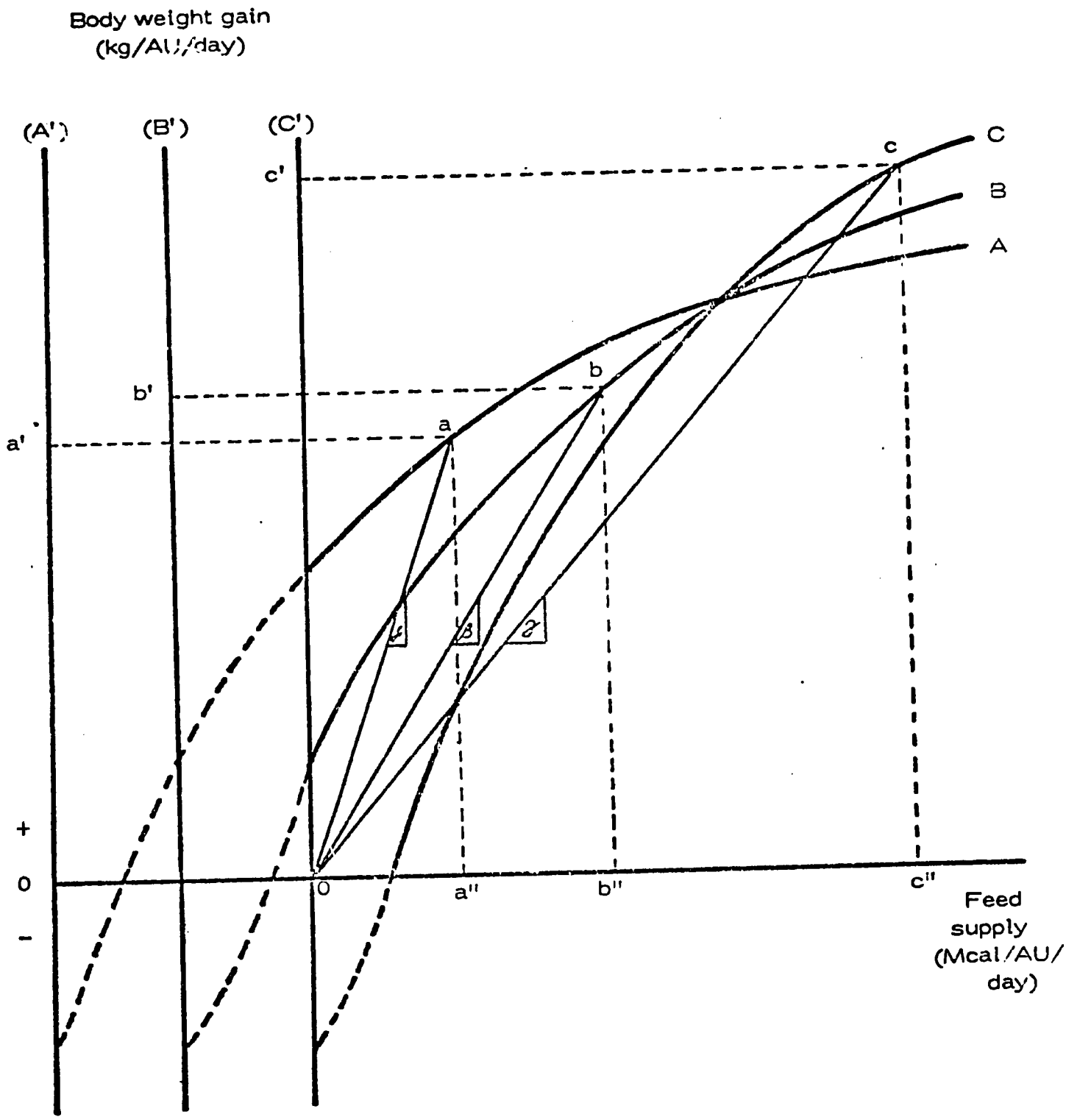

Figure 2. More probable (but hypothetical) curves of body weight gain of pigs, as a function of feed supply in free (A), semiconfined (B) and confined (C) systems.

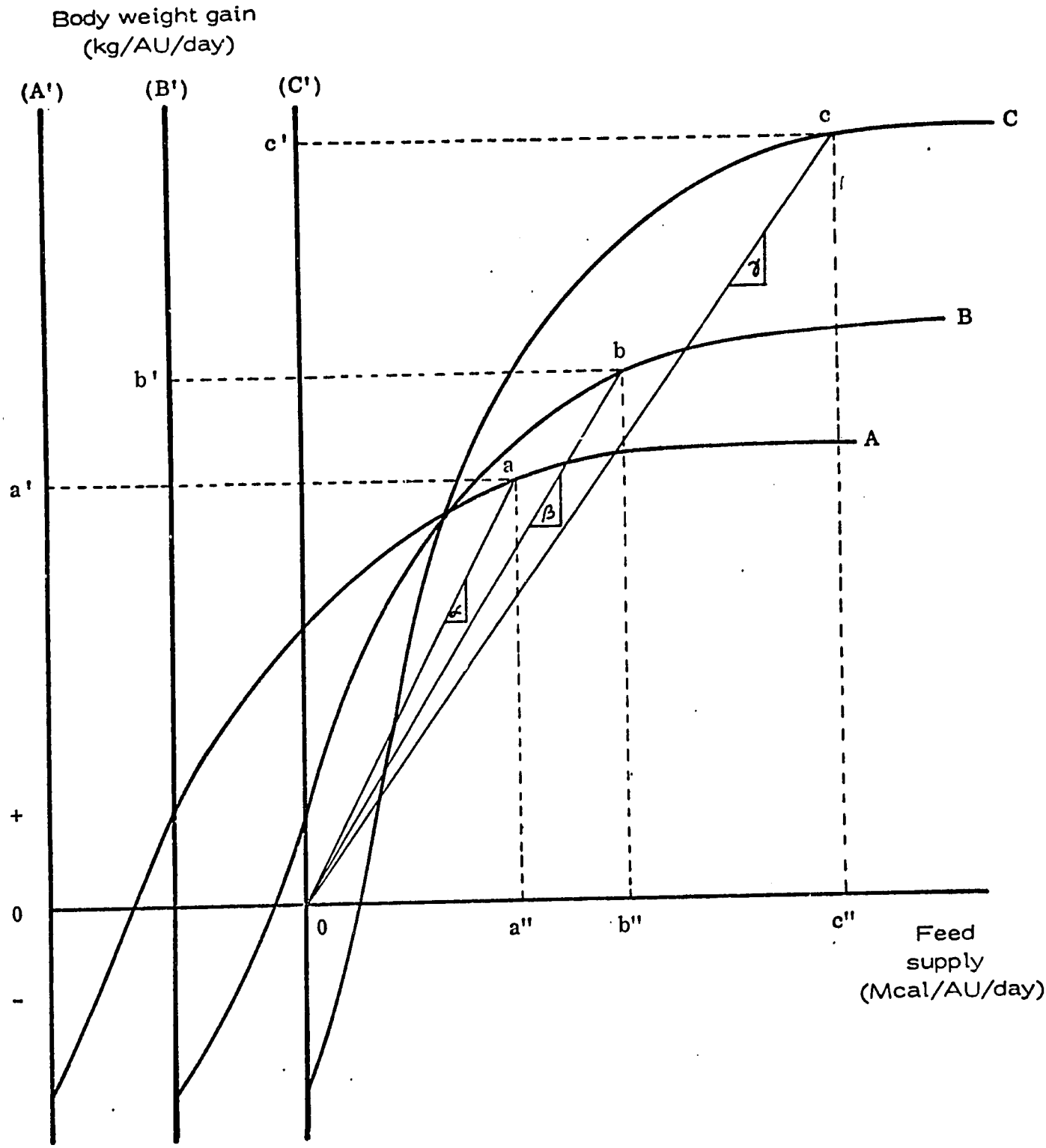

Figure 3. Hypothetical curves of body weight gain of pigs, as a function of feed supply in free (A), semiconfined (B) and confined (C)

8. References

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9. List of contributions

A. Summaries Annexes I-VIII

I. Swine production in Latin America, 1960-1976.
(by L. Rivas and G. A. Nores).

II. Swine production in Colombia.
(by J. Buitrago, C. Trujillo and L.E. Beltrán).

III. Swine production in Ecuador.
(by G. Gómez and F. Alvarado).

IV. Swine production in Bolivia.
(by R. Fiorentino).

V. Swine production in Guatemala.
(by C. Alvarez).

VI. Swine production in Paraguay.
(by M. Regunaga and H. Kugler).

VII. Evaluation of CIAT's swine training activities.
(by C. Trujillo and J. Buitrago).

VIII. Description, codification and availability of the survey system.
(by G. Mendoza, C. Alvarez and D. A. Saldarriaga).