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Agricultural holdings in the 1970 World Census of Agriculture:

a statistical analysis

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FOREWORD

The FAO Statistics Division has published the results of the 1970 World Census of Agriculture, in a standard form, periodically issued as Census Bulletins entitled "Results by Countries". A study of these results was presented in the "1970 World Census of Agriculture - Analysis and International Comparison of the Results", which included data on the main agricultural structures, such as number and area of agricultural holdings, land tenure, land use, characteristics of agricultural holders, and employment in agriculture.

The information presented here gives the results of a statistical analysis of the agricultural holdings' main characteristics (i.e., distribution of the number and area by size, using the lognormal distribution). The results show that the distribution of agricultural holdings can be represented fairly well for most of the countries by the lognormal distribution. Indices of concentration of agricultural land are also included. A practical application of the methods here described involves interpolating national data to match FAO standard size groups; this technique has been used by the FAO Statistics Division in preparing, in a standard form, the national agricultural census results. Accordingly, the results of this study are expected to contribute to the work on socio-economic indicators for monitoring and evaluating agrarian reform and rural development, and to further research work related to the structure of agriculture.

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Director
Statistics Division

1. INTRODUCTION

The purpose of this study is, using an appropriate statistical technique, to analyse the 1970 World Census of Agriculture data on number and area of holdings and to compare the agricultural structures of countries in different continents. Graphic presentation, and the results of applying lognormal distribution to estimations of parameters of the distribution of holdings, are used for this comparison. The methods are described in detail, and derived characteristics (such as median sizes and concentration indices) are presented.

1.1 Sources of information

The data used in this study are national results from countries that took their agricultural censuses during 1966-75, within the framework of the FAO Programme for the 1970 World Census of Agriculture. The census data on the distribution of number and area of holdings by size are used to analyse the structure of agricultural holdings. Generally, data used in this report are those published by the FAO Statistics Division in a series of the Census Bulletin called the "Report on the 1970 World Census of Agriculture: Results by Countries".

Included in this study are countries for which the national census results have been made available to FAO. Countries whose data are incomplete or insufficiently detailed are excluded.

This study covers data for 67 countries. Three of these (Japan, Pakistan and Zaire) did not report data for some sectors of agriculture by size; these sectors were therefore excluded. Only a partial analysis was done for three other countries (Fiji, Ghana and Togo) which did not report data on area classified by size. Countries where collective farming is practised on a large scale (Mexico, Israel, Czechoslovakia, Hungary and Peru) are excluded because mixing the small private holdings with the large collective (cooperative or national) farms creates a highly heterogeneous statistical population.

1.2 Definitions and concepts

The Programme for the 1970 World Census of Agriculture recommends the following definition of a holding: "a holding, for agricultural census purposes, is a techno-economic unit of agricultural production comprising all livestock kept and all land used wholly or partly for agricultural purposes and operated under the management of one person or more, without regard to title, legal form, size or location".

Details of different definitions and concepts used by some of the countries are explained in an FAO publication entitled "Report on the 1970 World Census of Agriculture" (FAO Statistics Series No. 10, Rome, 1977). Here, the fact that definitions of a holding differ widely among countries is stressed. Countries designate the minimum size of holdings to be included in the census enumeration, and these also vary considerably, depending on the importance and intensity of agriculture in the countries. In particular, some countries included holdings without land (e.g., livestock holdings) in their censuses, while others did not. This study's only adjustment for such countries is the exclusion of holdings without land for El Salvador and Panama, as these countries reported an exceptionnally large proportion of such holdings.

Therefore, the distribution of holdings, especially the very small and the very large holdings, may not be comparable among countries. But since the countries' adopted definitions of a holding are their current practices, we consider that the effect of these definitions on the results is not significant; and that the distribution of holdings describes, more

or less, the actual structures of agriculture. Thus, an international comparison of the agricultural structures can be made, with the precaution of ensuring that each structure corresponds to the practices of the related country.

A specific problem affecting international comparability relates to different criteria adopted by countries for classifying data by size. The 1970 FAO Programme recommended that data be classified by total area of holding. While most of the countries did provide data classified by total area, there are important exceptions. In African traditional agriculture, total area usually includes only area under crop, while fallow land, pastures, and wood and forest land are excluded. Data for these African countries are classified by area under crop. Many European countries, while reporting total area of holdings, have classified data by size of agricultural or arable land. This may have particularly affected the calculation of parameters in classification of area by size and the concentration index. Adjustment was made only for Norway, where the problem seemed to be especially notable. For the purpose of this study, agricultural area, instead of total area, was included for Norway, since the agricultural area was used as the criterion for classification by size. Five of the eight European countries which used the classification by agricultural area (Denmark, Greece, Norway, Luxembourg and the Netherlands) reported data on agricultural area, and are included in this study. For seven other countries presenting a similar problem (Austria, Belgium, Finland, France, Federal Republic of Germany, Sweden and Switzerland), total area of holdings was used for calculation, although the criterion for classification for these countries was not the total area. The calculations will probably be more affected for countries with a smaller ratio between the area used as criterion for classification (e.g., arable or agricultural area), and total area. The ratio for these countries is as follows: Finland, 0.18; Sweden, 0.29; Federal Republic of Germany, 0.83; France, 0.85; Austria, 0.90; Belgium, 0.96; and Switzerland, 0.98. (See The Census Bulletins, and Annex 1 and footnotes in this study, for details on the criteria used by countries for classification by size.)

2. DISTRIBUTION OF AGRICULTURAL HOLDINGS AND THEIR AREA BY SIZE

2.1 Results

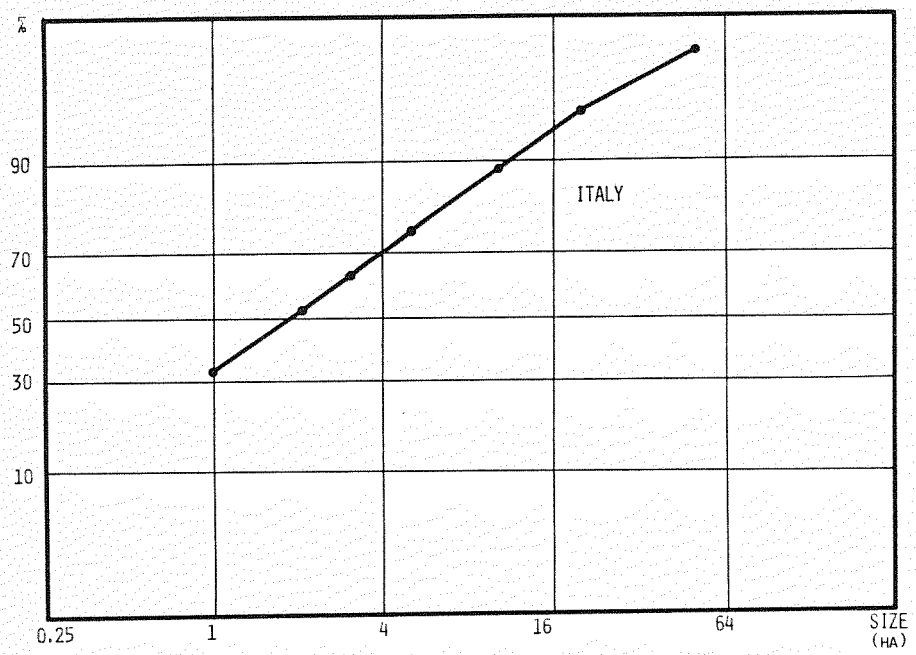
The limited data in Annex 1 are presented by country, and consist of the census year, total number of holdings and total area of holdings. Also presented are derived data on the average and median size for number, median size for area, concentration index, lognormal parameter σ, and ratio of the area under the type of land (criterion) used for classification of data to total area reported.

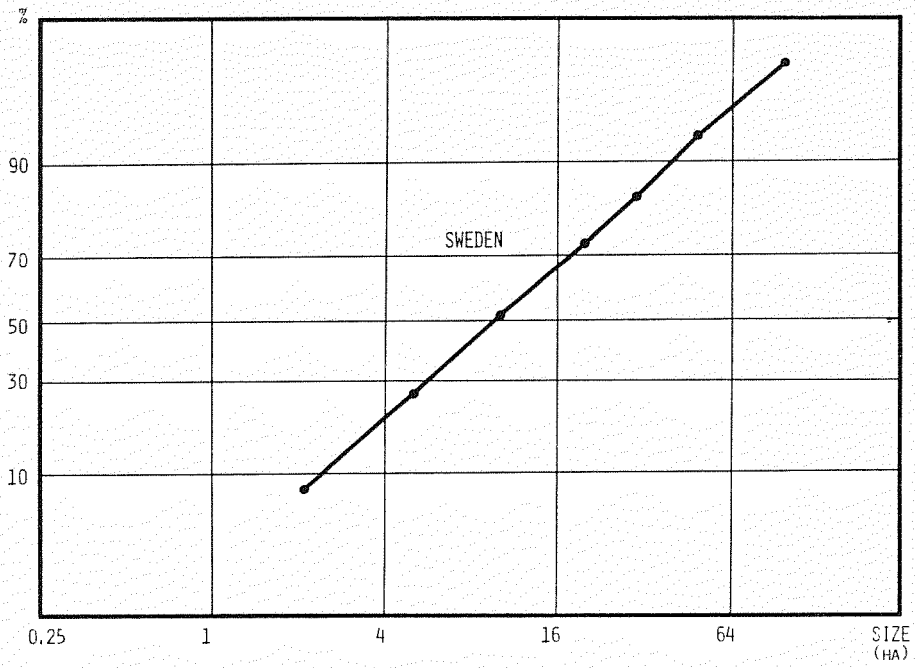
2.2 Use of lognormal scales for presenting results graphically

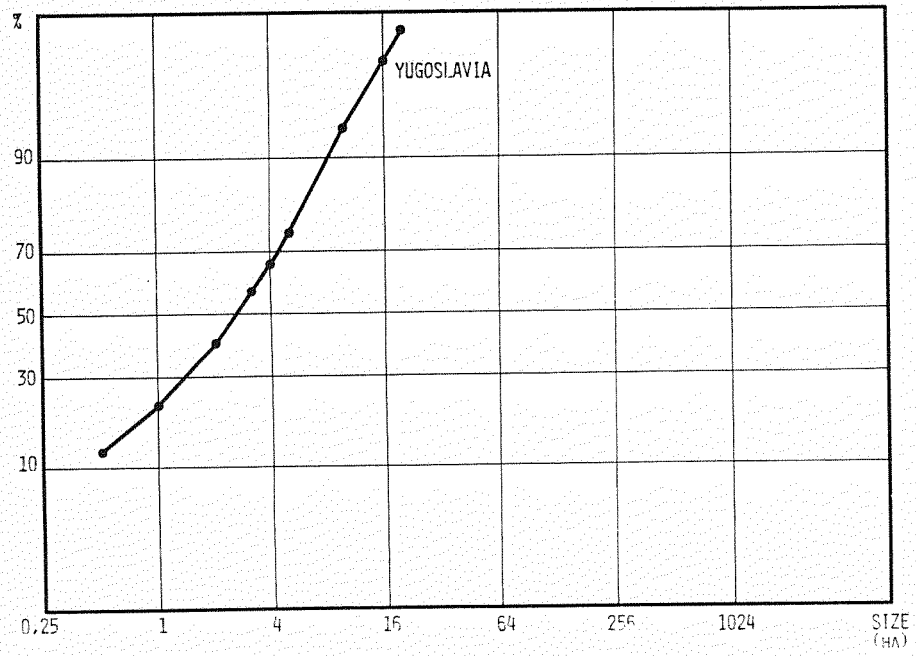
This analysis of the census results consists of presenting, in graphic form, data on the distribution of holdings, on a type of scale allowing easy interpretation of the graphs. The scales considered are lognormal scales, widely used to explain socio-economic phenomena, and fairly simple in application to empirical analysis. This study will be limited to the application of lognormal distribution. (See Annex 2 for a brief definition of lognormal distribution.)

(a) Number of holdings by size

Different points corresponding to the distribution of number of holdings by size are plotted on lognormal scales. The size is measured along the horizontal axis, and the proportion of holdings whose size is less than a given figure is measured on the vertical axis. Plottings are done for all the countries whose data are







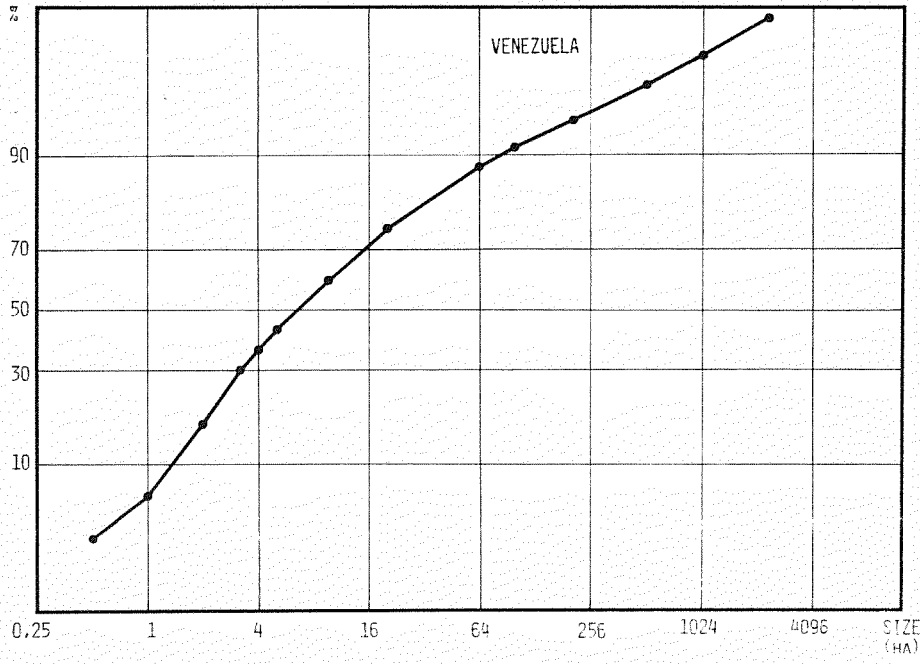
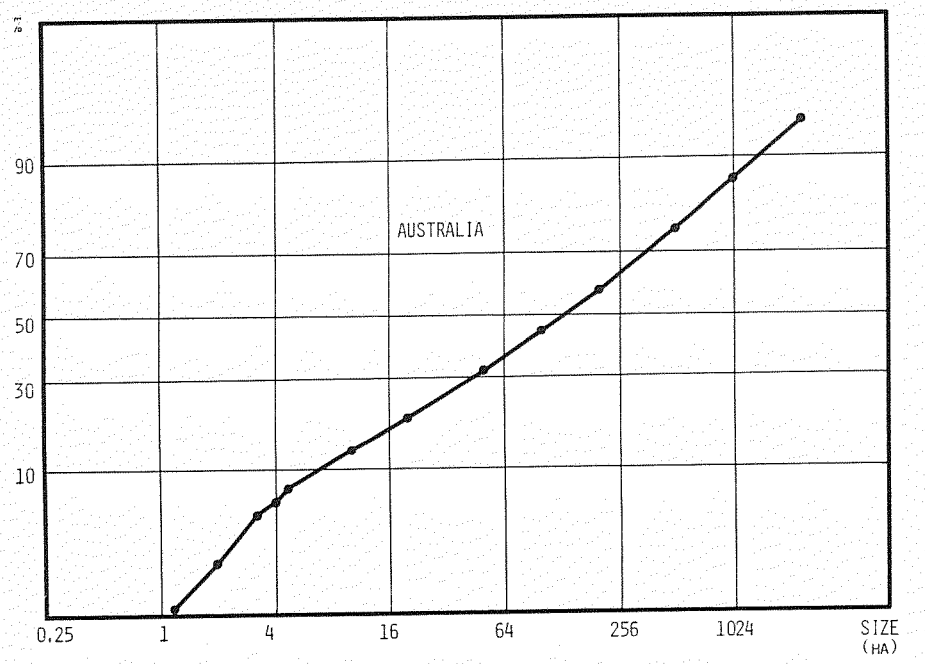
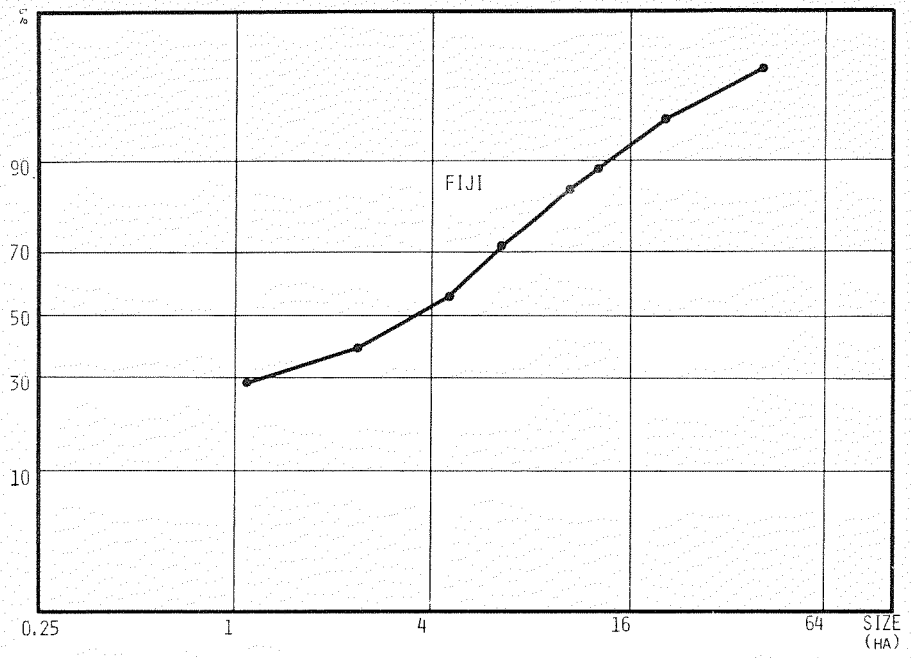
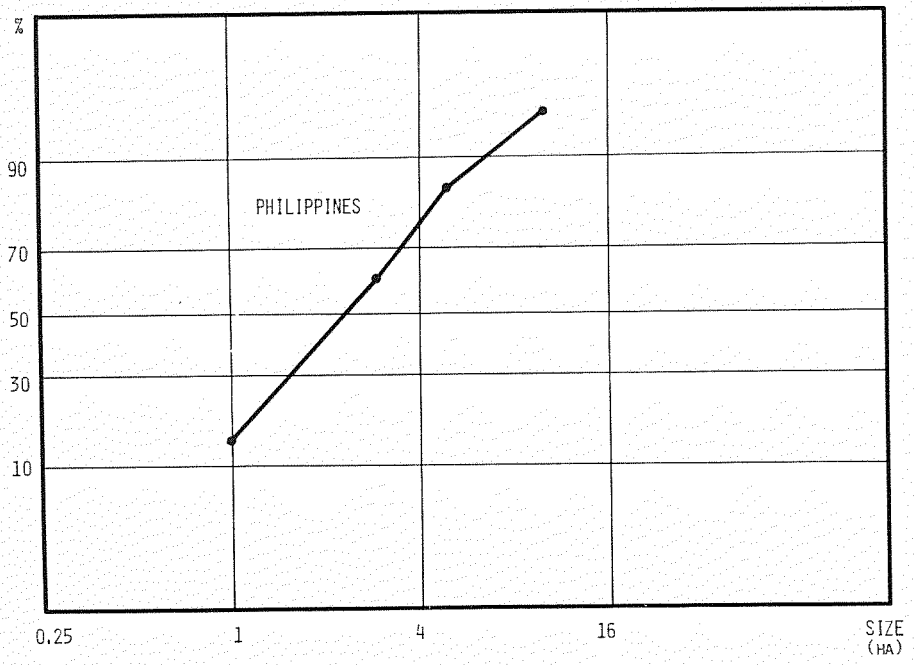


FIG. 1 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER OF HOLDINGS FOR ITALY, SWEDEN, YUGOSLAVIA AND VENEZUELA







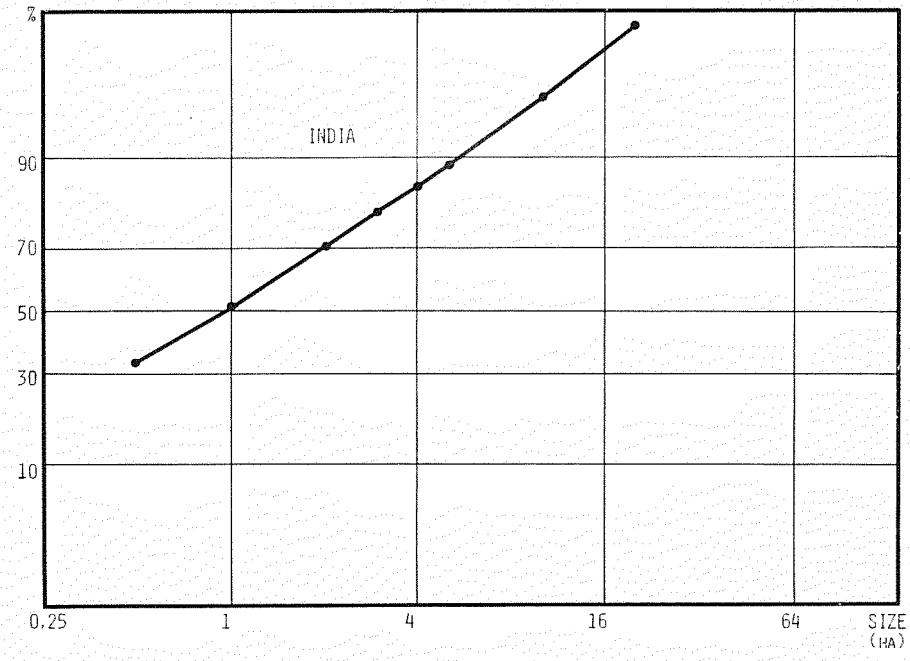
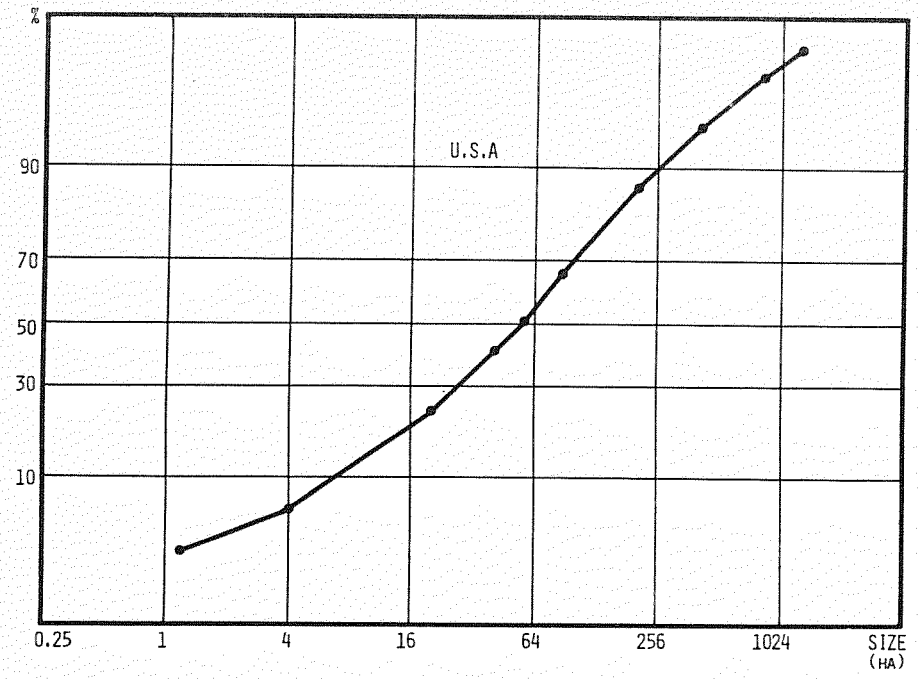
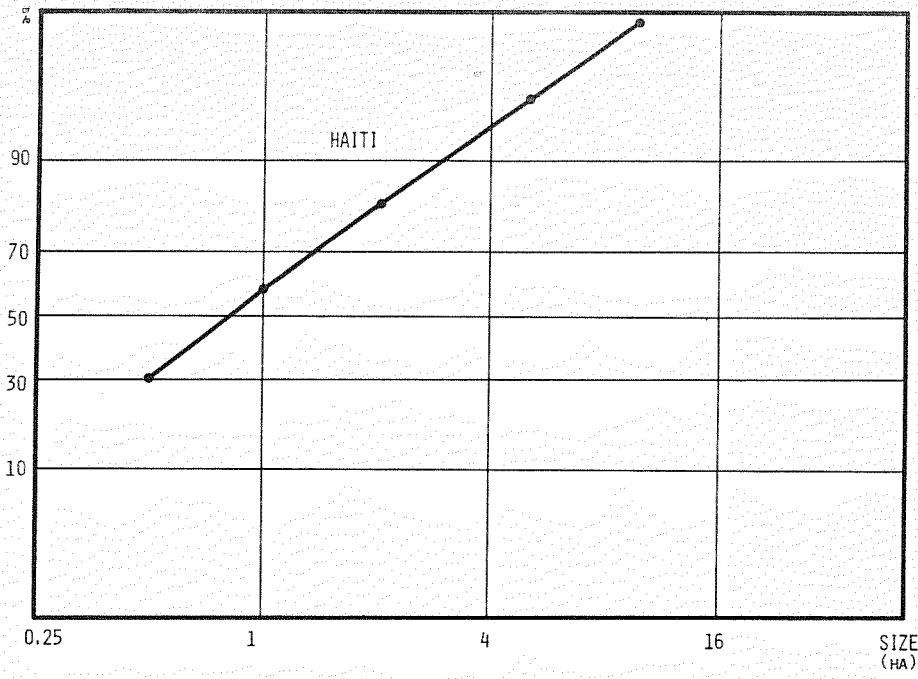
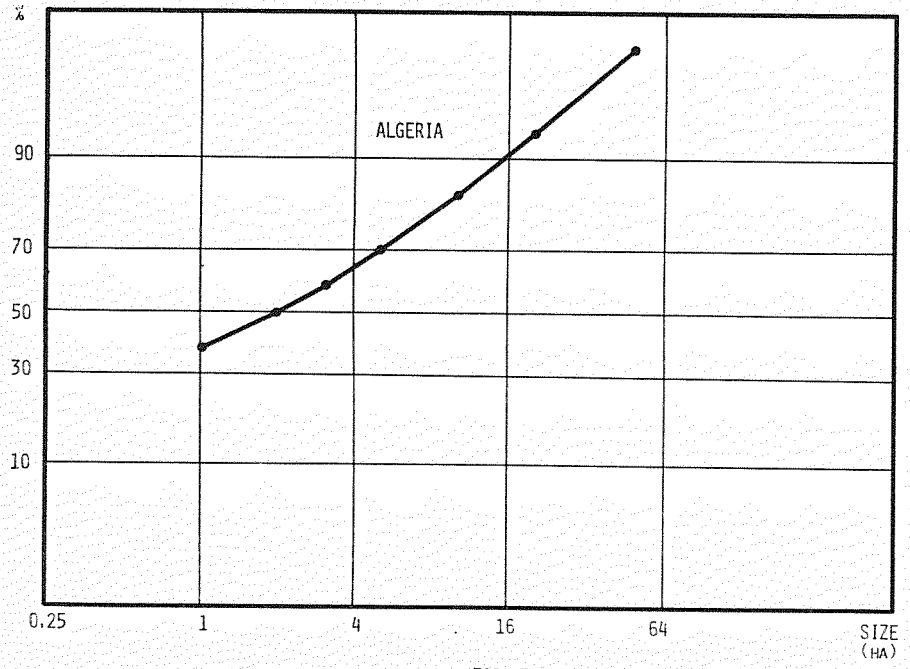


FIG. 2 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER OF HOLDINGS FOR AUSTRALIA, FIJI, PHILIPPINES AND INDIA







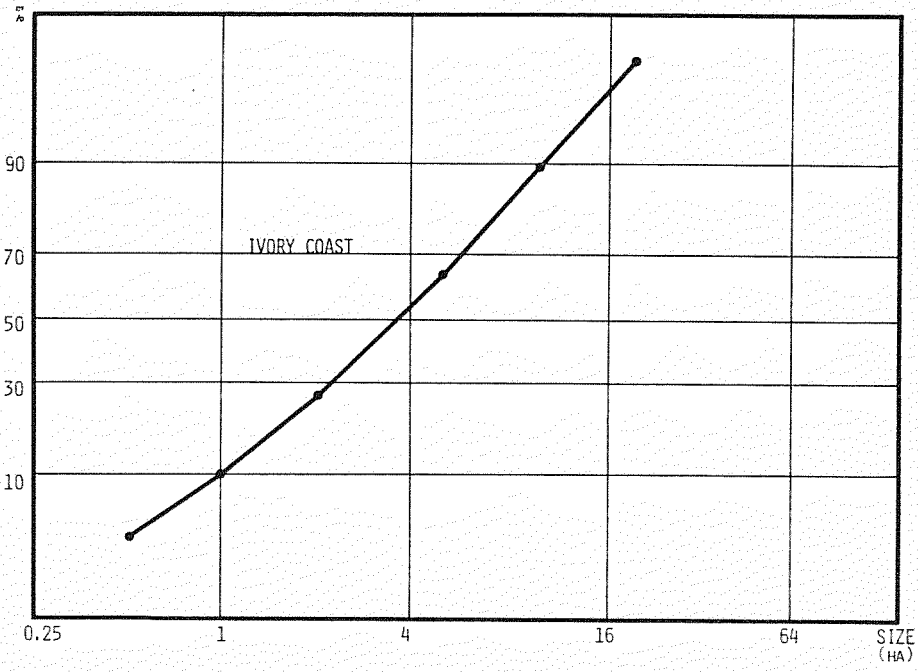


FIG. 3 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER OF HOLDINGS FOR USA, HAITI, ALGERIA AND IVORY COAST

complete. In general, the plotted points related to a country lie on a nearly straight line, a true observation for most of the countries. Therefore, we can consider that the number of holdings by size for one country is well represented by the lognormal distribution. (See Figures 1, 2, and 3, in which graphs for a few countries are given.)

To form a straight line from the points so plotted, an appropriate method can be applied. If the slope of the line for one country is large, a relatively small percentage of holdings are of a smaller size than average for that country. A small slope indicates that a very large percentage of holdings is larger than the average size for that country. Therefore, the degree of concentration of land is large when the slope is small.

Considering together the proportions of number, and total area, of holdings whose size is less than a given size, the usual concentration index can be calculated. The reasoning given above can also be applied to measuring the land concentration, when only the distribution of the number of holdings is known, using the slope of the line.

(b) Area of holdings by size

The same method is used to chart the distribution of area of holdings by size. For all the countries, results are approximately equivalent (i.e., the points for one country are almost on a straight line). In addition, if we plot a country's distribution of number of holdings, and distribution of total area of holdings, on the same axes, the two lines are almost parallel.

With the two slopes nearly the same, the distribution of total area of holdings can be used alone to measure the concentration of area by determining the value of the slope of the distribution. Therefore, one distribution (number or area of holdings) by size suffices to describe the concentration of agricultural area.

There are exceptions in which the graphs for number and area are not parallel, or the lines are not significantly straight. But these are results for countries where agriculture is not an important economic activity; or where the holdings of the traditional sector, and the modern sector or collective farms, are tabulated together in the same classification. These exceptions could also be due to errors made while collecting agricultural census data. M. Fansten stated another possible reason in his study, "Distribution des facteurs de production et comportements individuels dans l'activité agricole" (published in Supplément "Série études" No. 48 of Statistique agricole, Ministère de l'agriculture (France)); he showed that a non-lognormal distribution is a mixture of several lognormal variates with different parameters.

The following figures are a sample of graphs for different countries. Figures 4, 5 and 6 show the distribution of area of holdings for a few countries. Figures 7 and 8 represent the distribution of number and area of holdings for some countries. Figure 9 gives the distribution of holdings for some other countries whose results are inconsistent with the others.

(c) Use of lognormal parameters to compare agricultural structures

If we consider that the distribution of holdings for two countries can be approximated by two lognormal distributions, a comparison of their agricultural structures is reduced to the comparison of the lognormal parameters.

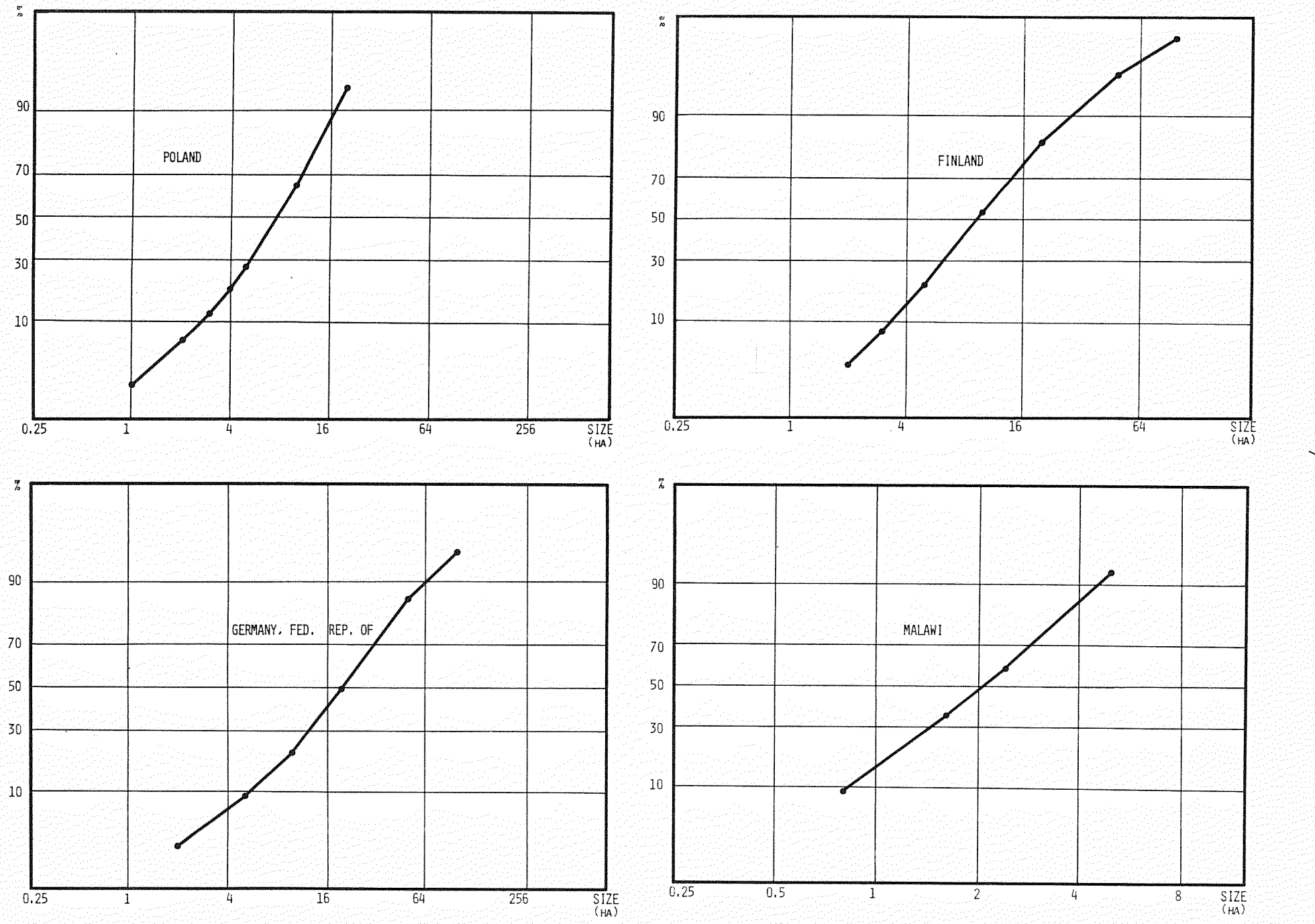
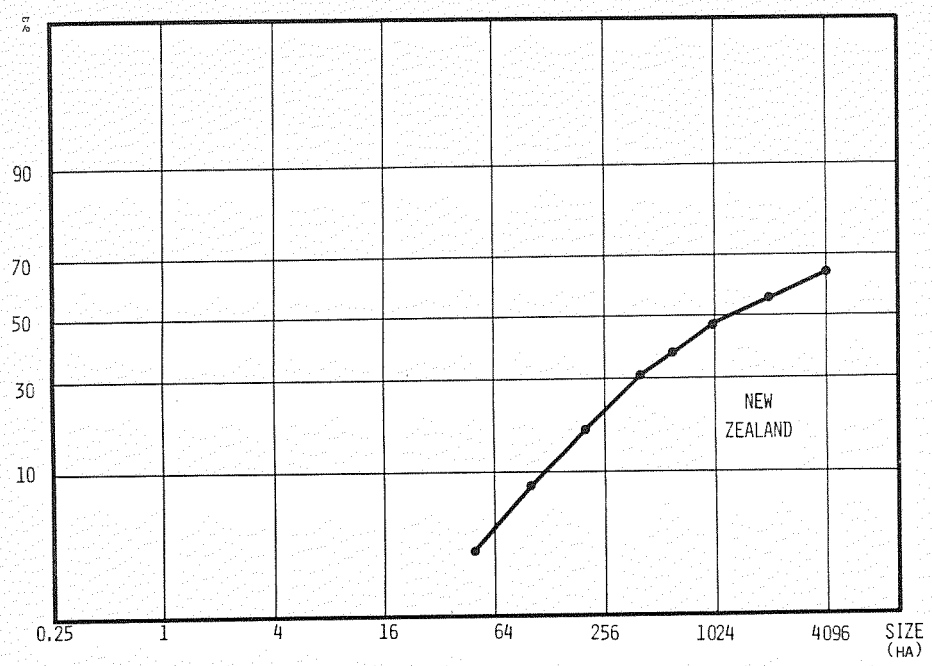
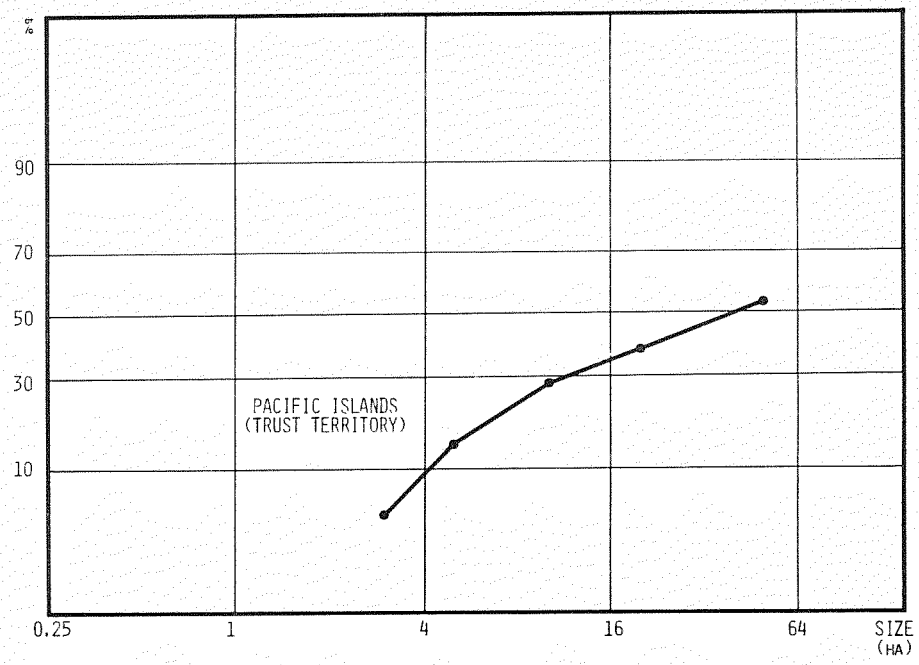
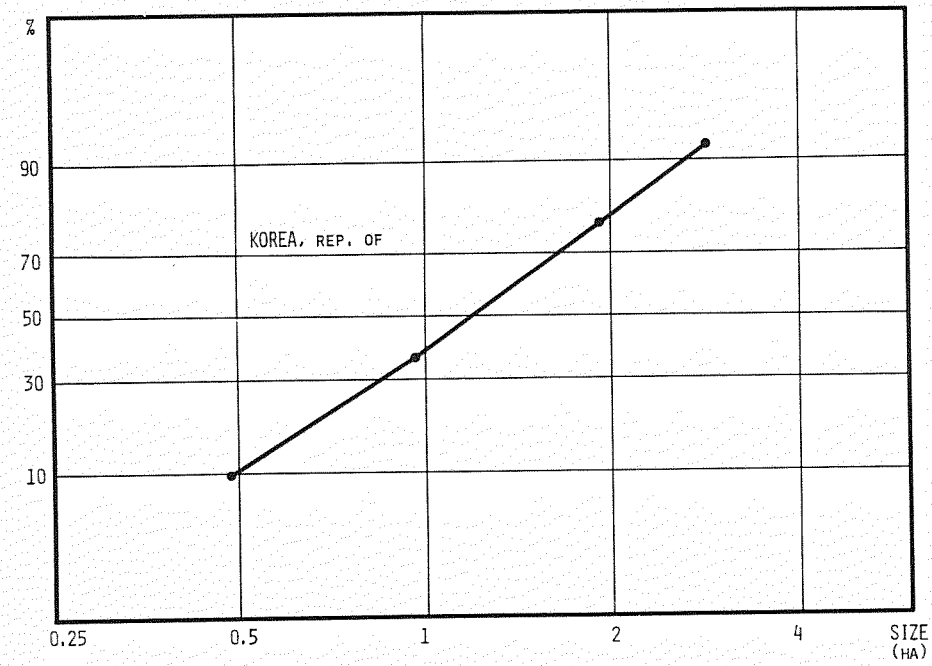


FIG. 4 - CUMULATIVE PERCENTAGE DISTRIBUTION OF AREA OF HOLDINGS FOR POLAND, FINLAND, GERMANY (FED. REP. OF) AND MALAWI







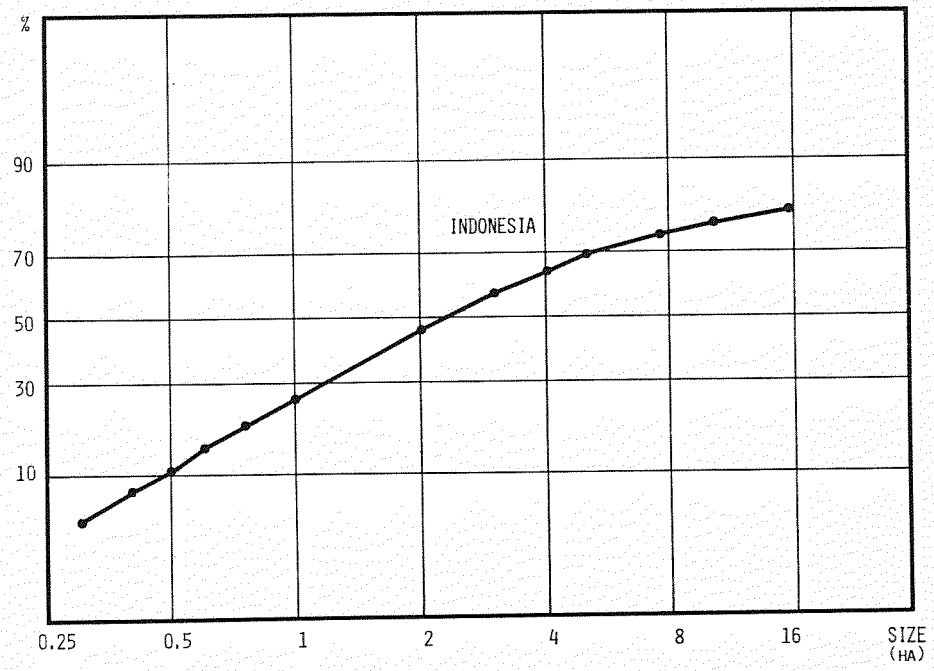
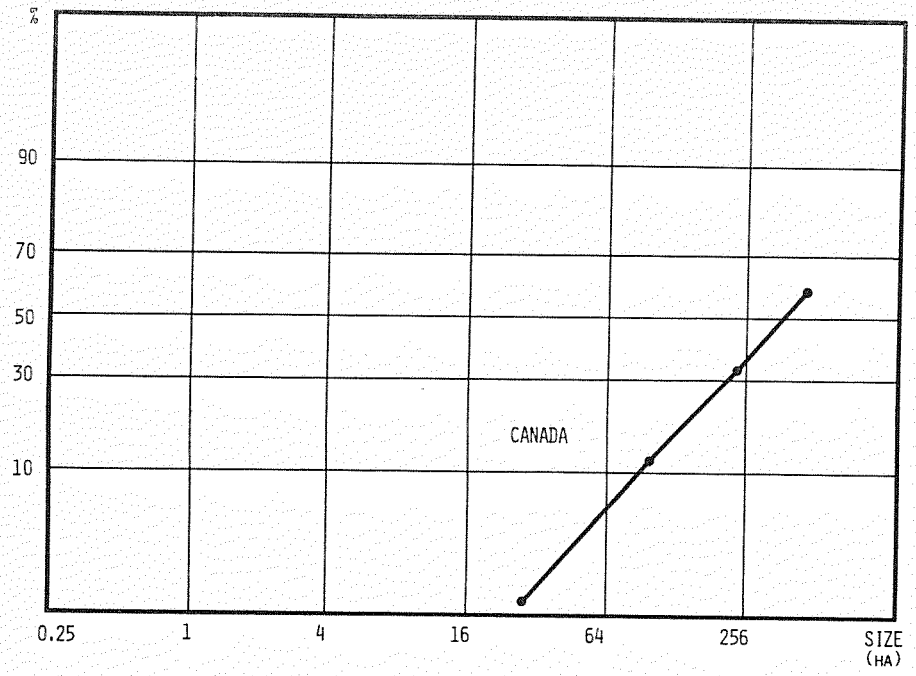
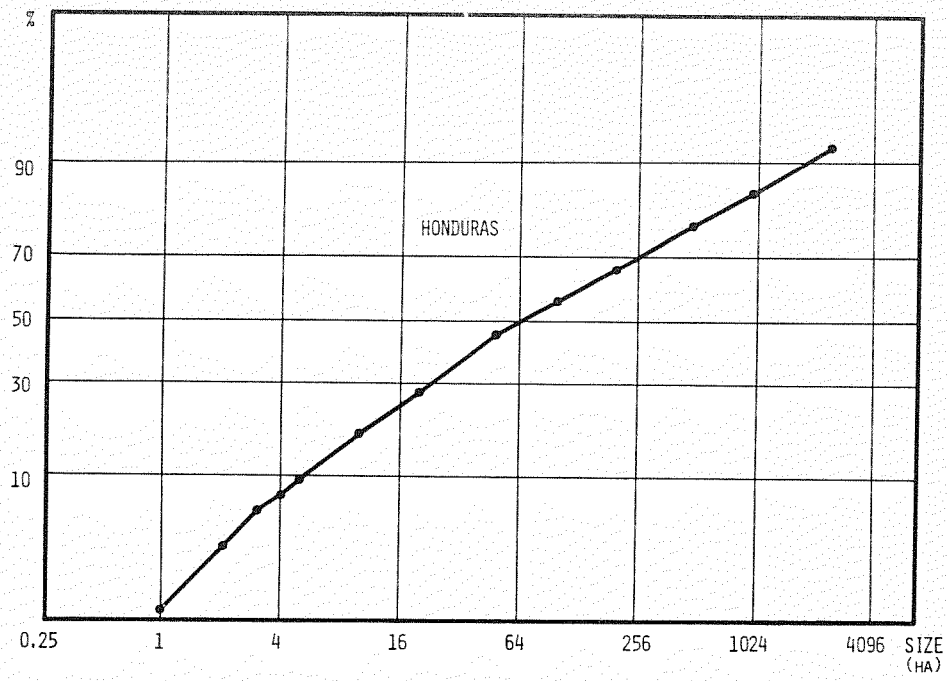
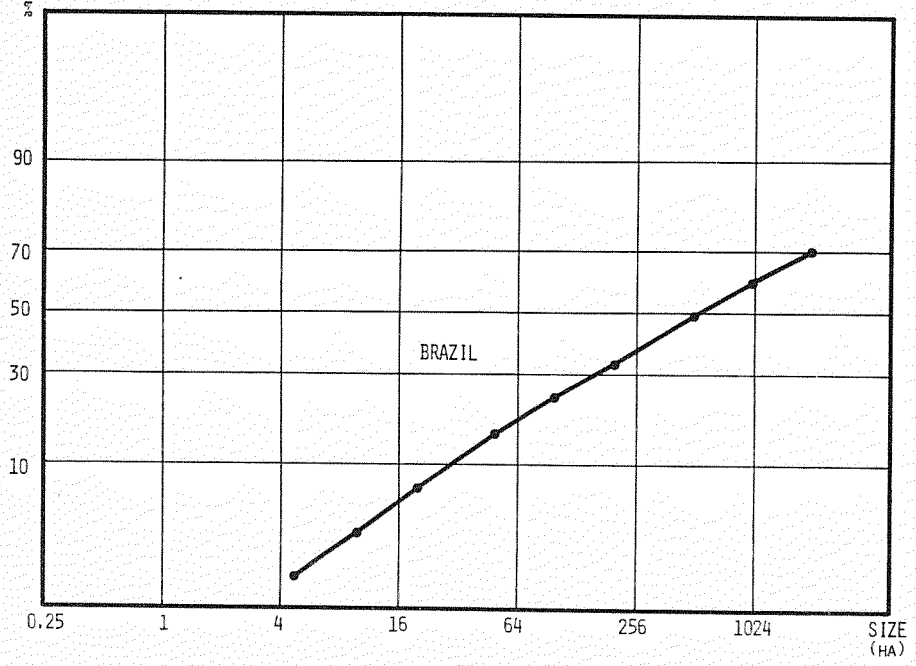


FIG. 5 - CUMULATIVE PERCENTAGE DISTRIBUTION OF AREA OF HOLDINGS FOR NEW ZEALAND, PACIFIC ISLANDS (TRUST TERRITORY), KOREA (REP. OF) AND INDONESIA







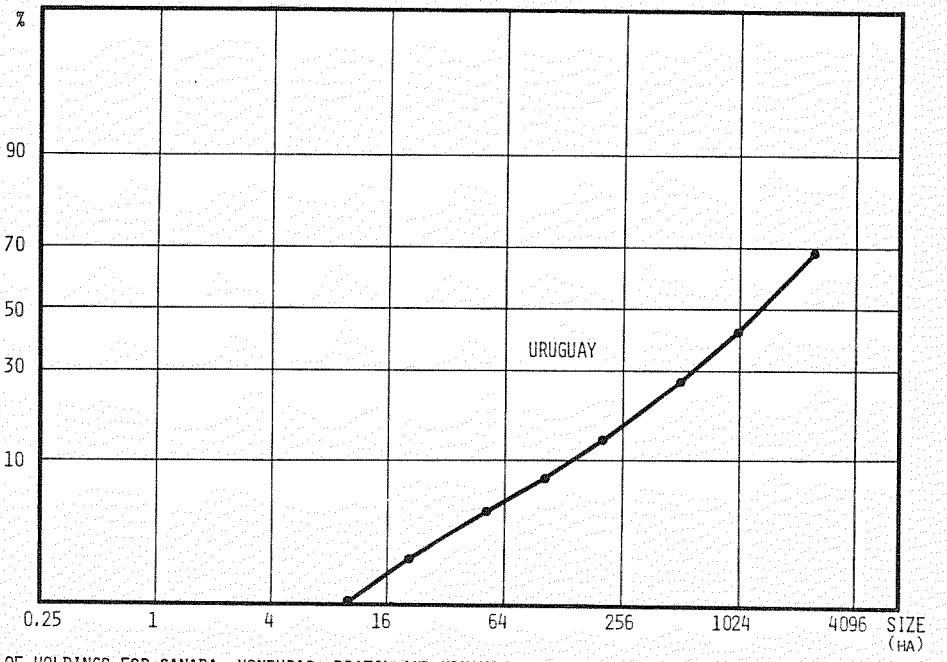


FIG. 6 - CUMULATIVE PERCENTAGE DISTRIBUTION OF AREA OF HOLDINGS FOR CANADA, HONDURAS, BRAZIL AND URUGUAY

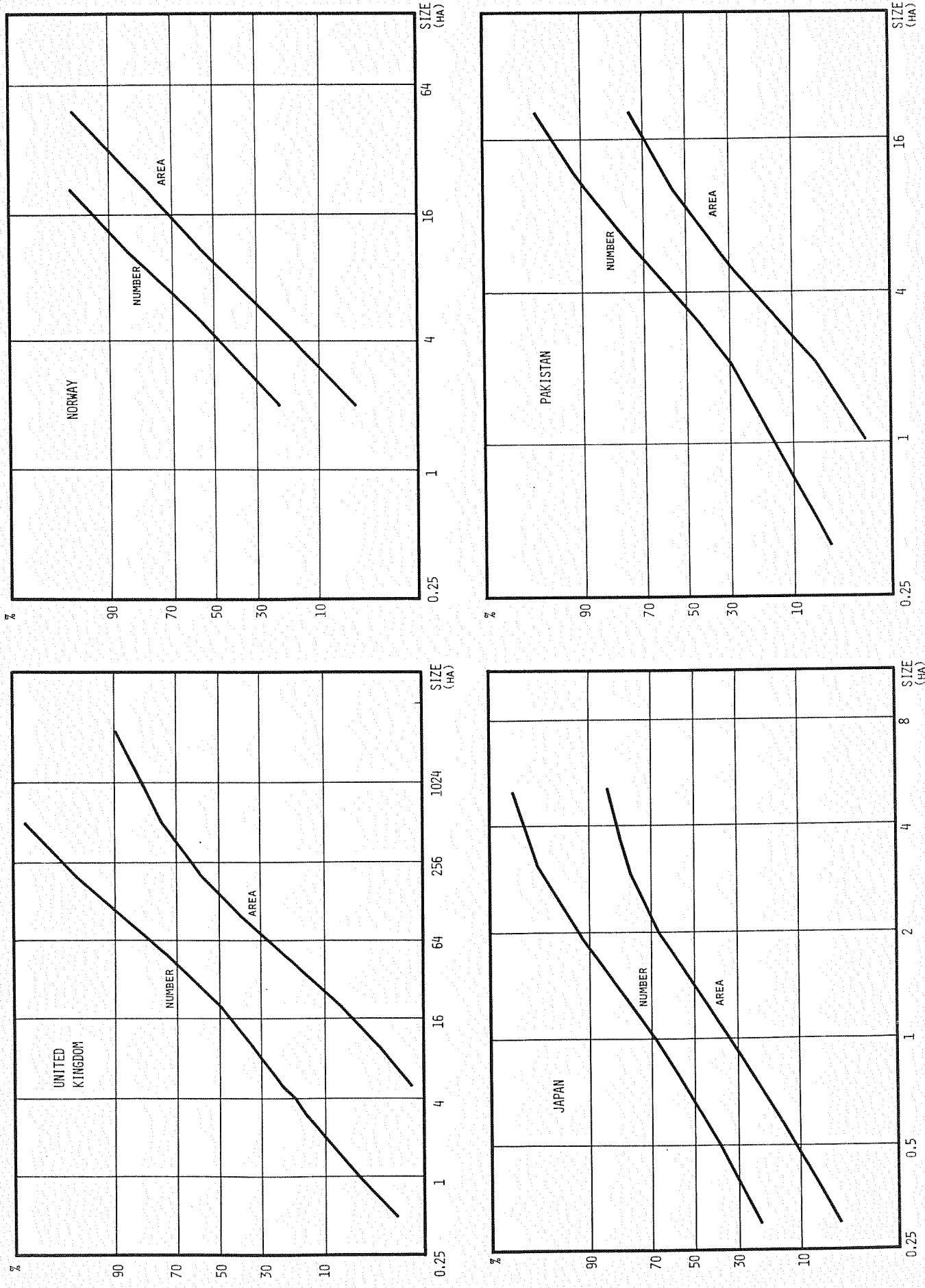


FIG. 7 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR U.K., NORWAY, JAPAN AND PAKISTAN

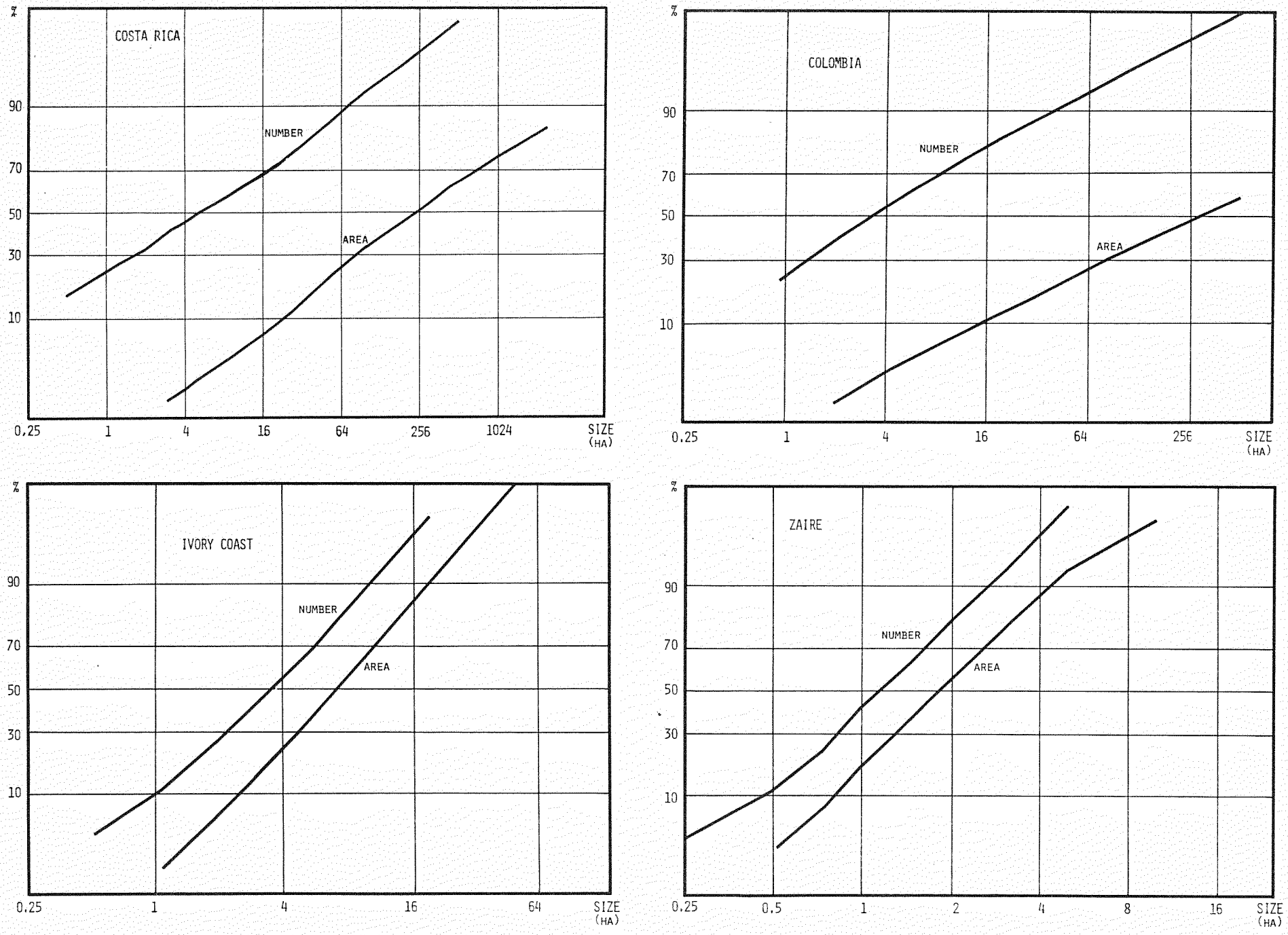


FIG. 8 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR COSTA RICA, COLOMBIA, IVORY COAST AND ZAIRE

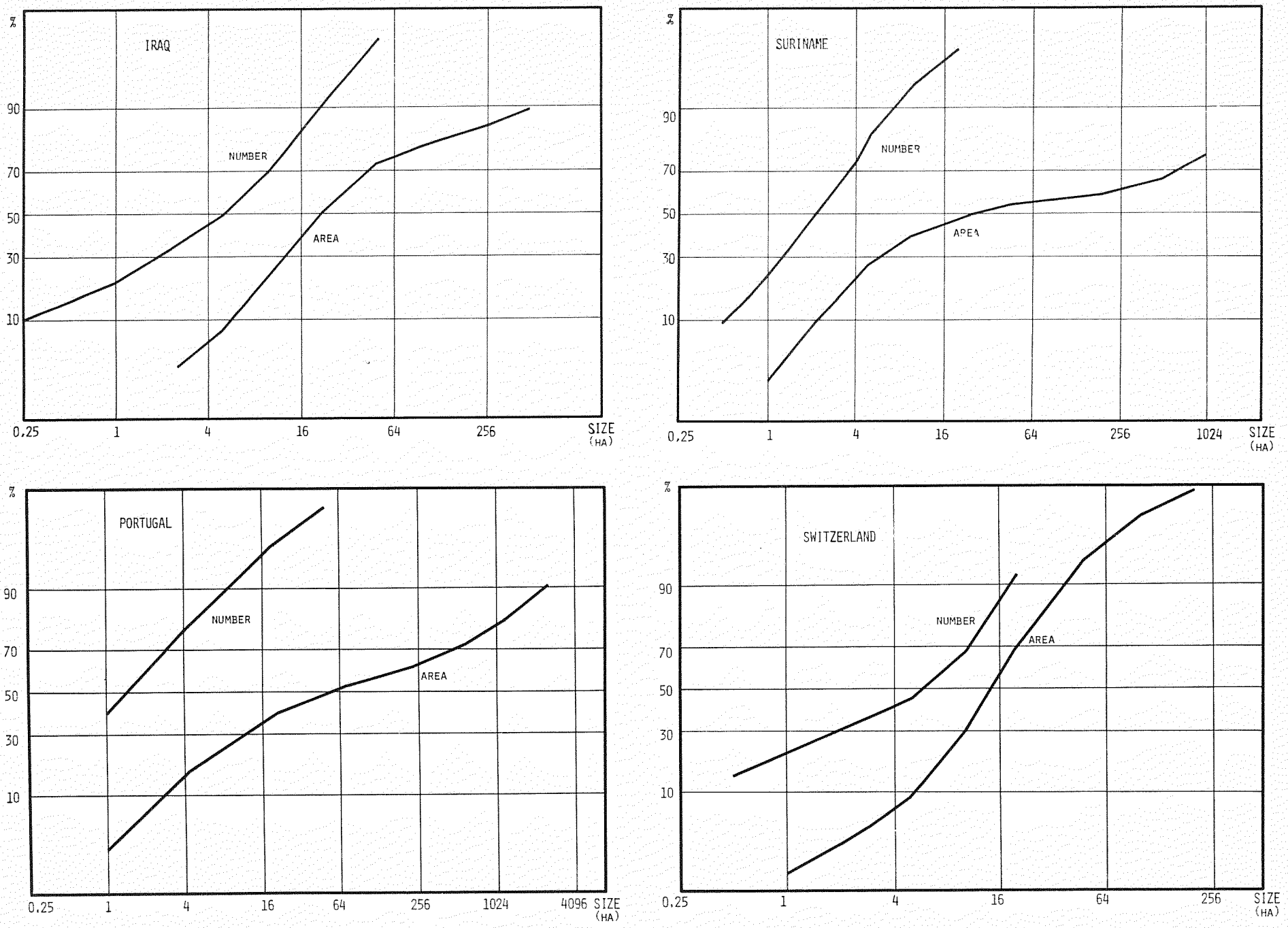


FIG. 9 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR IRAQ, SURINAME, PORTUGAL AND SWITZERLAND

Median is a central parameter, while the standard deviation σ is a shape, or structure, characteristic. When the countries are grouped according to their estimated σ, the central parameters within each group will determine the relative difference in size of holdings among countries.

(d) Graphic comparison

The agricultural structures can also be compared graphically by plotting points for different countries on the same axes. If the lines for two countries are parallel, these countries have identical agricultural structures; and their respective central parameters determine the position of the lines (to the left for a small, and to the right for a large, median size).

For each continent, the countries are grouped according to their structures (i.e., the slopes of the lines). Graphs corresponding to each group are presented separately for the distribution of both number and area, of holdings.

AFRICA

The lognormal hypothesis appears to be satisfactory for the distribution of number of holdings, and of area of holdings, for African countries. For each of these countries, the lines for number and for area appear to be parallel. The continent may be divided into three groups for analysis, as follows:

- Central African Republic, Chad, Lesotho, Malawi and Zaire. These countries have very similar agricultural structures, and a fair distribution of agricultural land. Since the lines are close to each other, the differences between their concentration indices are small; the indices range from 0.36 to 0.39, and their estimated σ are close to 0.70. (See Figure 10.)

- Cameroon, Gabon, Ivory Coast and Sierra Leone. These countries form a homogeneous group. Their concentration indices vary from 0.42 to 0.47, and their σ are approximately 0.90. Togo, for which we have only data on number of holdings, can be added to this group, since its slope is comparable to those for these countries. (See Figure 11.)

- Algeria, Liberia and Reunion. These countries constitute a group with high concentration indices (about 0.70) and σ (about 1.50). Ghana, for which only the distribution of number of holdings is available, can be included in this group because its graph is similar to the others'. The results for area of holdings for Reunion are not satisfactory, but its graphs are roughly parallel to the others. (See Figure 12.)

The first and third groups constitute the two extremes of the equity of the distribution of agricultural area. Apart from the countries entering in the three groups, the Congo (Figure 13) appears to have a better agricultural structure than the rest because it has the lowest concentration index (0.29).

NORTH AND CENTRAL AMERICA

The results for the countries in North and Central America generally appear consistent with the lognormal hypothesis. The graphs for the distribution of area of holdings for Guadeloupe and Jamaica tend to curve in

the part where the sizes exceed 8 hectares. The countries in this continent may be classified into four groups:

- Guadeloupe and Haiti. These countries have the most homogeneous holdings in the region. The discrepancies observed for Guadeloupe affect the calculation of the parameters of its distributions, resulting in an increased concentration index and σ. (See Figure 14 for the graphs for these countries.)

- Canada and U.S.A. These countries are characterized by their large holdings, resulting in large average size and median sizes. Canada seems to have a better distribution of agricultural holdings than the U.S.A.; their concentration indices are 0.56 and 0.72, respectively. (See Figure 14.)

- Costa Rica, Dominican Republic, El Salvador, Honduras, Jamaica, Panama, Puerto Rico and St. Lucia. These eight countries have large holdings operating most of their agricultural area. The ratios between the median size for area and for number of holdings are very large. Their concentration indices range from 0.78 to 0.84. (See Figure 15.)

- Virgin Islands (U.S.A.). This territory has an even higher concentration index (0.88) than the preceding groups. The slopes of the lines given in Figure 16 are very small, revealing a high concentration of agricultural area in a relatively small number of holdings. The estimated σ for this territory is 2.28.

The two extreme groups of countries for the North and Central American Region are clearly contrasted, but each group contains few countries. In general, the countries of this Region have rather high concentration indices and, consequently, high estimated σ.

SOUTH AMERICA

The median sizes for area are much higher than those for number of holdings for all South American countries covered. Relatively few large holdings cover the agricultural area of these countries. All their concentration indices are larger than 0.70, and their estimated σ are more than 1.50, signifying a highly concentrated distribution of agricultural area. Suriname has a better distribution than the other countries classifiable in the same group (Brazil, Colombia, Uruguay and Venezuela). Although the graph for area of holdings for Suriname is far from a straight line, this disturbance is observed for larger holdings only. (See Figure 17 for representation of these countries.)

ASIA

The distribution of holdings of Asian countries is generally close to the lognormal distribution. These countries are classified into three groups:

- Japan, Republic of Korea and the Philippines. These countries have similar distribution of agricultural holdings. The agricultural areas of these countries appear to be distributed with equity among the holdings; the ratios between median sizes for area, and for number of holdings, are fairly small. Their concentration indices are the smallest in this region: 0.37 for the Republic of Korea, 0.47 for Japan and 0.51 for the Philippines. The corresponding estimated σ are 0.69 for the Republic of Korea and 0.90 for Japan and the Philippines. (See Figure 18.)

- Bahrain, India, Indonesia, Iraq and Pakistan (forming a homogeneous group). Interestingly, India, Indonesia and Pakistan, with the largest numbers of holdings, have almost identical structures of

agricultural holdings. Indonesia has the smallest average size and median sizes, indicating fragmentation of the country's agricultural area. The concentration indices of the five countries range from 0.52 to 0.65, and their estimated σ from 0.97 to 1.31. (See Figure 19.)

- Kuwait and Saudi Arabia. Agriculture is not the most important economic sector for these countries. In both, a relatively small number of holdings operate most of the total agricultural area. Their concentration indices are close to 0.80; their σ, to 1.75. (See Figure 20.)

The first two groups of countries provide the main features of the agricultural structures in Asia. The Republic of Korea appears to have the best distribution of agricultural area among the Asian countries, but its average size per holding is also the smallest in Asia.

EUROPE

Some European countries use practices in tabulating data which yield results unsatisfactory for the application of the lognormal law. Examples are the inclusion of state or collective farms in the tabulation of data in Yugoslavia, and the use of arable land in classifying the agricultural holdings by size in Finland and Sweden. The former practice makes the distribution of holdings non-lognormal (i.e. the graphs are not straight lines); whereas the latter impedes interpretation of the results, and makes calculation of some parameters impossible. Nevertheless, the graphic comparison can be made with the help of the estimated parameters whenever their calculation is possible.

We identify two main groups of countries. The first group, shown in Figures 21 and 21 bis, includes the following: Denmark, Greece, Malta, Norway, Poland, Yugoslavia, Belgium, France, Federal Republic of Germany, Luxembourg, Netherlands and Switzerland. Their concentration indices are around 0.50. Denmark has the lowest concentration index (0.43); Belgium, the highest (0.60). The distribution curves for Switzerland and Luxembourg deviate only a little from straight lines. Finland and Sweden, using a different criterion to classify their holdings by size (i.e., arable land instead of agricultural area) can be added to this group.

The second group of countries includes those with high concentration indices and σ: Austria, Italy, Portugal and the United Kingdom. For these countries, the median sizes for area are much higher than those for number of holdings. A relatively small number of holdings in each country control most of the total agricultural area. The concentration indices range from 0.69 to 0.79; the estimated σ, from 1.41 to 1.77. (See Figure 22.)

When the criterion for classification used and the type of area reported are the same, the distribution of agricultural holdings is close to lognormal for most European countries. The available data for Finland and Sweden do not permit the estimation of adequate lognormal parameters of their agricultural structure.

SOUTHWEST PACIFIC (OCEANIA)

The difference in size of holding among countries in the Southwest Pacific renders classification of these countries difficult. The graphic comparison however, suggests two main features of this continent's agricultural structures. American Samoa, Fiji, New Zealand and Pacific Islands (Trust Territory) constitute the first group; the second group consists of Australia and Guam. The latter have similarly structured agricultural holdings, although these are widely disparate in size. No data are available on Fiji's distribution of area of holdings by size; therefore, estimations cannot be made for all of this country's lognormal

parameters. The concentration indices for the first group vary from 0.53 to 0.75; for the second, they are about 0.90. (See Figures 23 and 24.)

3. ESTIMATION OF PARAMETERS OF DISTRIBUTION

When analysing the distribution of holdings, the first and common parameter to be determined is the average size per holding. Another useful parameter is the measure of the concentration of areas (i.e., Lorenz index or concentration index). We have seen that the distribution of holdings is generally close to lognormal; therefore, such distributions are approximately specified by their parameters: mean and variance. Considering the close relationship between the median and the mean, the estimations of the medians and standard deviations σ suffice to describe these distributions.

The methods used in this study to estimate the parameters are described below.

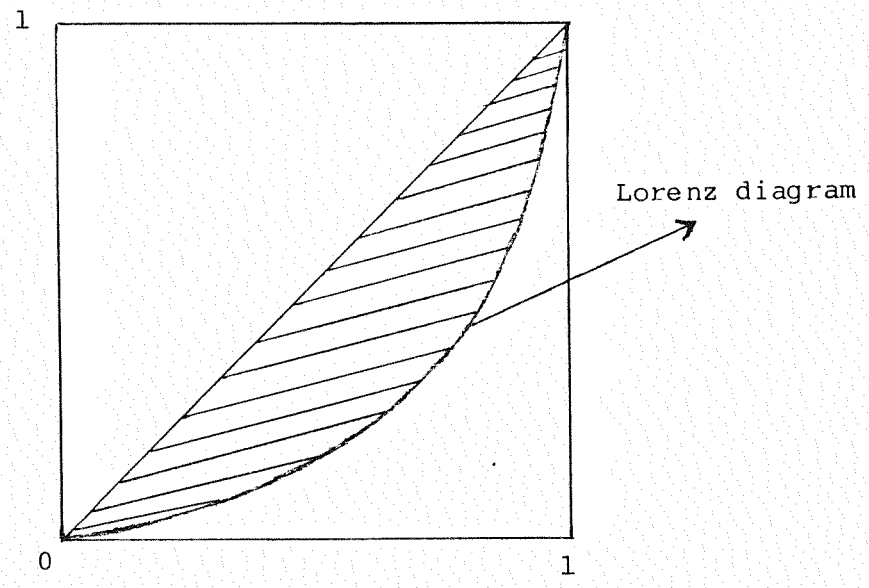
3.1 Average size

Average size is the easiest parameter to estimate, since we know the total number of holdings and the total agricultural area of holdings. The average size is the ratio between the total area of holdings and the total number of holdings.

3.2 Lorenz index or concentration index

The Lorenz, or concentration, index is an important measure of the concentration of agricultural areas. If we plot, on arithmetic scales, the point whose coordinates are the proportion of holdings of size less than s, and the proportion of total area operated by these same holdings, the Lorenz diagram - the curve traced by points plotted for the various values of s - results.

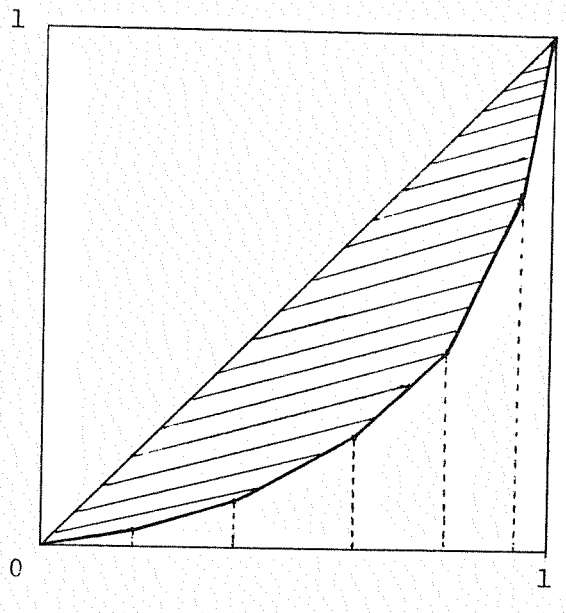
Chart A



In Chart A, the Lorenz index is the ratio of the shaded area delineated by the Lorenz diagram, and the 45^{o} line sloping upwards to the right from the origin to the area of the triangle under the 45^{o} line. Since the area of this triangle is 0.5, the Lorenz index is twice the shaded area. This index varies from zero, when all holdings have the same area, to unity, when the total agricultural area of a country is operated by one holding and a large number of other holdings have zero area.

In practice, data on the distributions of number and area of holdings are available only by class of size, not for the continuous value of size. Therefore, we cannot obtain a proper Lorenz curve, but rather a succession of segments, as shown in Chart B:

Chart B



If the number of classes of sizes is large, the Lorenz curve can be approximated by the broken line. But if the data on the holdings are classified according to few size classes, this approximation is not satisfactory.

In this study, we use such an approximation whenever the number of classes is large enough, which is the case for most countries; for a few others, no estimation is calculated because the data are not sufficiently detailed. To calculate the value of the shaded area in Charts A and B, we first calculate the area under the approximated Lorenz curve by summing up the areas of the trapezia corresponding to the size classes. The Lorenz index L is then estimated as the complement of twice this sum. Empirically, this is obtained by the following formula:

$$L = 1 - \sum_{i=1}^{n} (N_i - N_{i-1})(A_i + A_{i-1})$$

where $N_o = 0$

N_i = proportion of holdings belonging to the first i classes of the holdings

$A_o = 0$

A_i = proportion of area operated by the holdings in the first i classes of the holdings

n = number of classes.

The methods used here for estimating the median and σ are detailed in the following sections.

3.3 Median size

Let $N_1, N_2, \ldots N_n$ be the proportion of holdings of size less than $s_1, s_2, \ldots s_n$, and $A_1, A_2, \ldots A_n$ be the proportion of the total area operated by these holdings, (s_i being the lower limit of the size class i, and n the number of classes). These proportions are plotted on lognormal scales. The median size for the distribution of number of holdings is the size s_m such that the proportion of holdings of size less than s_m is 0.5. Since the distribution of holdings is not known for the continuous values of size of holding, the median size cannot be exactly derived from the data available. Here we consider that the distribution of holdings is lognormal (i.e., between two class limits s_i and s_{i+1} the distribution of holdings is the segment joining the points corresponding to the sizes s_i and s_{i+1}).

Therefore, to derive the median size for the distribution of number of holdings, we must determine first the class j such that $N_j \leq 0.5$ and $N_{j+1} > 0.5$. Then the median size s_m is calculated by interpolation, bearing in mind the facts that the size of holding is measured along the logarithmically graduated horizontal axis and the proportion of holdings along the vertical axis (which is graduated according to the normal distribution). A polynomial function is used to estimate the distribution function of the normal law.

The median size for the distribution of area of holdings, s_{ma}, is determined using the same method of interpolation, applied to the proportions $A_1, A_2, \ldots A_n$.

3.4 Estimation of σ

Here, the relations between the lognormal characteristics are used. On the one hand, we consider the relation between the parameter σ and the concentration index (Lorenz index) L:

$$L = 2\Pi\left(\frac{\sigma}{\sqrt{2}}\right) - 1$$

where Π is the distribution function of the normal law whose parameters are 0 and 1. Since we have estimated the Lorenz index L, σ can be derived from this formula using a proper estimator of the inverse function of Π. In this study, a polynomial function is used for this estimation.

On the other hand, the following relations between the average size $\bar{s}$, the median size for the distribution of number of holdings s_m, and the median size for the distribution of area of holdings s_{ma} are used:

$$\bar{s} = s_m \exp\frac{\sigma^2}{2} = s_{ma} \exp\left(-\frac{\sigma^2}{2}\right).$$

Having estimated $\bar{s}$, s_m and s_{ma}, we can also determine two estimated values of σ, one (σ_1) from the relation $\bar{s} = s_m \exp\frac{\sigma^2}{2}$ and the other (σ_2) from the relation $\bar{s} = s_{ma} \exp\left(-\frac{\sigma^2}{2}\right)$.

Calculations of the three estimated values of σ for all the countries whose data are available show that the first estimation σ_o is generally between the two other σ_1 and σ_2. Considering these indications, the preference is, of course, given to σ_o as an estimate of the parameter σ. This estimator is used here when its value is between σ_1 and σ_2; whenever this is not the case, the nearest value to σ_o of the estimators σ_1 and σ_2 is taken.

Analyses of other possible estimators of σ, such as the maximum likelihood estimator, were omitted from this study because of methodological difficulties involved when handling grouped data, and various limitations in data described earlier.

4. FURTHER USES OF THE STUDY

The preceding pages show that the distribution of a country's holdings can be presented by a fairly simple graph, describing the structure of its agricultural holdings. Such graphs also permit an international comparison of agricultural structures, and a grouping of countries according to the structure of their agricultural holdings. Some results (e.g, that the graphs for the distribution of number and area of holdings are generally parallel) indicate that the lognormal properties can be used to complete some missing data on distribution by size; for example, knowing only the distribution of number of holdings by size and the total agricultural area, we can derive the distribution of area of holdings.

Lognormal properties of the distribution of number and area of holdings by size have been used by the FAO Statistics Division for interpolating data on countries reporting size classes different from those proposed by FAO. These countries generally use units other than hectares for measuring land area. The interpolation was accomplished by using lognormal curves, drawn between each two consecutive points of the cumulative frequency distribution of the original data (the method applied in this study for estimating the median size). The interpolated data have been published in the "Report on the 1960 World Census of Agriculture, Analysis and International Comparison of Census Data", and in the "1970 World Census of Agriculture, Analysis and International Comparison of the Results".

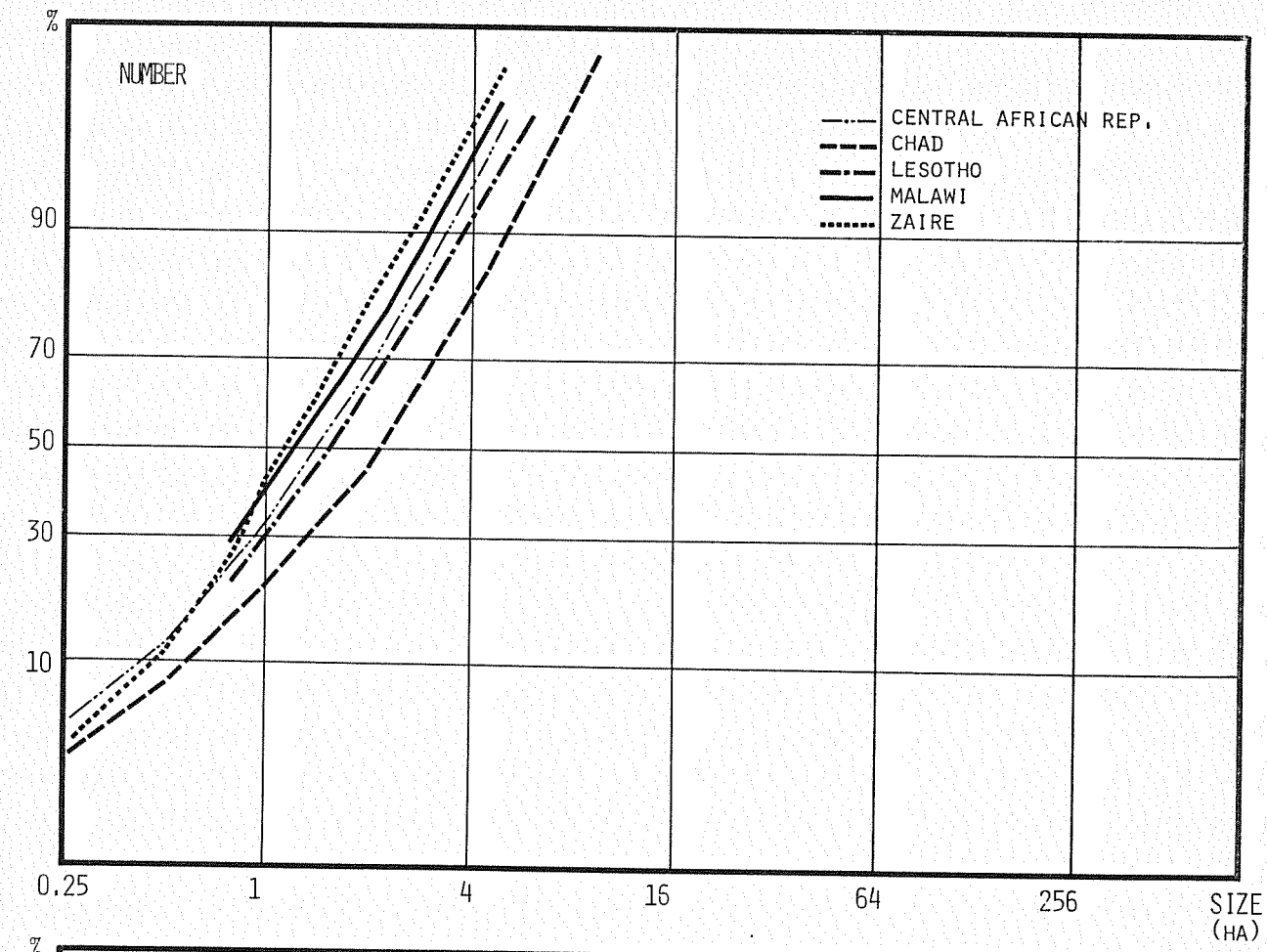
The change over time of the structure of one country's agricultural holdings is generally rather slow, unless a major policy decision for agriculture is made (e.g., an agrarian reform). Therefore, the graphs plotted for one country's distribution of holdings in two different reference periods (e.g., two censuses) are roughly parallel; and the agricultural structure can be projected, using lognormal properties. For example, if a census is not included in a regular programme of censuses (i.e., censuses taken over regular intervals of time), the data on such a missing census can be estimated if at least two censuses have been carried out.

Within a country, the same type of analysis can be undertaken, using the data classified by size at the regional or lower administrative units level. This analysis will reveal differences between the agricultural structures of various administrative units, which will help in formulating agricultural policies or agrarian reform.

We consider the method adopted in this study satisfactory for calculating the median size of the distribution of agricultural holdings, especially when there are many size classes used for the presentation of data; thus, individual countries can use this method in practice. (Significantly, the ratio between the median size for the distribution of area, and that of number of holdings, provides a measure of the agricultural area's concentration).

The results obtained for a few countries show that when analysing the agricultural census results, the traditional sector (farms) must be separated from the modern sector (collective farms). Criteria for classifying the data must also be standardized.

The scope of this study is admittedly limited; but it clearly contributed to a better understanding of world agricultural structures. It is hoped that these results will help promote further research, at national or international levels, for improving the formulation, implementation or monitoring of agrarian reform and rural development programmes.



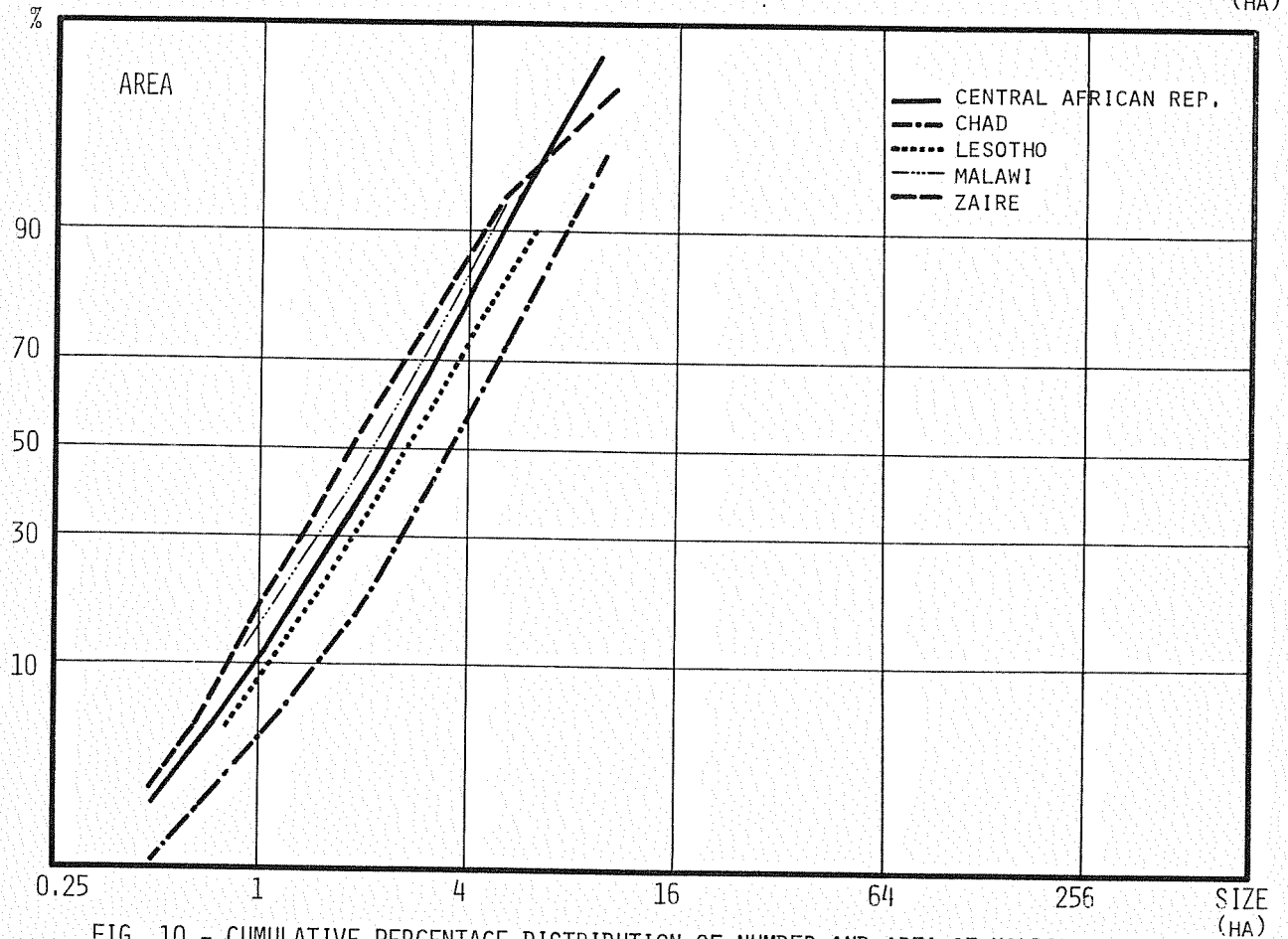
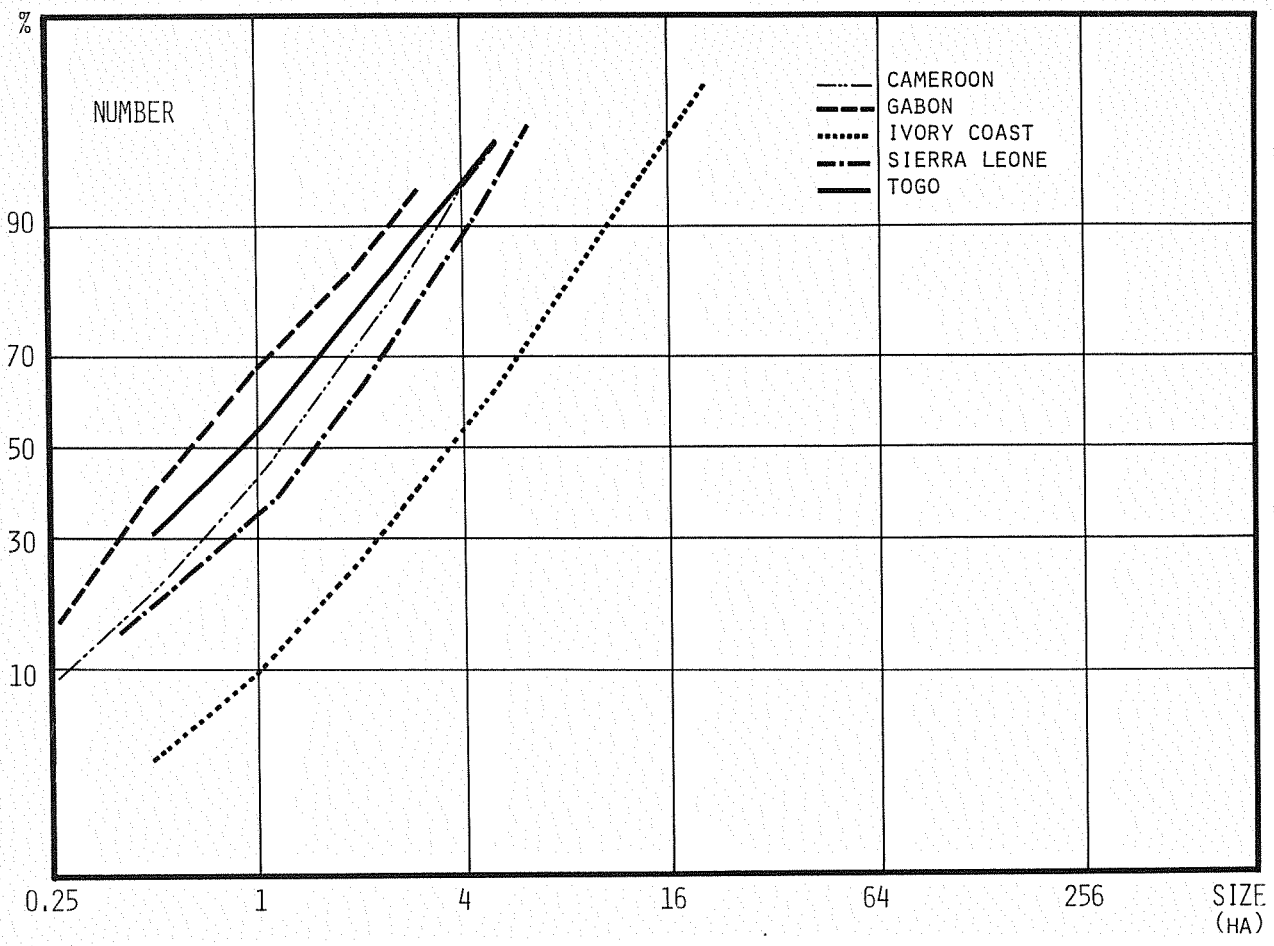


FIG. 10 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FIRST GROUP OF AFRICAN COUNTRIES



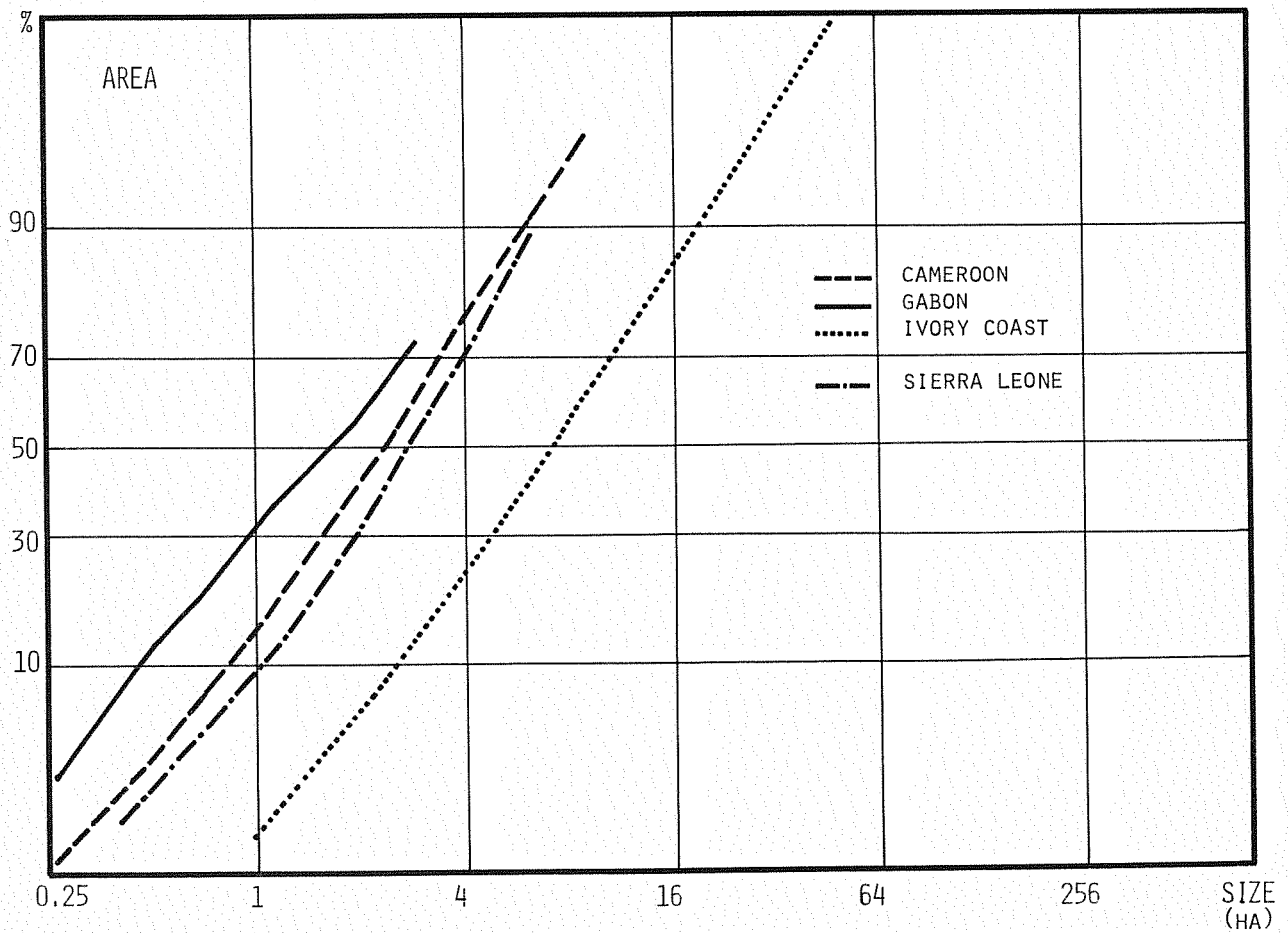
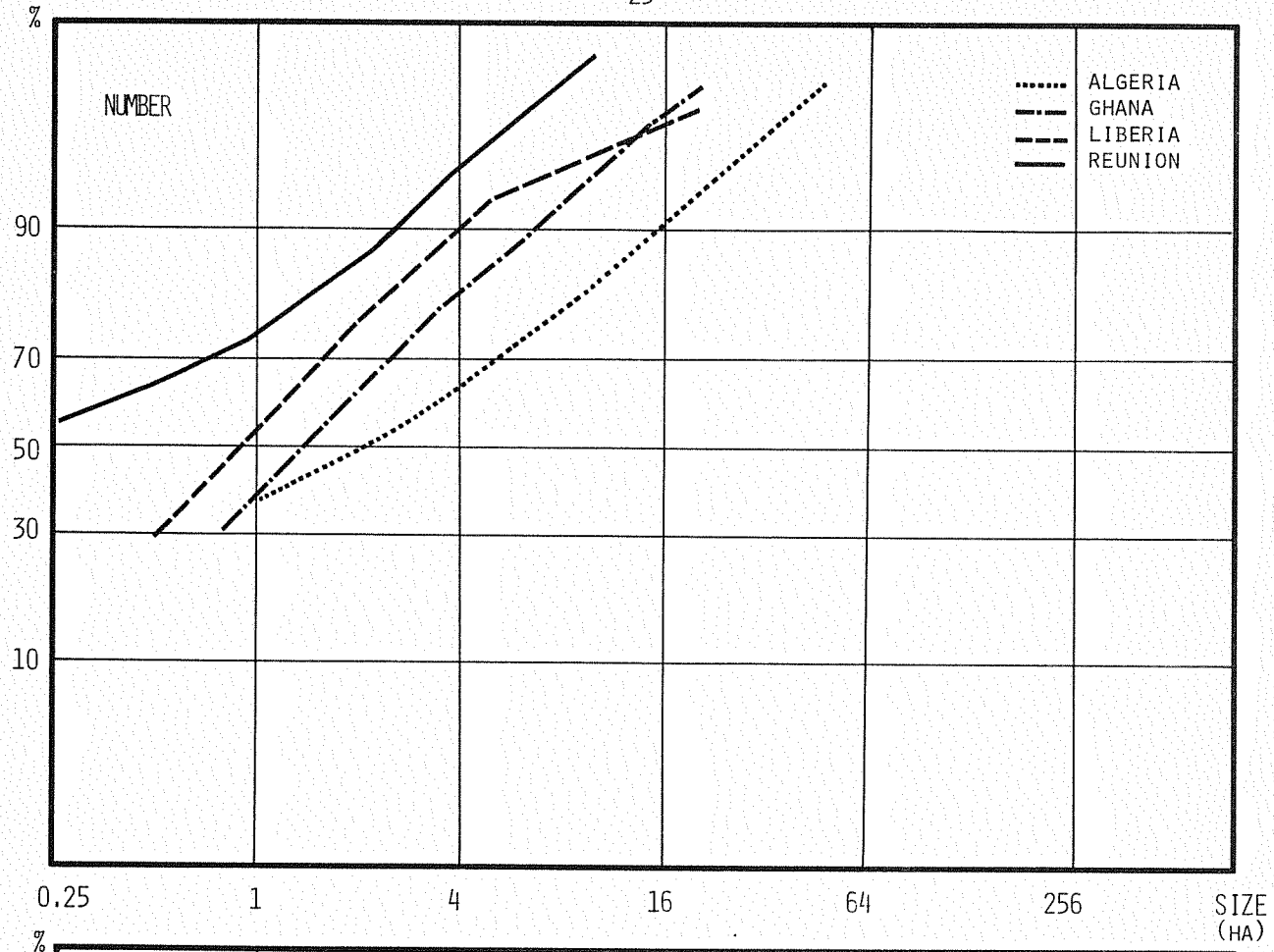


FIG. 11 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE SECOND GROUP OF AFRICAN COUNTRIES



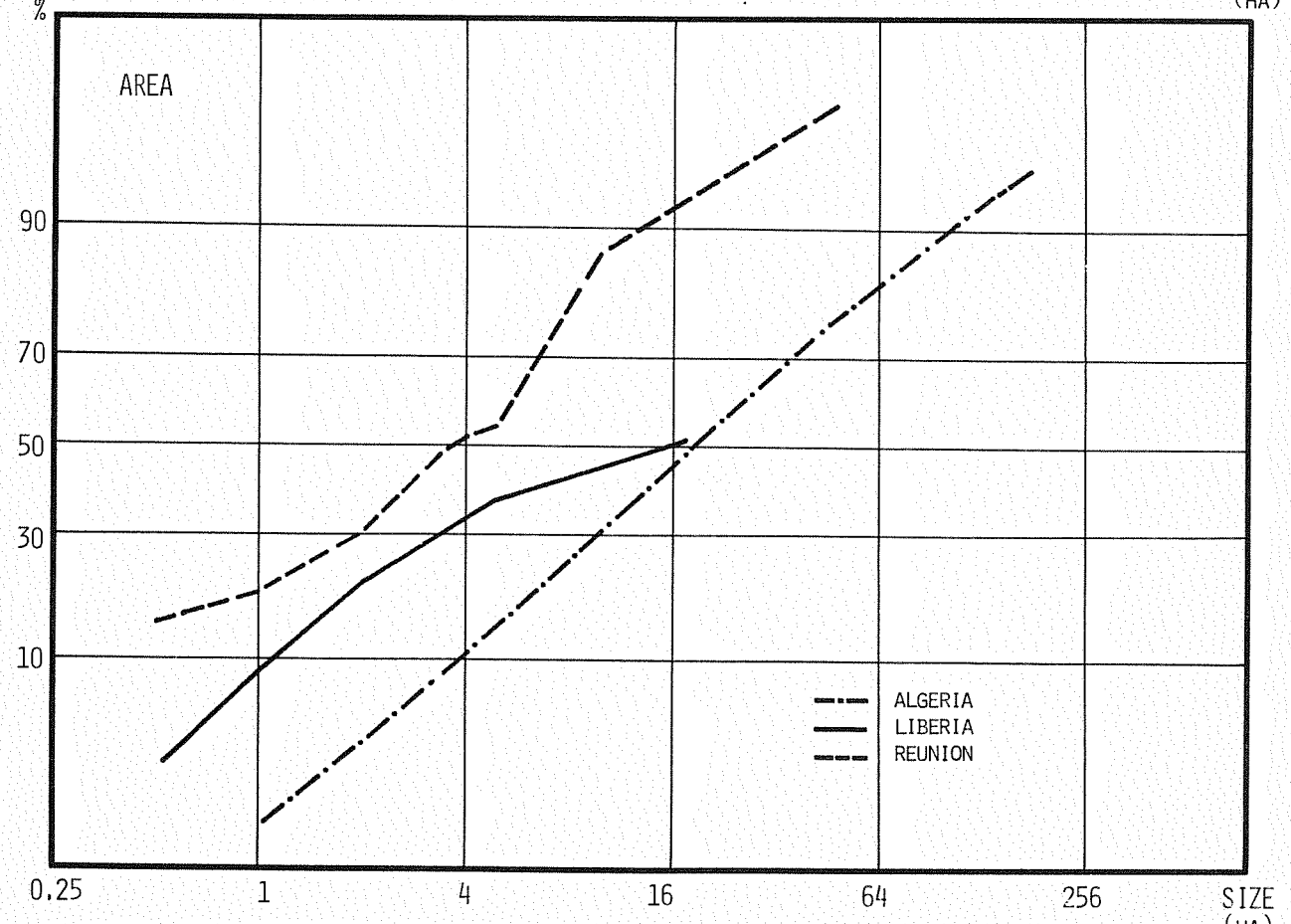
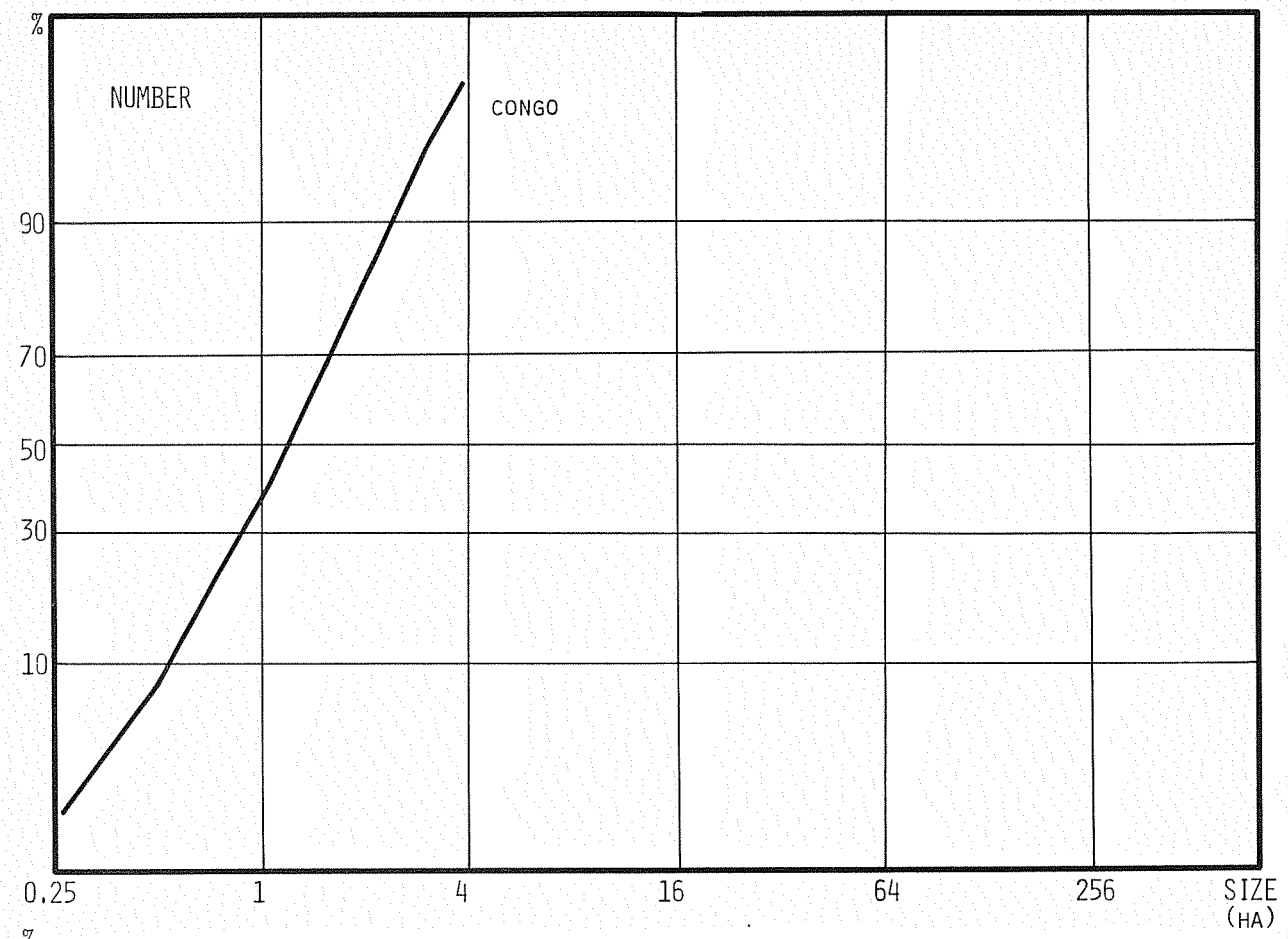


FIG. 12 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE THIRD GROUP OF AFRICAN COUNTRIES



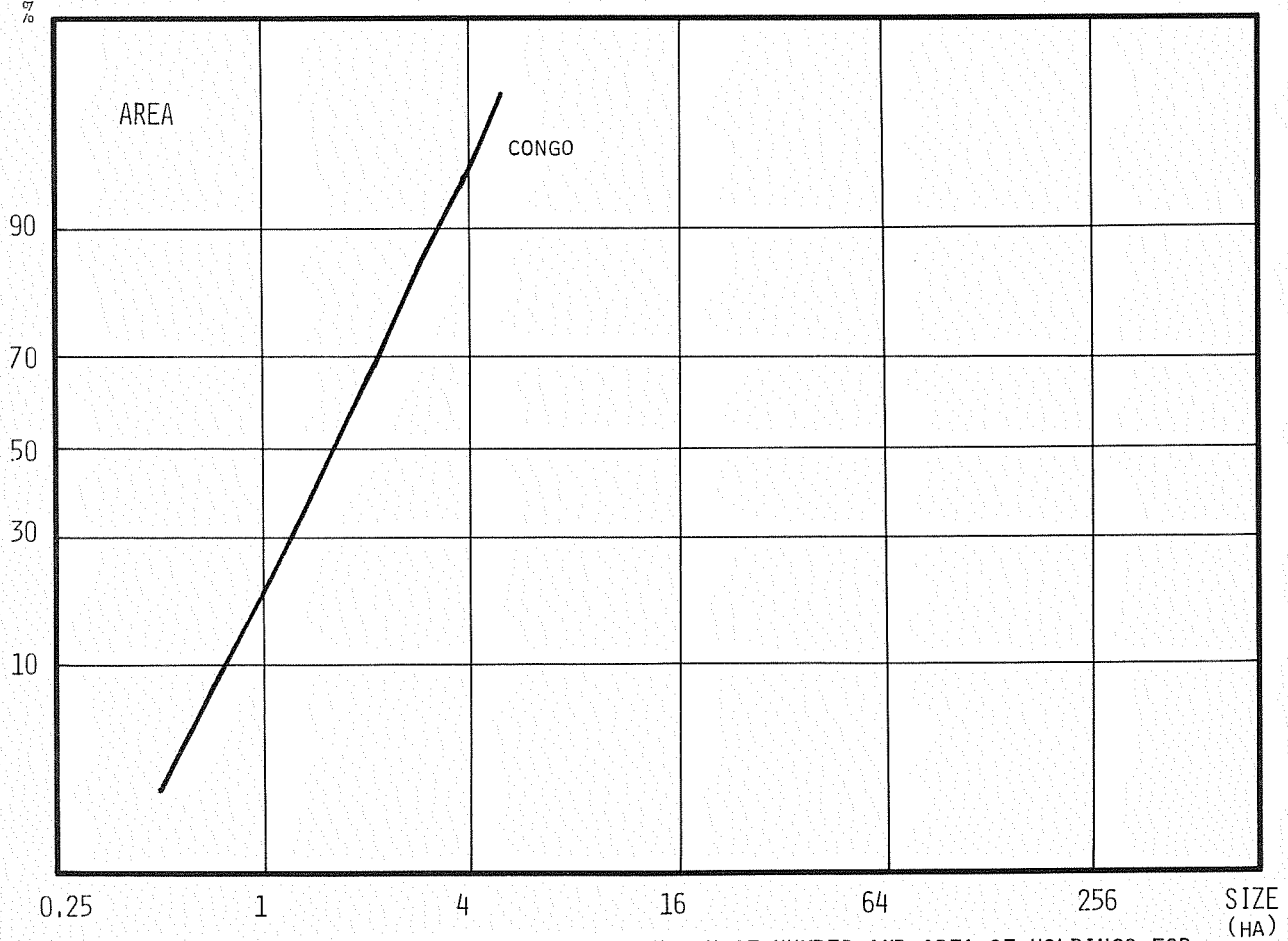
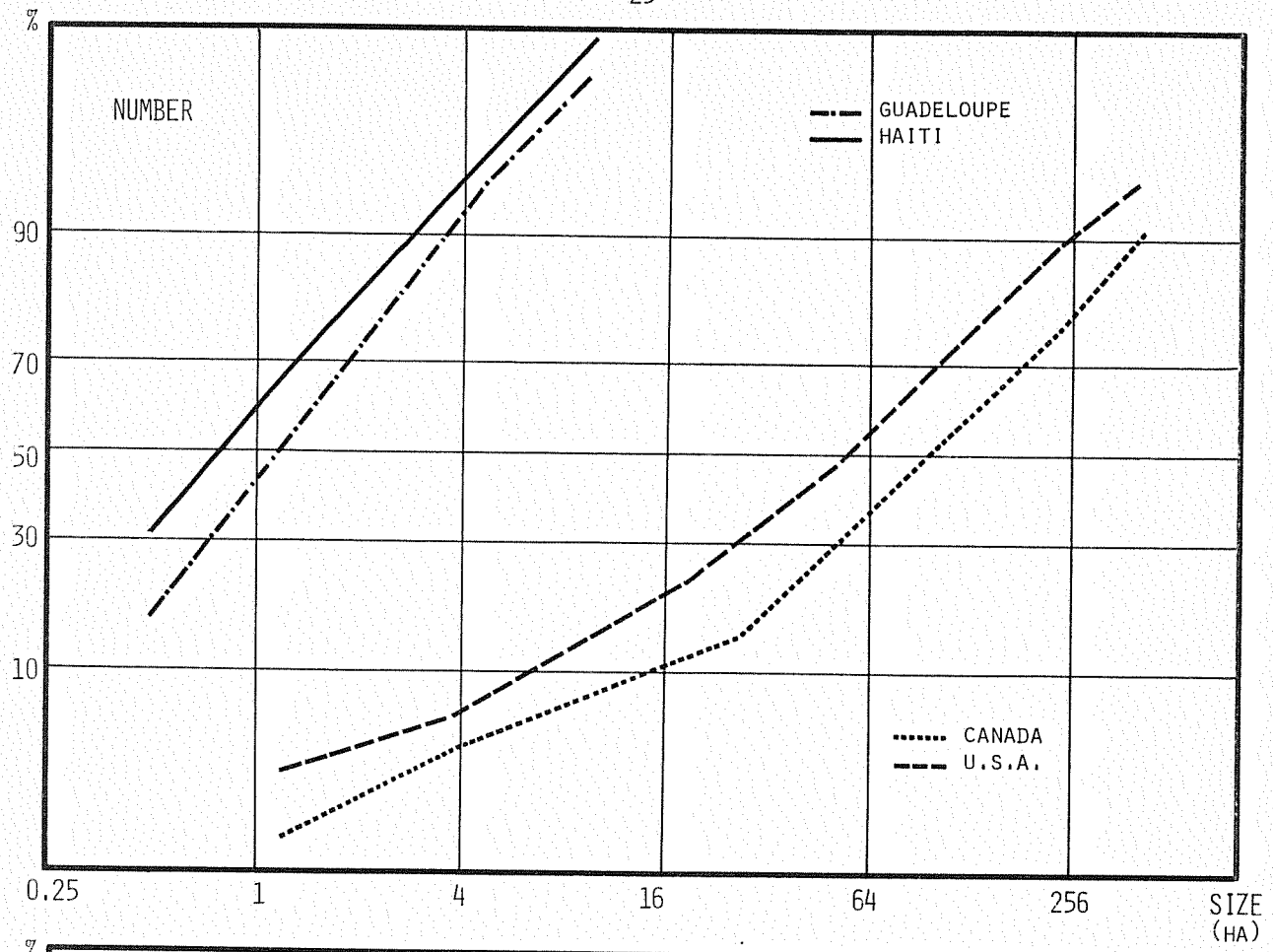


FIG. 13 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE CONGO



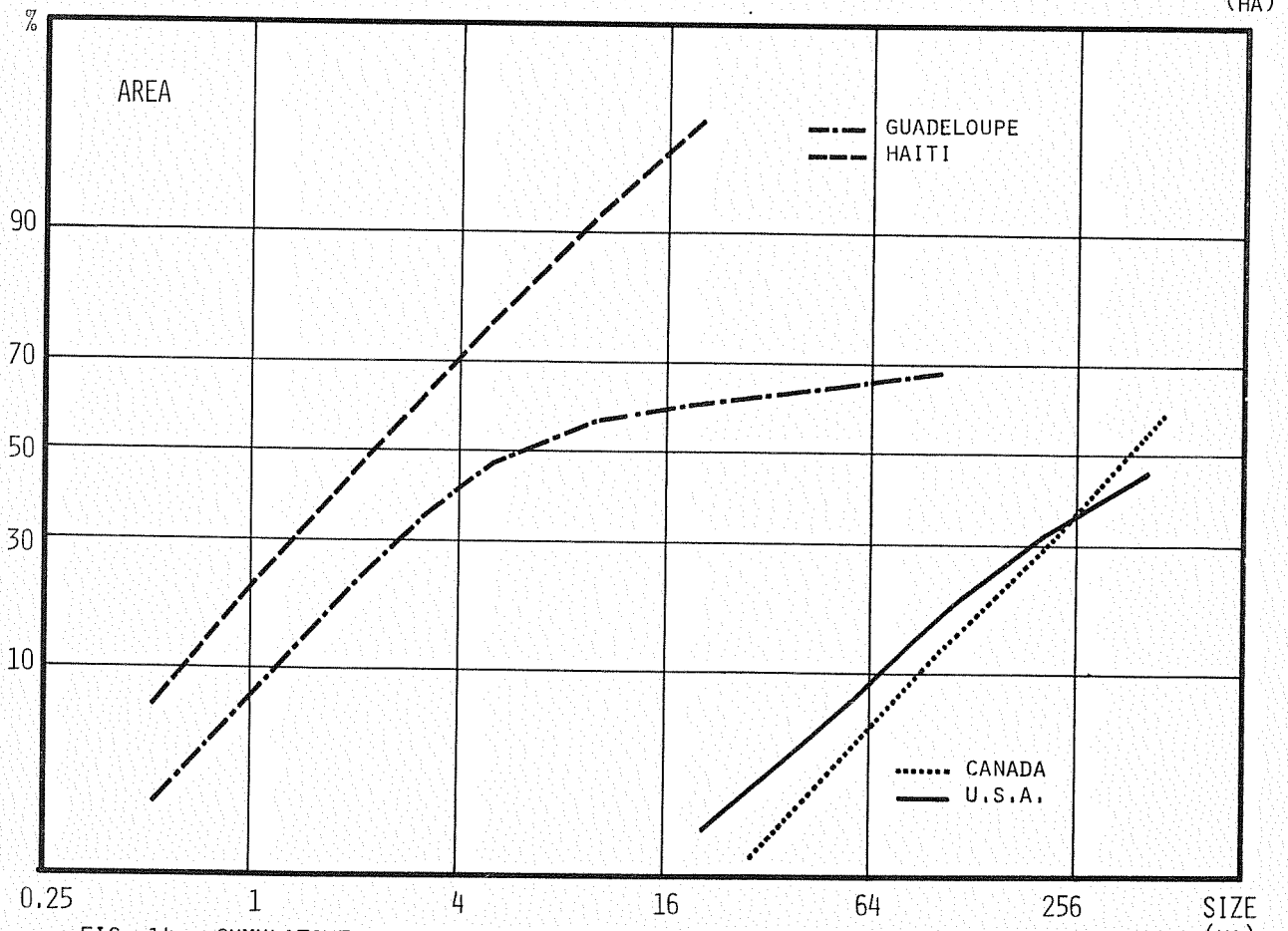
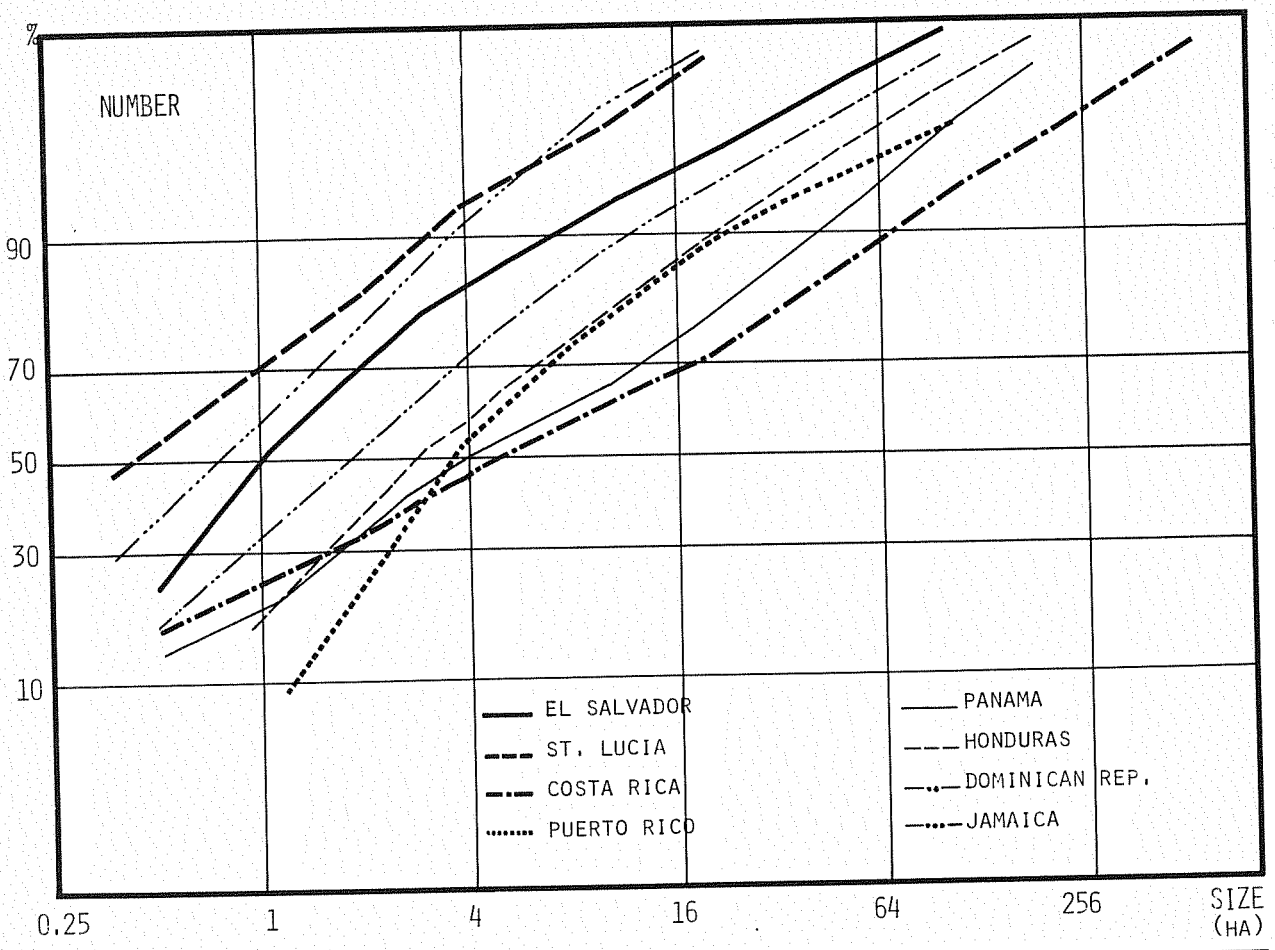


FIG. 14 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FIRST AND SECOND GROUPS OF NORTH AND CENTRAL AMERICAN COUNTRIES



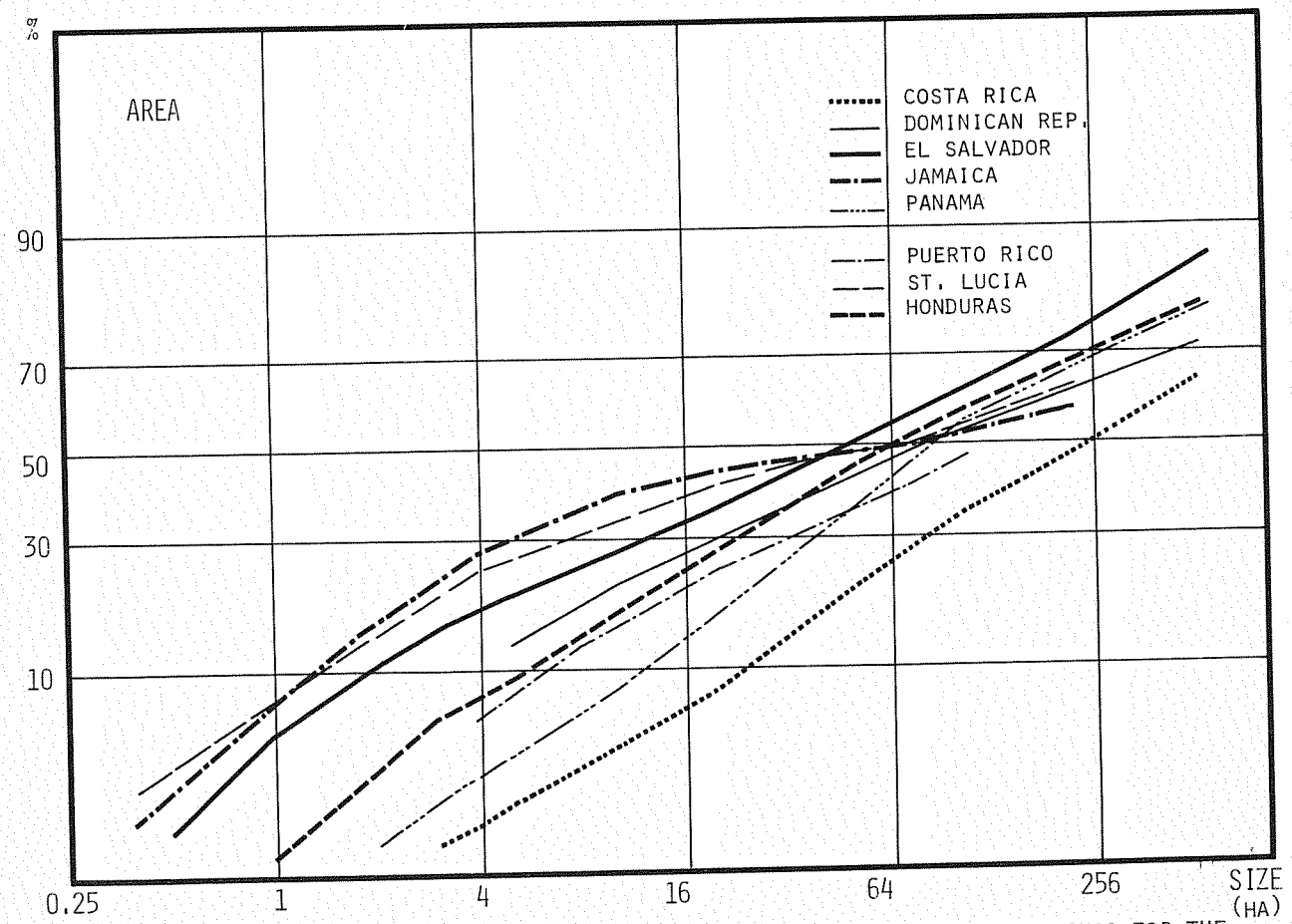
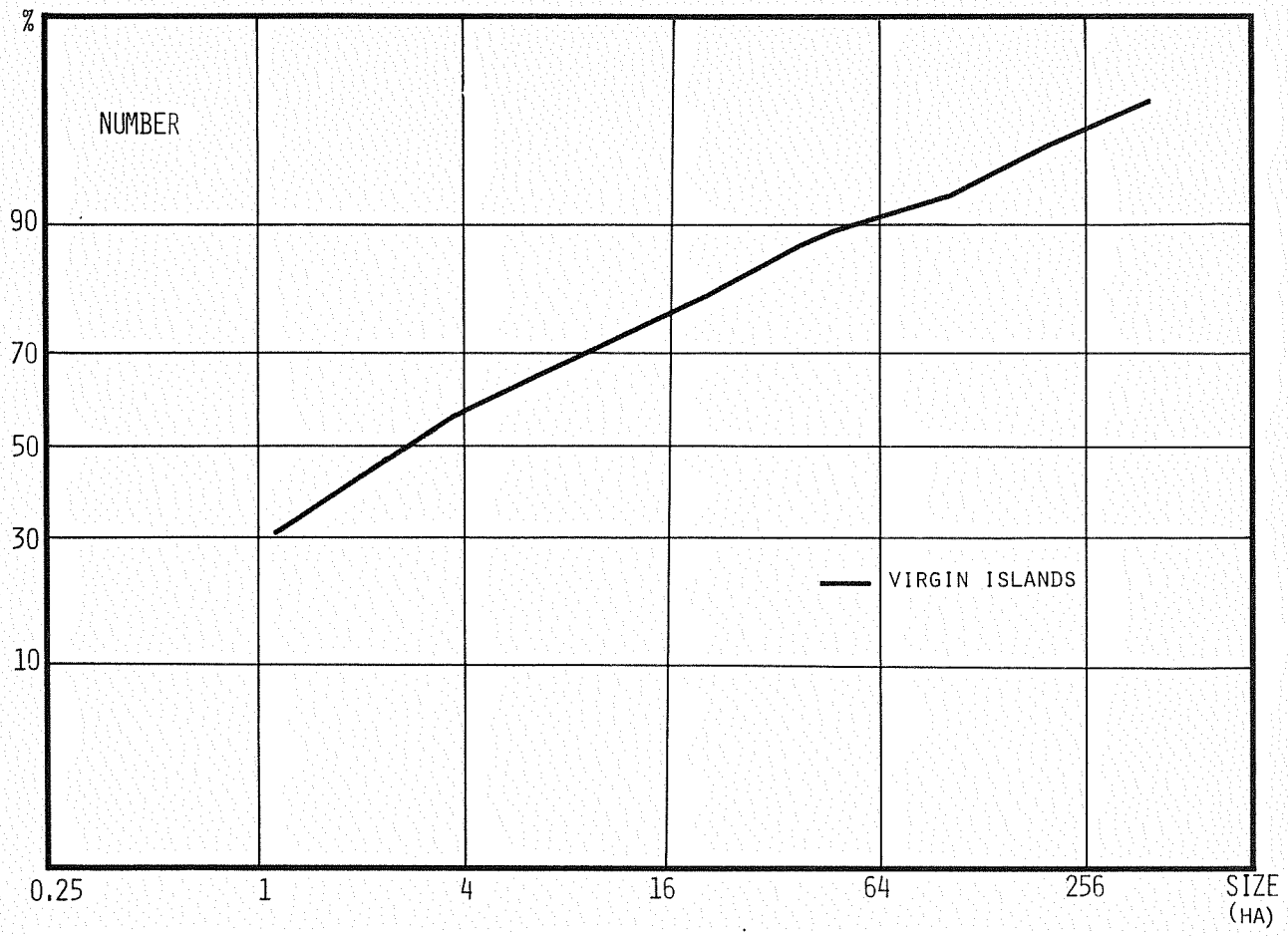


FIG. 15 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE THIRD GROUP OF NORTH AND CENTRAL AMERICAN COUNTRIES



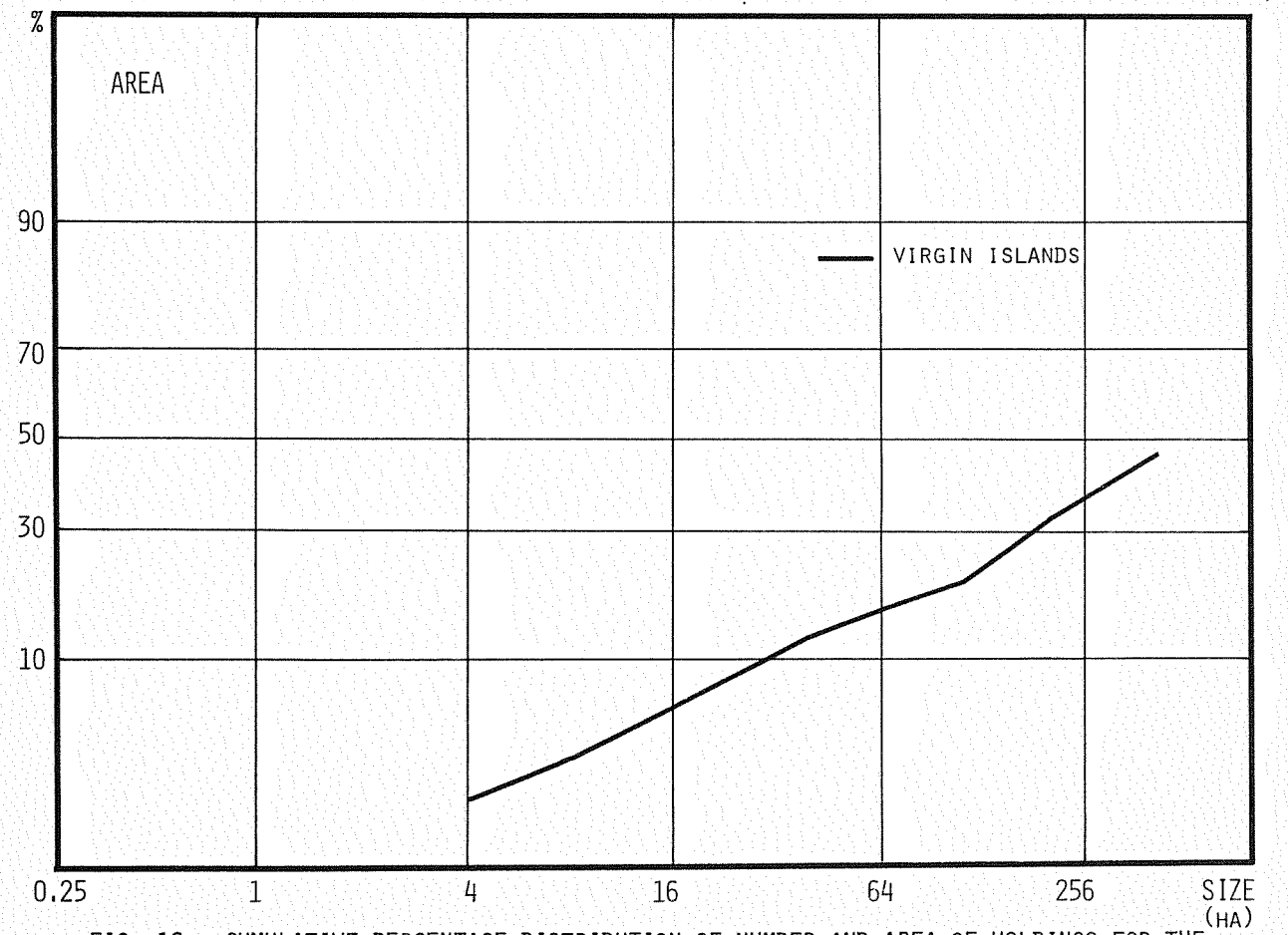
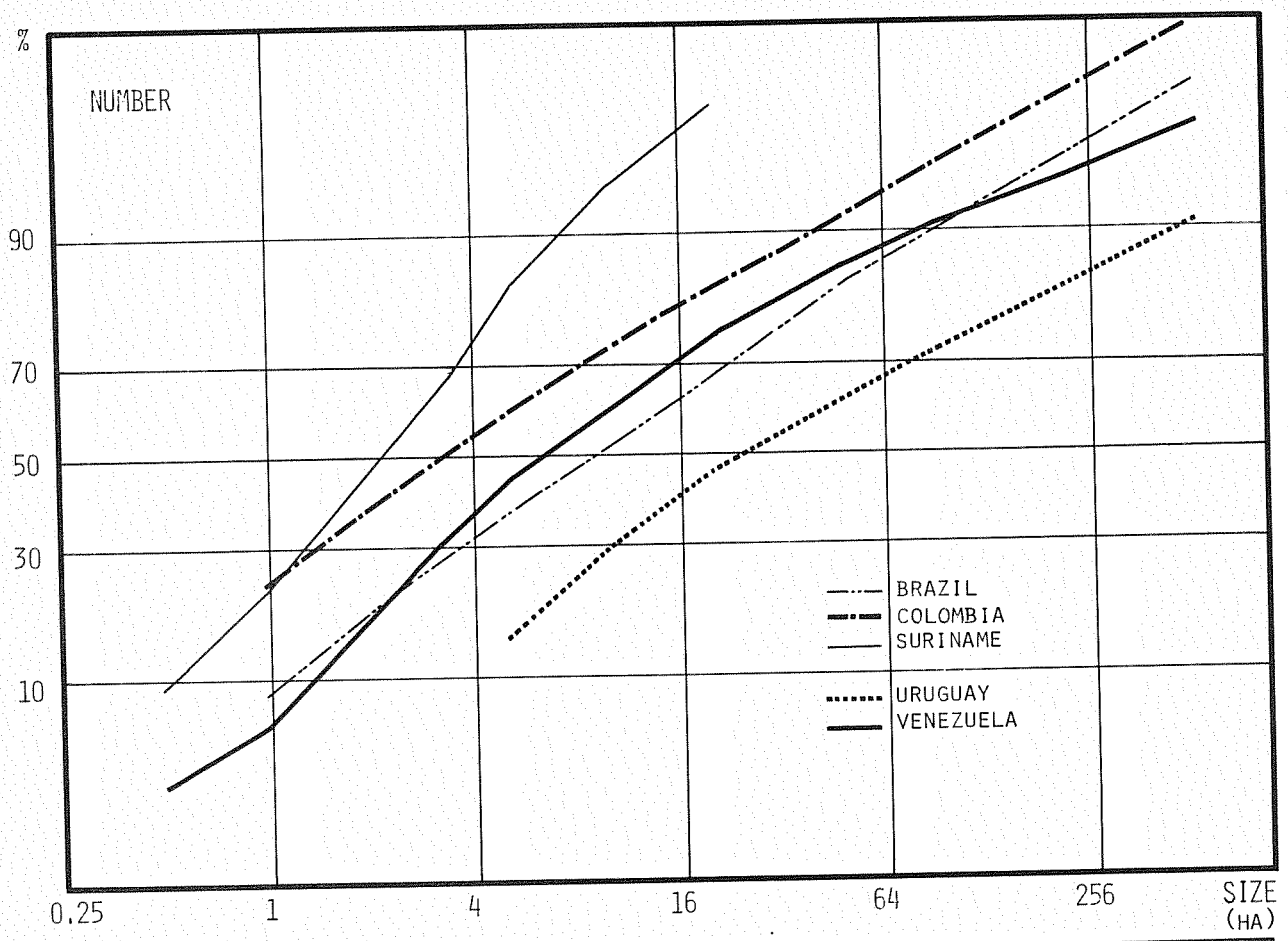


FIG. 16 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FOURTH GROUP OF NORTH AND CENTRAL AMERICAN COUNTRIES



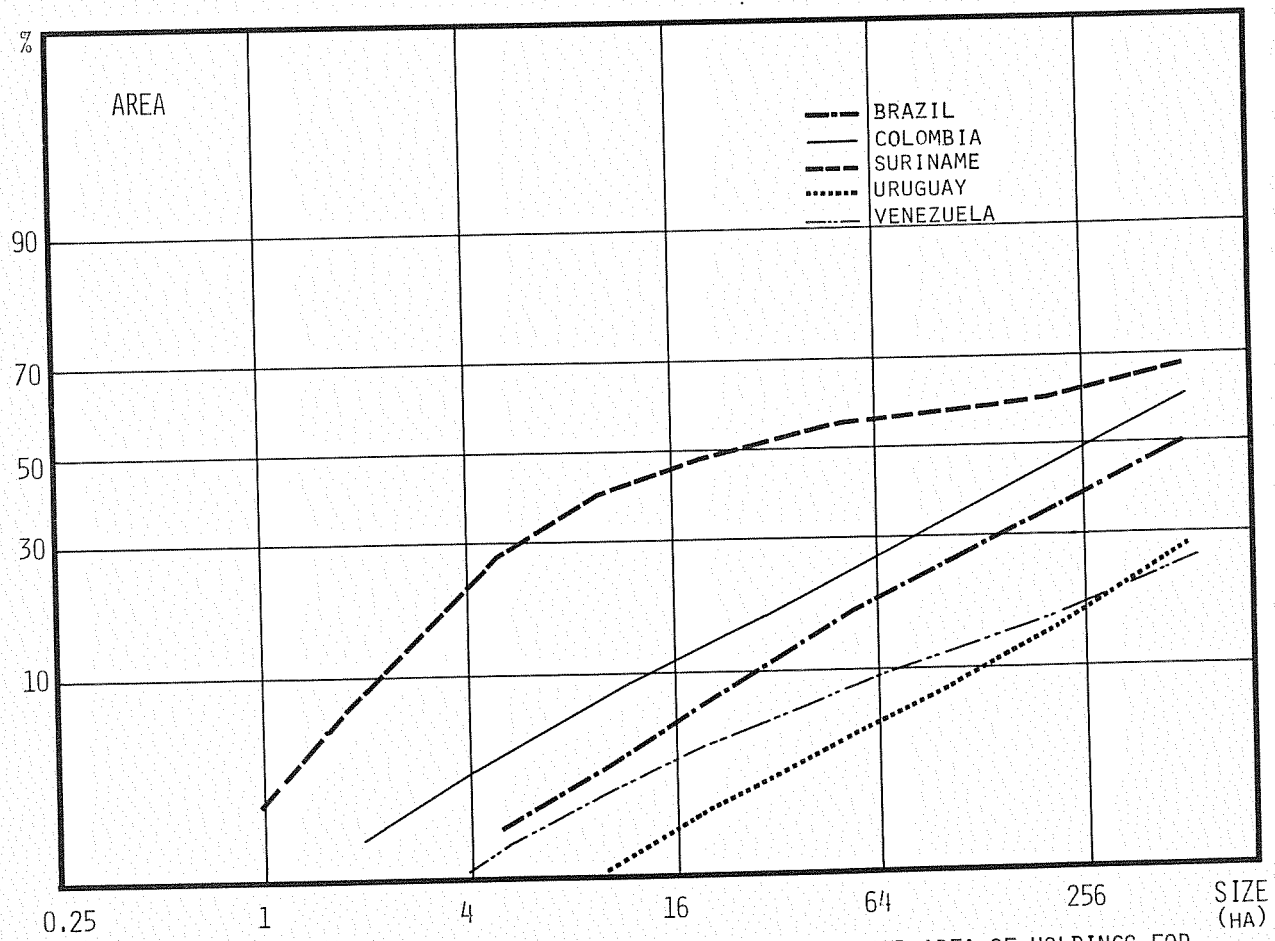
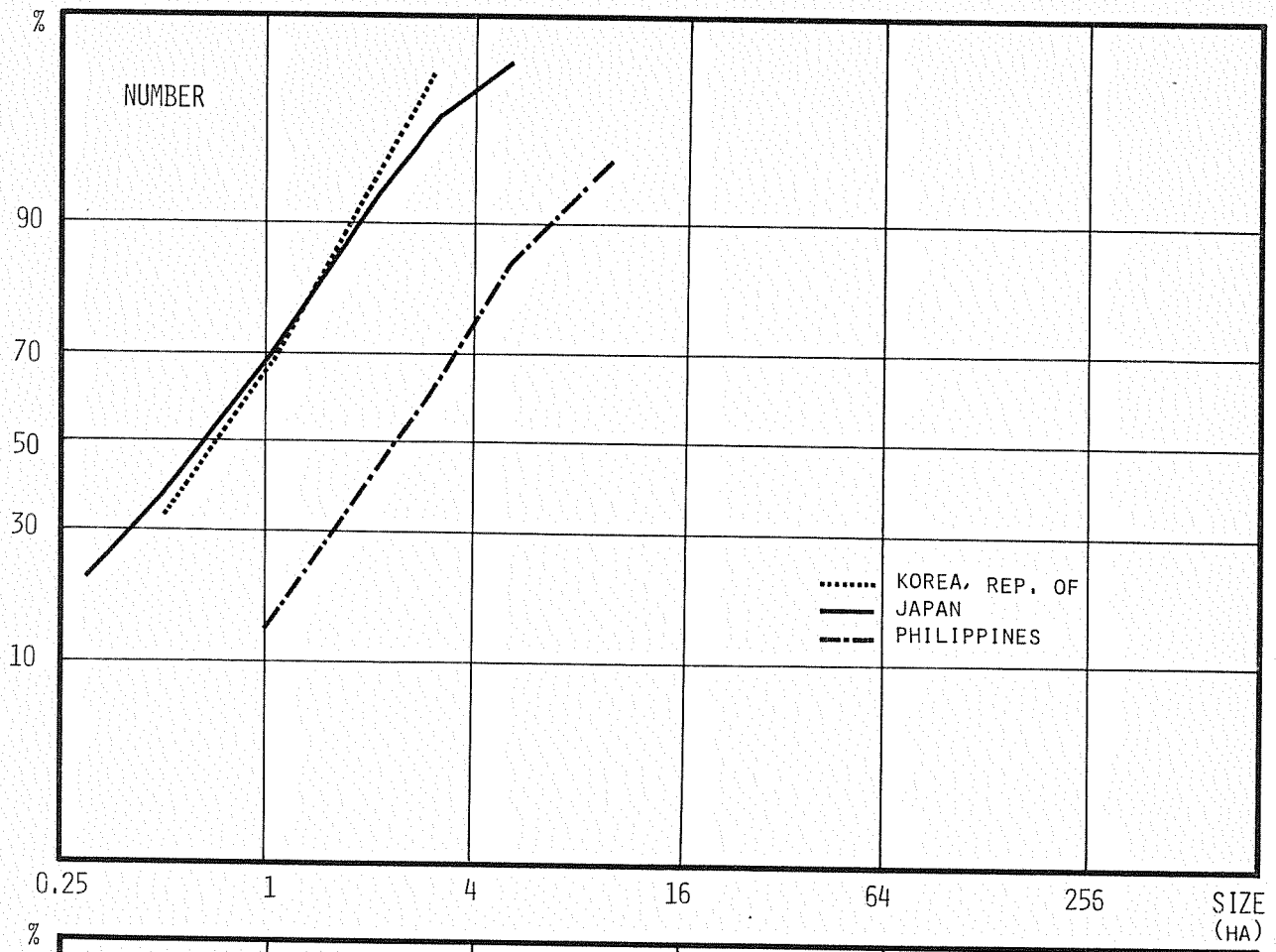


FIG. 17 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR SOUTH AMERICAN COUNTRIES



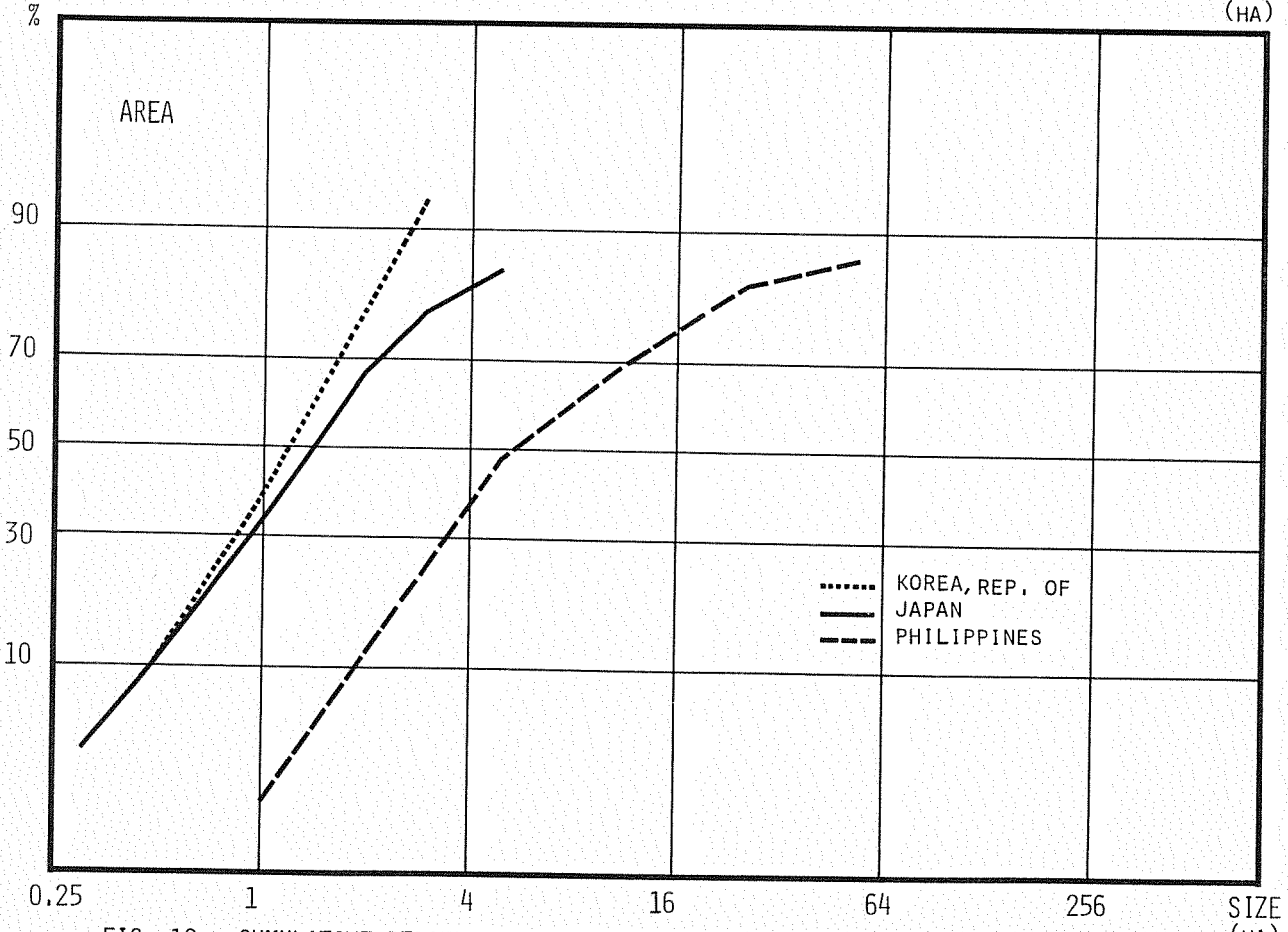
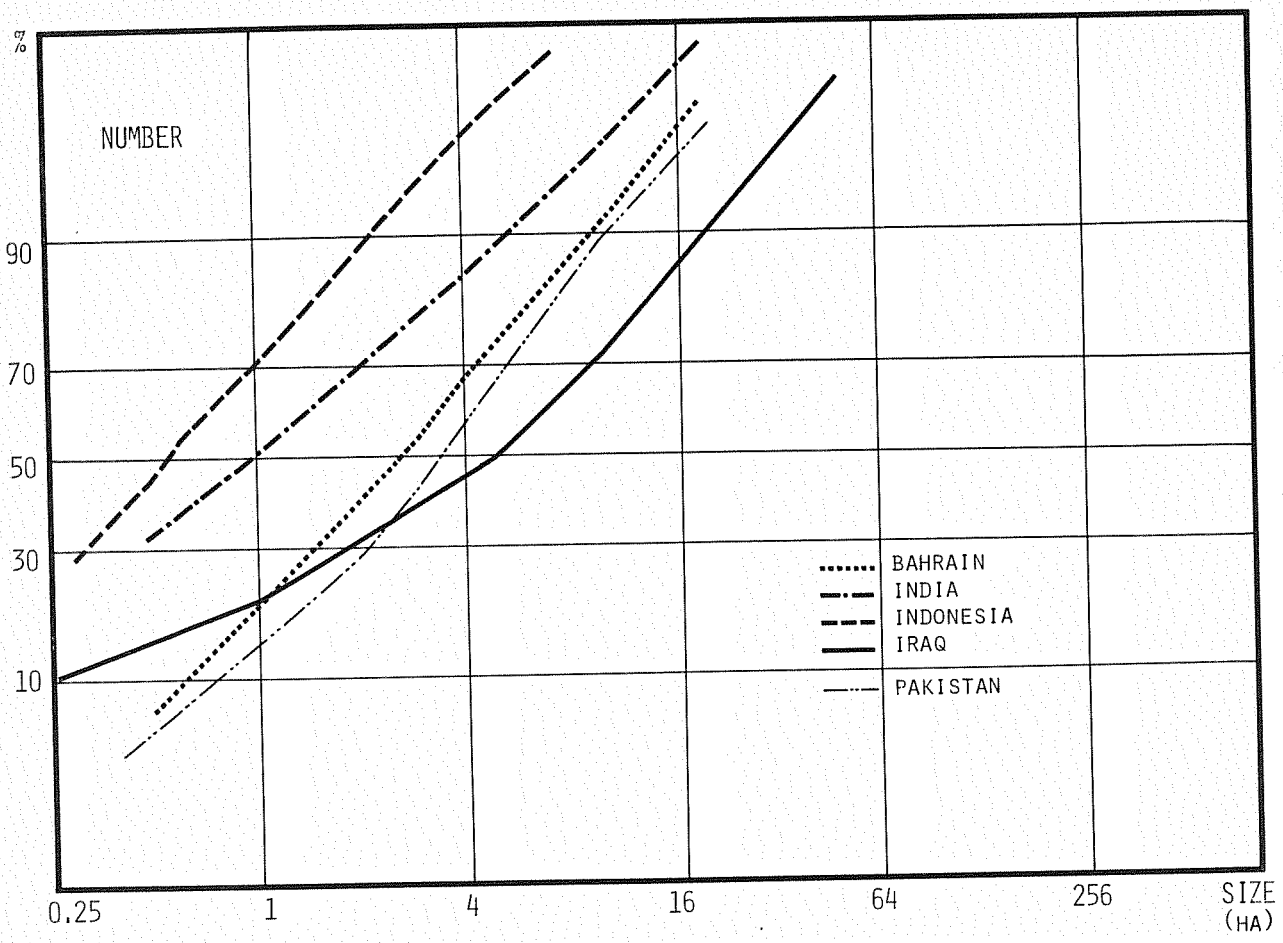


FIG. 18 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FIRST GROUP OF ASIAN COUNTRIES



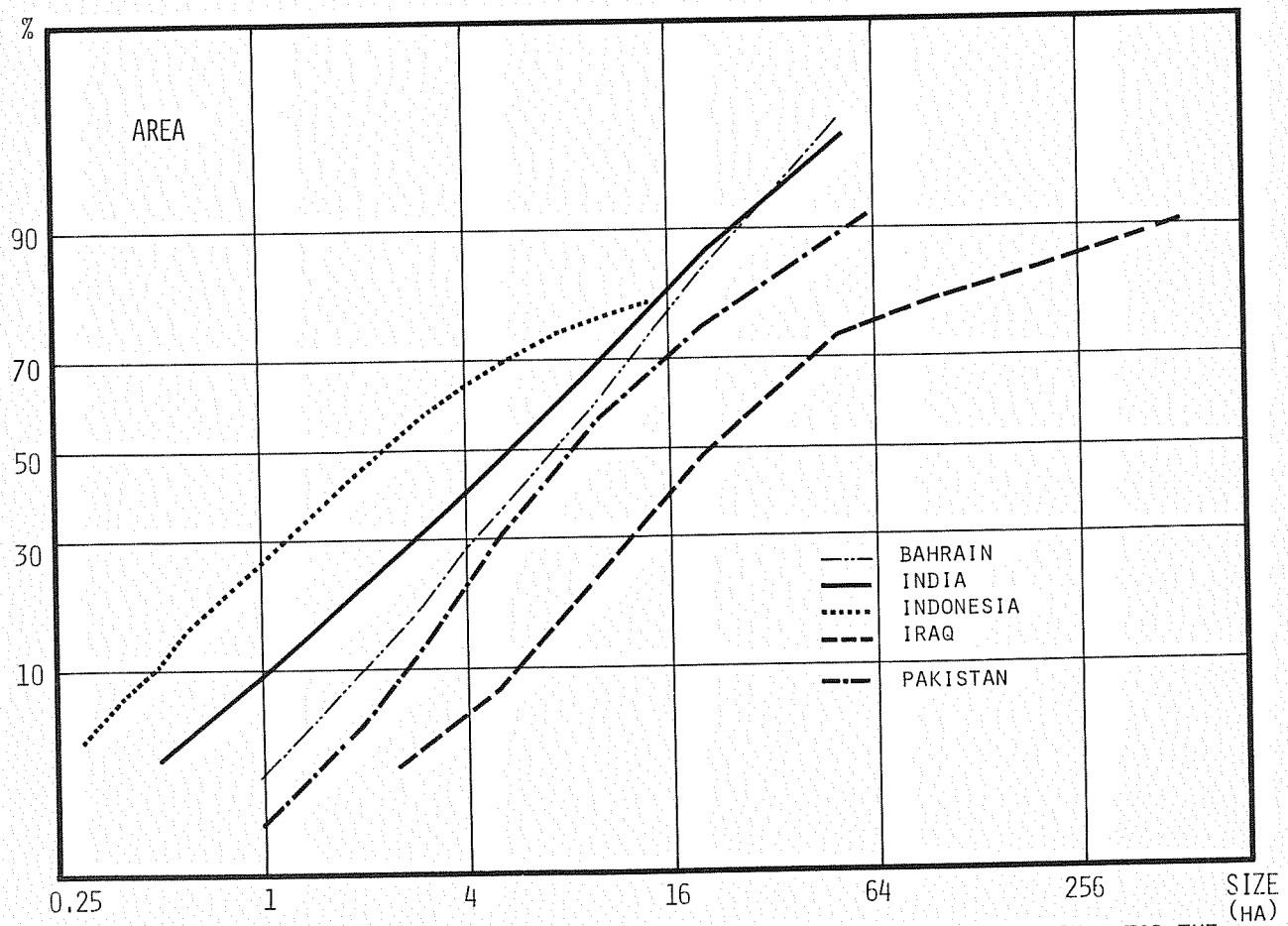
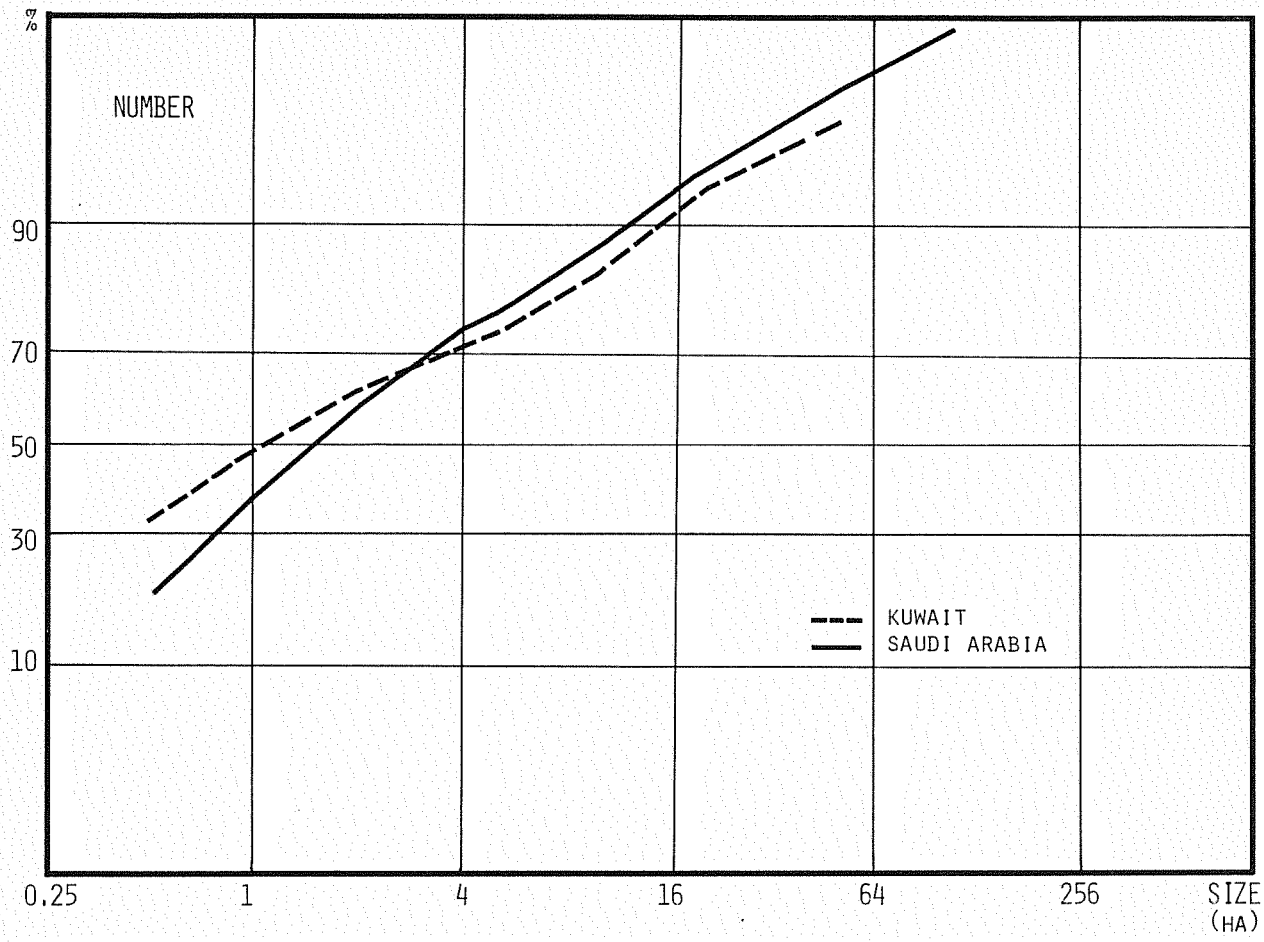


FIG. 19 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE SECOND GROUP OF ASIAN COUNTRIES



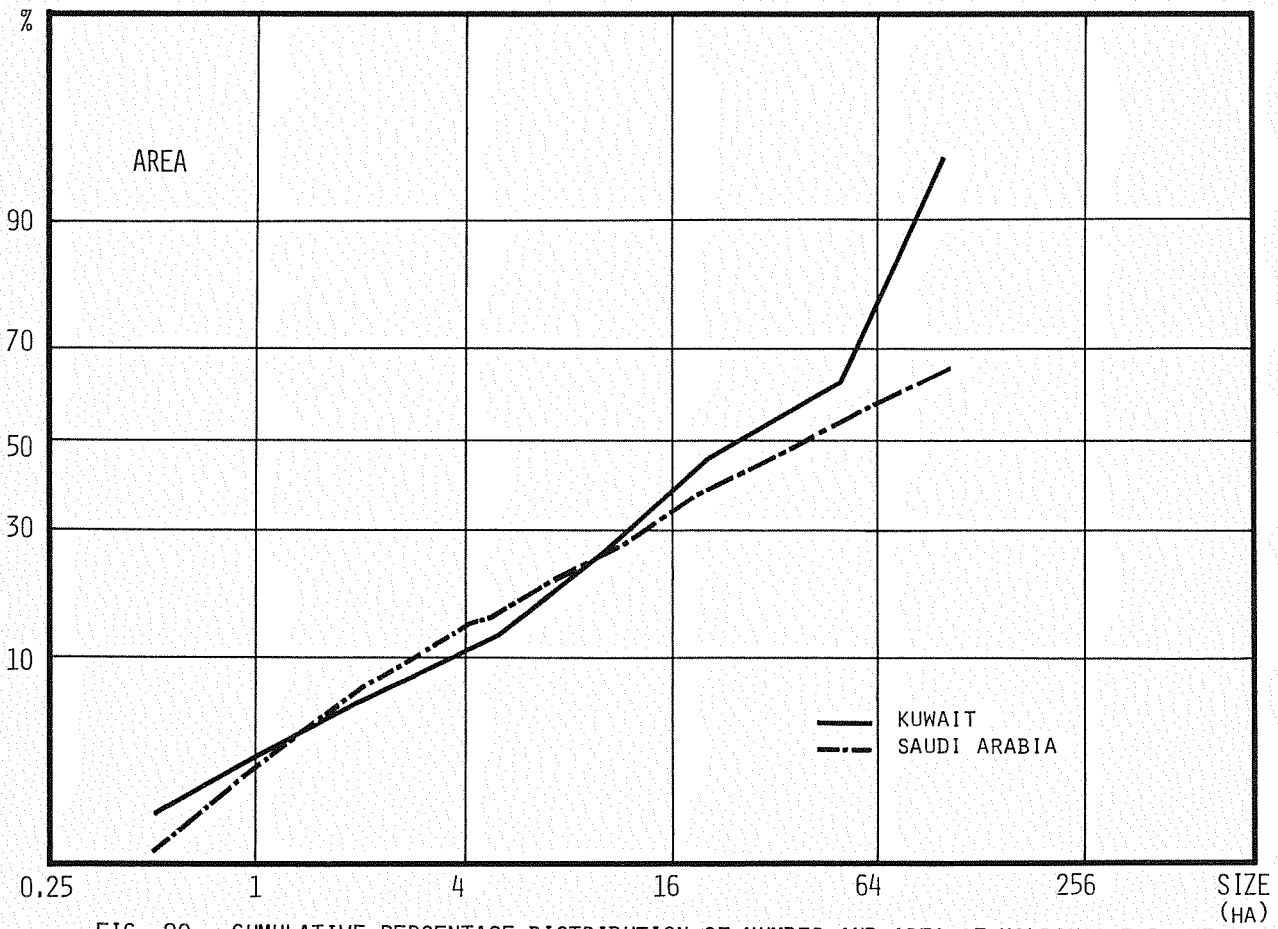
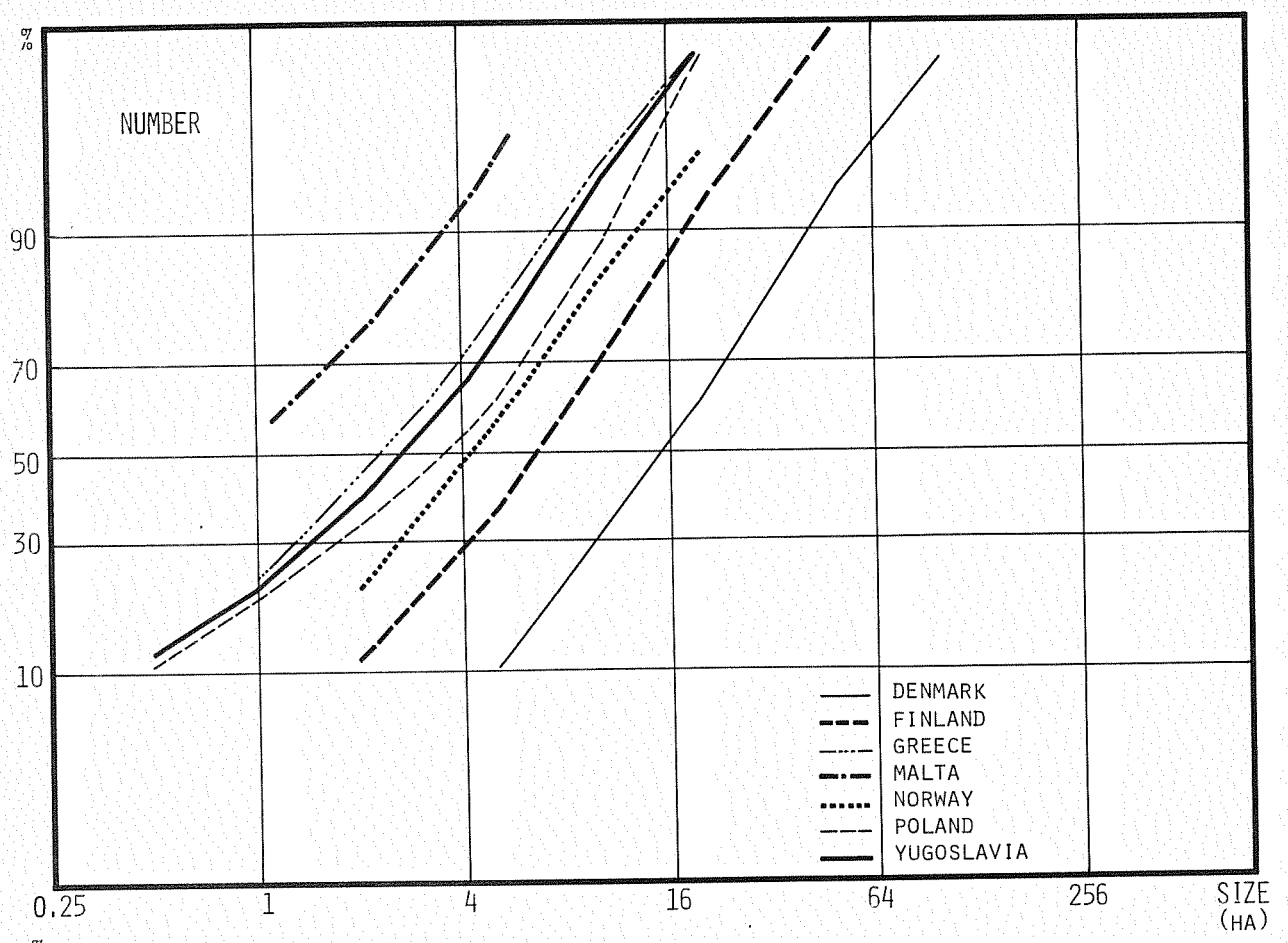


FIG. 20 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE THIRD GROUP OF ASIAN COUNTRIES



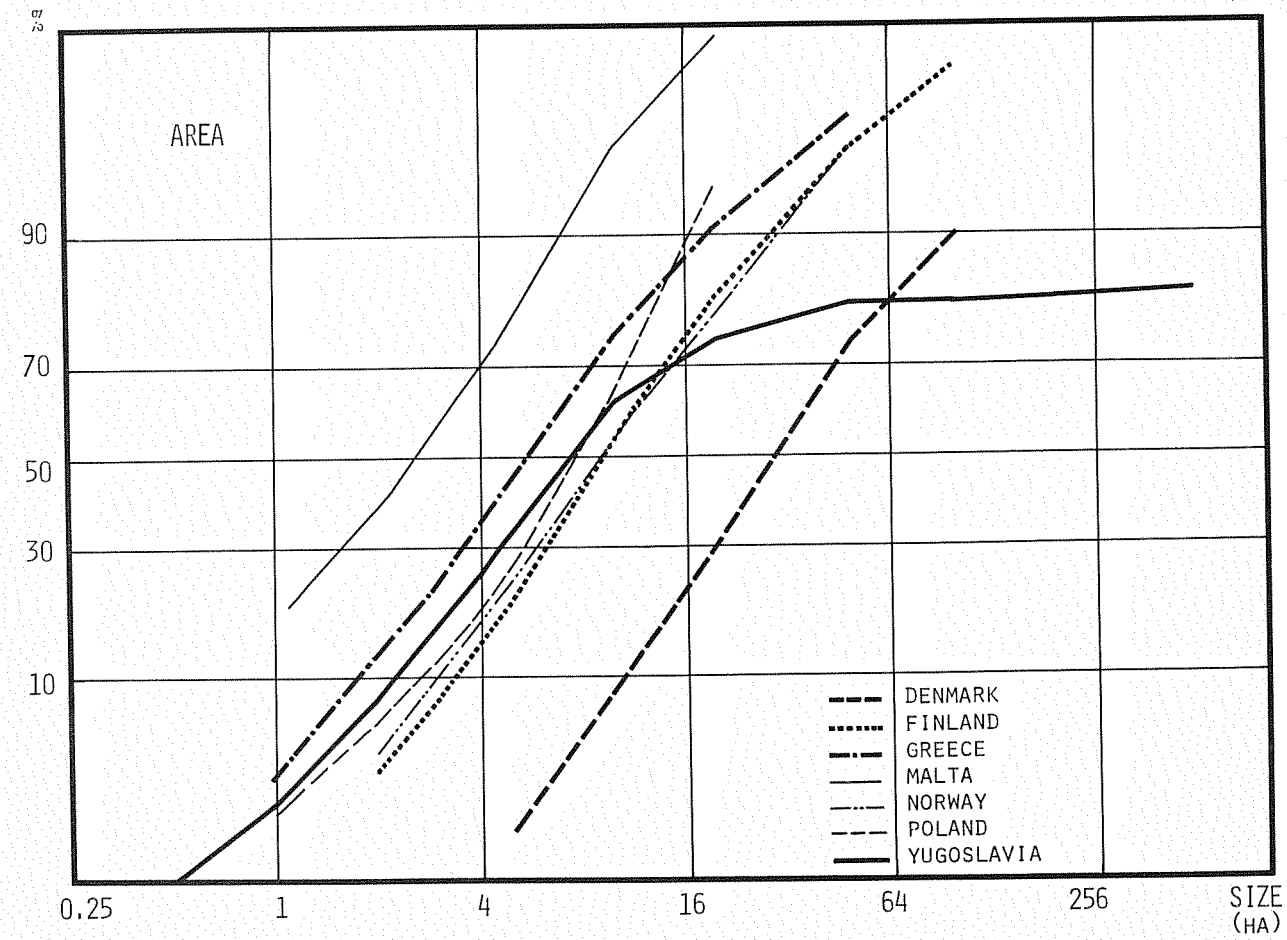
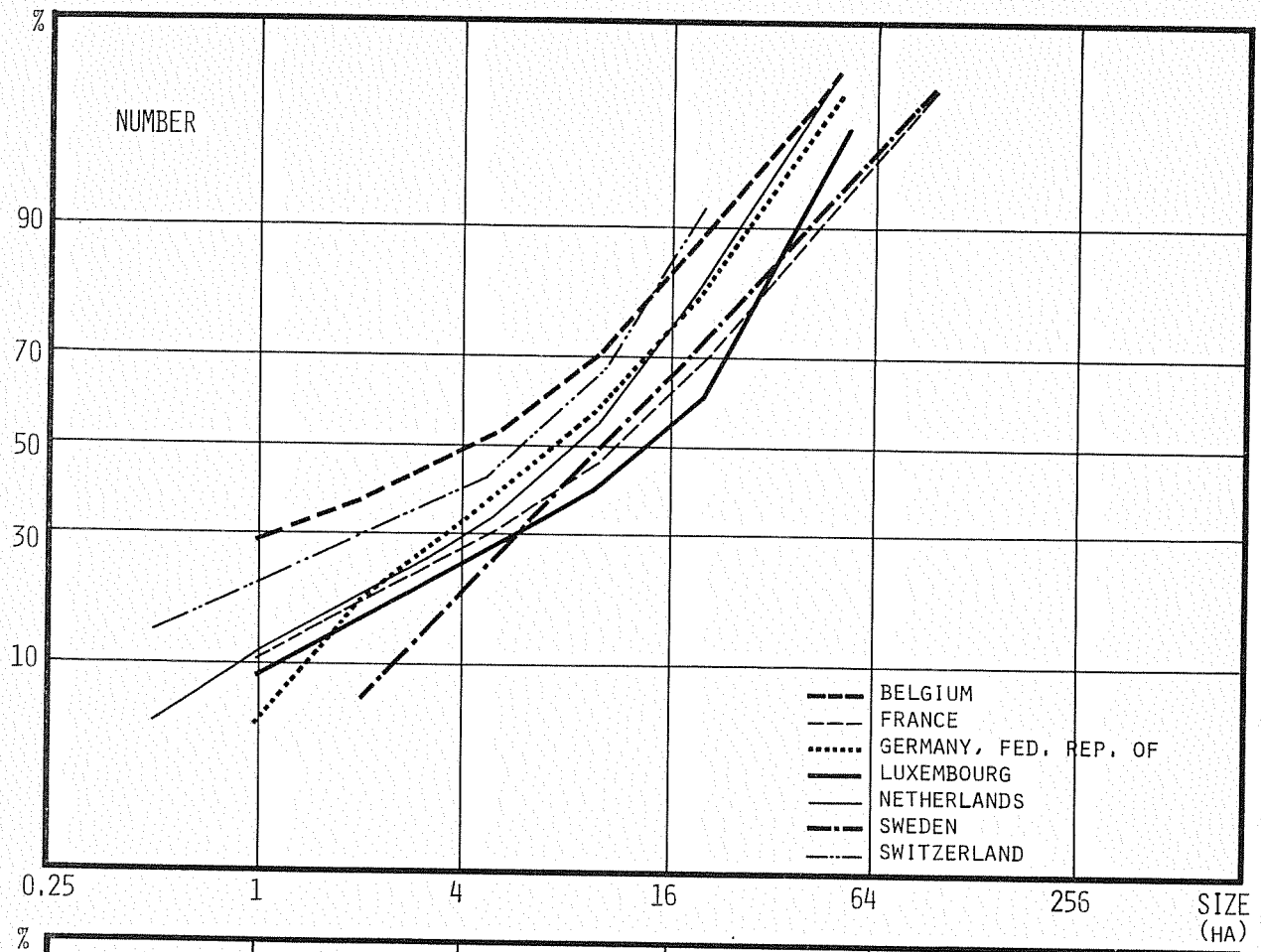


FIG. 21 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FIRST GROUP OF EUROPEAN COUNTRIES (PART A)



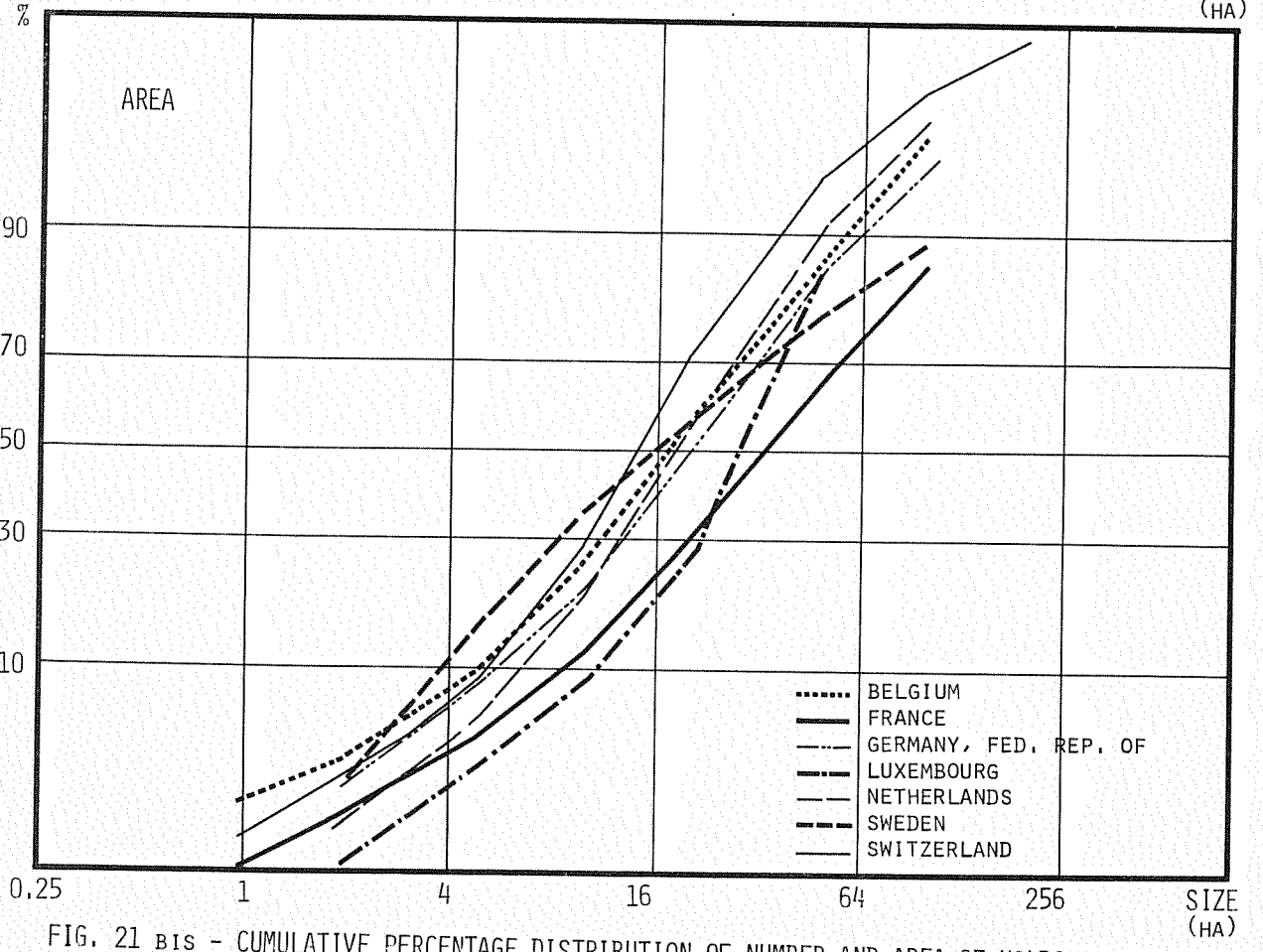


FIG. 21 BIS - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FIRST GROUP OF EUROPEAN COUNTRIES (PART B)

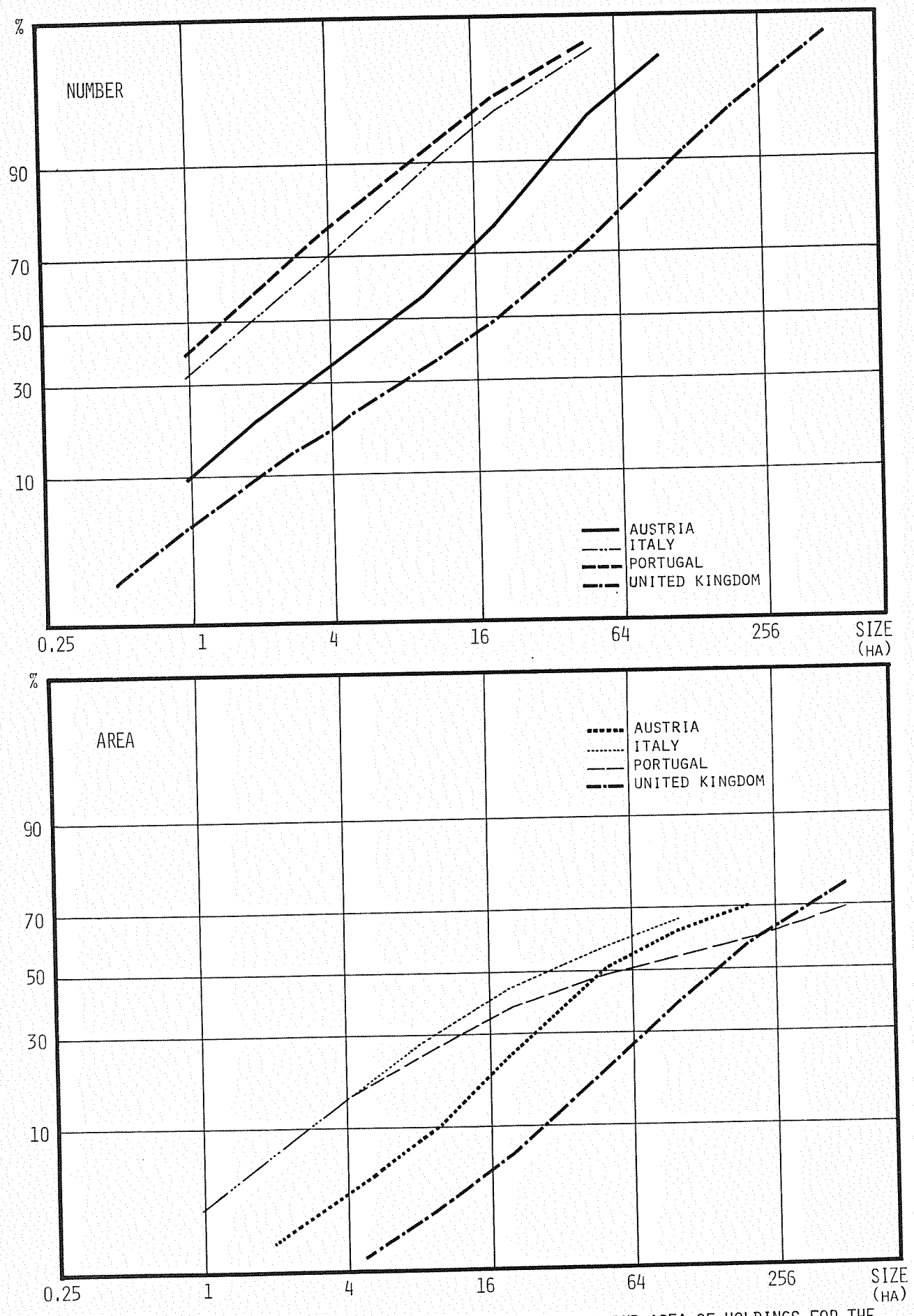
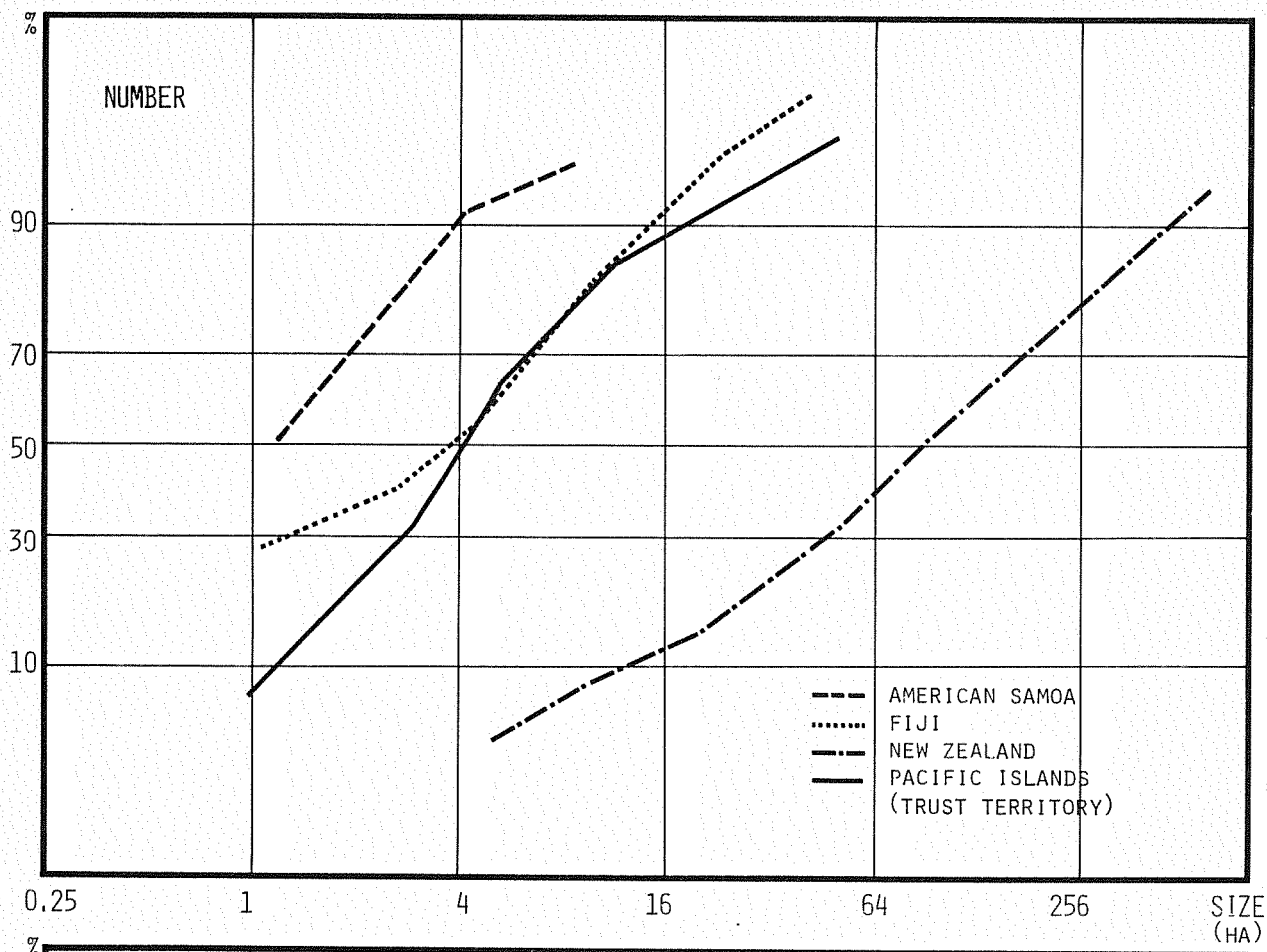


FIG. 22 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE SECOND GROUP OF EUROPEAN COUNTRIES



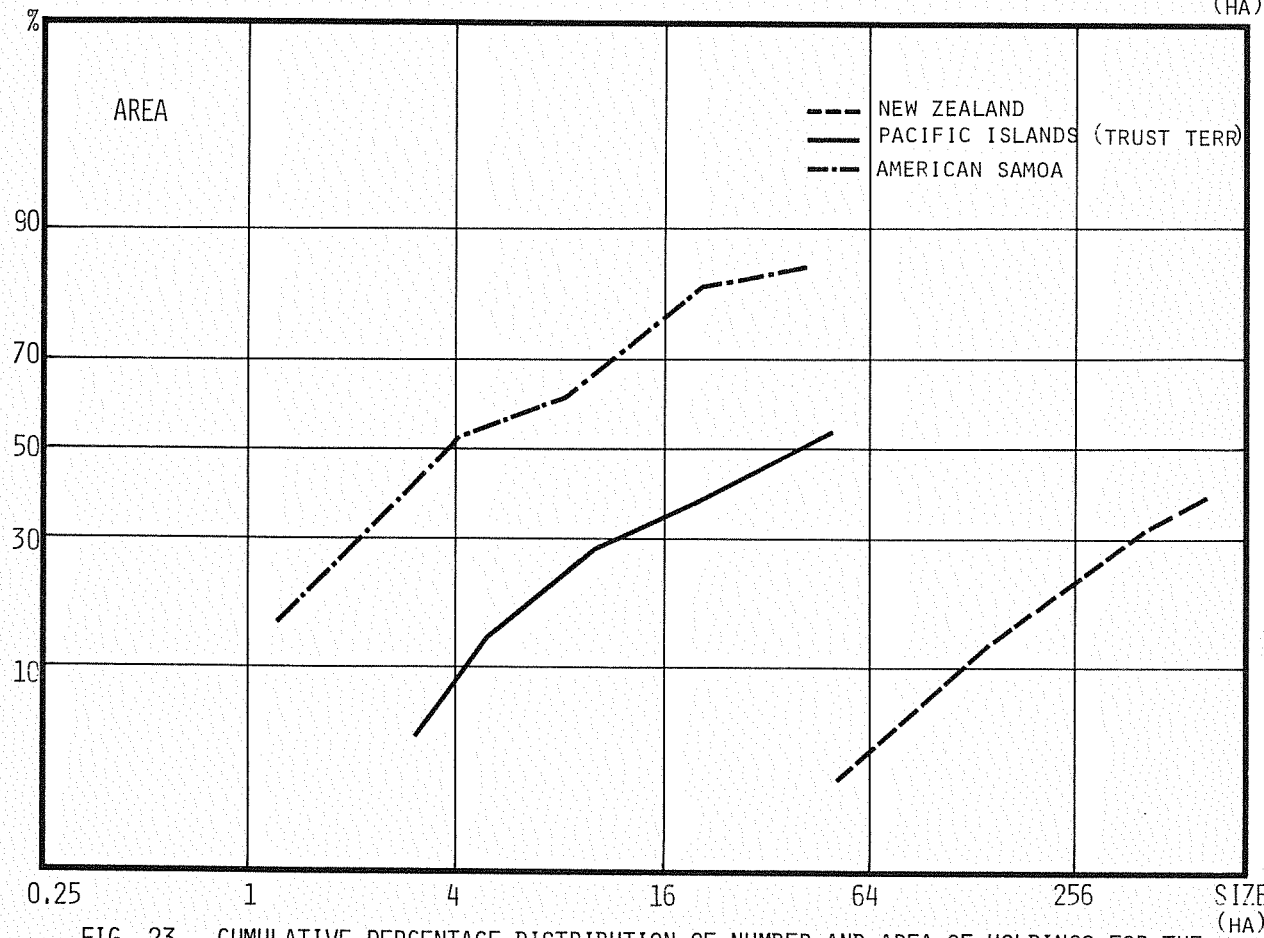
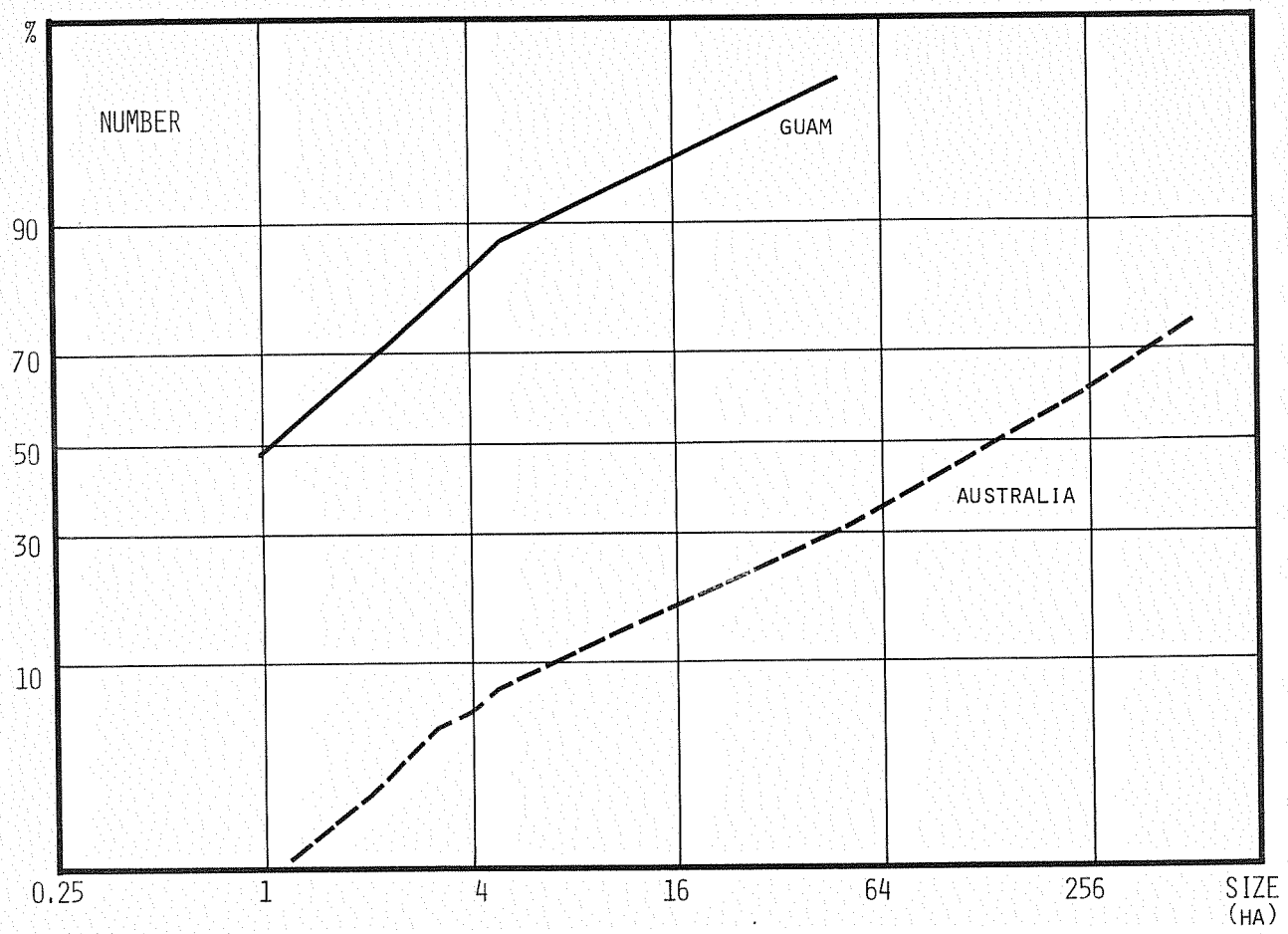


FIG. 23 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE FIRST GROUP OF COUNTRIES IN OCEANIA



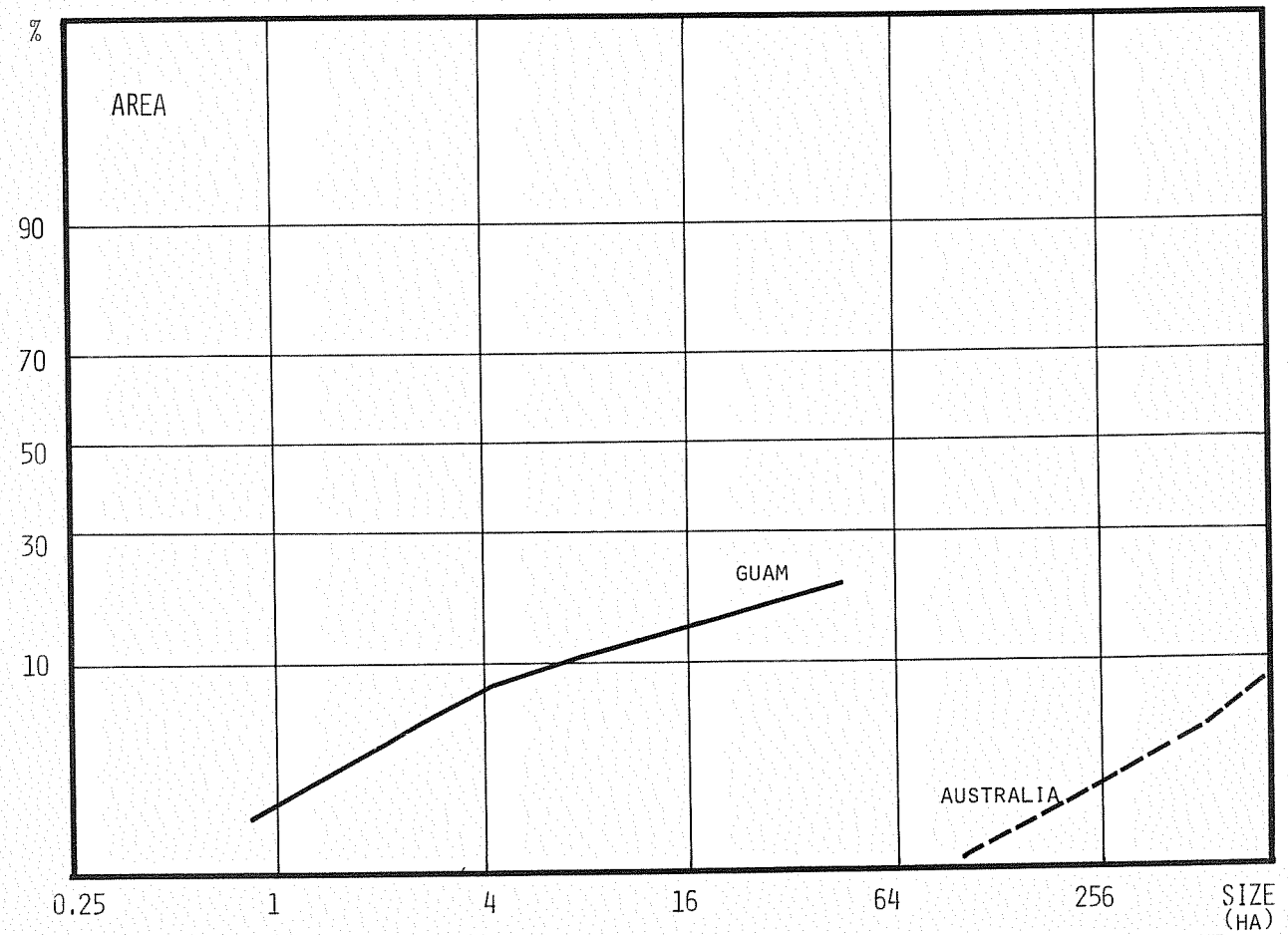


FIG. 24 - CUMULATIVE PERCENTAGE DISTRIBUTION OF NUMBER AND AREA OF HOLDINGS FOR THE SECOND GROUP OF COUNTRIES IN OCEANIA

TOTAL NUMBER AND AREA OF HOLDINGS, CENTRAL AND STRUCTURAL CHARACTERISTICS BY COUNTRY[1/]

Countries by continents	Census year	Total number of holdings	Total area of holdings (ha.)	Average size (ha.)	Median size for number (ha.)	Median size for area (ha.)	Concentration index	Estimated σ	Classifying area as % of total area [2/]
AFRICA									
Central African Rep.[3/]	1973	283 450	491 465	1.7	1.4	2.3	0.37	0.68	100
Chad[3/]	1972	366 475	962 166	2.6	2.2	3.5	0.38	0.70	100
Lesotho[3/]	1970	187 421	372 342	2.0	1.6	2.6	0.39	0.72	100
Malawi[3/]	1969	885 000	1 361 400	1.5	1.2	2.1	0.36	0.67	100
Zaire[3/4/]	1971	2 536 616	3 821 916	1.5	1.2	1.8	0.37	0.68	100
Cameroon[3/5/]	1972	925 895	1 480 558	1.6	1.2	2.4	0.44	0.83	100
Gabon[3/]	1973-74	71 074	72 738	1.0	0.6	1.7	0.47	0.96	100
Ivory Coast[3/]	1973-74	549 708	2 753 491	5.0	3.6	7.3	0.42	0.81	100
Sierra Leone[3/6/]	1971	275 127	520 572	1.9	1.5	2.8	0.44	0.82	100
Togo[3/]	1970	232 657	...	...	0.9	...	...	...	...
Algeria	1973	899 545	5 544 145	6.2	2.1	19.2	0.72	1.51	100
Ghana[3/]	1970	805 200	...	...	1.4	...	...	...	...
Liberia[3/]	1971	121 745	365 673	3.0	0.9	17.6	0.73	1.56	100
Reunion[7/]	1972-73	39 111	77 231	2.0	...	4.1	0.70	1.46	96.62
Congo[3/]	1972	143 485	196 774	1.4	1.2	1.6	0.29	0.52	100

See Footnotes at end of Table.

Cont'd.

TOTAL NUMBER AND AREA OF HOLDINGS, CENTRAL AND STRUCTURAL CHARACTERISTICS BY COUNTRY[1/] (Cont'd)

Countries by continents	Census year	Total number of holdings	Total area of holdings (ha.)	Average size (ha.)	Median size for number (ha.)	Median size for area (ha.)	Concentration index	Estimated σ	Classifying area as % of total area [2/]
NORTH & CENTRAL AMERICA									
Guadeloupe[7/]	1972	22 577	62 465	2.8	1.2	5.9	0.66	1.28	100
Haiti	1971	616 710	863 520	1.4	0.8	2.2	0.50	0.96	100
Canada	1971	366 128	68 663 191	187.5	99.3	359.1	0.56	1.13	100
U.S.A.	1969	2 730 250	430 321 437	157.6	56.1	525.7	0.72	1.54	100
Costa Rica	1973	81 562	3 122 456	38.3	5.4	248.7	0.83	1.93	100
Dominican Rep.	1971	304 820	2 736 274	9.0	1.9	83.7	0.79	1.79	100
El Salvador[8/]	1971	270 868	1 451 894	5.4	1.0	47.9	0.81	1.86	100
Honduras	1974	195 341	2 629 859	13.5	2.9	69.8	0.78	1.76	100
Jamaica	1968-69	193 359	602 659	3.1	0.8	77.0	0.80	1.80	100
Panama[9/]	1971	105 272	2 098 062	19.9	4.6	86.2	0.78	1.71	100
Puerto Rico	1970	32 687	524 575	16.0	3.7	...	0.78	1.73	100
St. Lucia	1973-74	10 938	29 138	2.7	0.4	63.6	0.84	2.00	100
Virgin Islands (US)	1970	212	8 284	39.1	2.9	...	0.88	2.28	100

Cont'd

See Footnotes at end of Table.

TOTAL NUMBER AND AREA OF HOLDINGS, CENTRAL AND STRUCTURAL CHARACTERISTICS BY COUNTRY[1] (Cont'd)

Countries by continents	Census year	Total number of holdings	Total area of holdings (ha.)	Average size (ha.)	Median size for number (ha.)	Median size for area (ha.)	Concentration index	Estimated σ	Classifying area as % of total area [2]
SOUTH AMERICA									
Brazil	1970	4 924 019	294 145 466	59.7	9.3	524.0	0.84	1.98	100
Colombia	1970-71	1 176 811	30 993 190	26.3	3.3	287.0	0.86	2.09	100
Uruguay	1970	77 163	16 517 730	214.1	25.2	1335.6	0.82	1.91	100
Venezuela	1971	287 919	26 470 134	91.9	6.5	2 581.6	0.92	2.45	100
Suriname	1969	16 078	93 833	5.8	2.1	27.7	0.73	1.55	100
ASIA									
Japan [10]	1970	5 341 844	5 253 418	1.0	0.7	1.4	0.47	0.90	97.25
Korea, Rep.of [11]	1970	2 421 420	2 132 233	0.9	0.7	1.2	0.37	0.69	99.31
Philippines	1971	2 354 469	8 493 735	3.6	2.4	5.4	0.51	0.90	100
Bahrain	1973-74	855	3 702	4.3	2.6	7.4	0.52	1.00	100
India	1970-71	70 493 000	162 124 000	2.3	1.0	5.5	0.64	1.31	100
Indonesia	1973	14 375 343	16 393 826	1.1	0.5	2.3	0.62	1.21	100
Iraq	1971	591 178	5 732 481	9.7	5.1	21.6	0.65	1.26	100
Pakistan [12]	1972-73	3 761 688	19 854 311	5.3	3.4	8.5	0.52	0.97	100
Kuwait	1970	449	2 726	6.1	1.1	25.9	0.76	1.70	100
Saudi Arabia	1972	180 670	1 213 462	6.7	1.5	39.4	0.79	1.77	100

See Footnotes at end of Table.

Cont'd.

TOTAL NUMBER AND AREA OF HOLDINGS, CENTRAL AND STRUCTURAL CHARACTERISTICS BY COUNTRY[1] (Cont'd)

Countries by continents	Census year	Total number of holdings	Total area of holdings (ha.)	Average size (ha.)	Median size for number (ha.)	Median size for area (ha.)	Concentration index	Estimated σ	Classifying area as % of total area [2]
EUROPE									
Denmark[7]	1970	140 197	2 941 316	21.0	15.2	30.1	0.43	0.80	100
Finland[13]	1969	297 257	15 150 223	51.0	6.6	9.4	(0.26)	...	17.62
Greece[7]	1971	1 047 260	3 586 294	3.4	2.3	5.6	0.49	0.93	100
Malta	1969	10 803	15 899	1.5	...	2.7	0.49	0.93	100
Norway[7]	1969	154 977	955 333	6.2	4.2	9.2	0.45	0.87	100
Poland	1970	3 398 959	16 418 552	4.8	3.6	7.8	0.47	0.89	100
Yugoslavia	1969	2 600 140	12 462 422	4.8	2.7	7.5	0.58	1.08	100
Belgium[7]	1970	184 005	1 602 864	8.7	4.2	17.5	0.60	1.18	96.10
France[7]	1970-71	1 587 643	35 039 217	22.1	11.0	33.3	0.53	1.01	85.35
Germany, Fed.Rep.[7]	1971-73	1 074 637	15 236 139	14.2	7.3	20.5	0.51	0.97	83.03
Luxembourg[7]	1970	7 608	135 143	17.8	13.4	28.4	0.45	0.85	100
Netherlands[7]	1970	184 613	2 142 597	11.6	8.4	18.7	0.48	0.92	100
Sweden[13]	1971	161 946	10 589 946	65.4	10.0	16.0	(0.24)	...	28.63
Switzerland[14]	1969	152 859	1 292 110	8.5	5.8	14.2	0.51	0.99	98.39
Austria[14]	1970	362 216	7 490 463	20.7	7.3	48.2	0.70	1.44	89.66

Cont'd.

See Footnotes at end of Table.

TOTAL NUMBER AND AREA OF HOLDINGS, CENTRAL AND STRUCTURAL CHARACTERISTICS BY COUNTRY[1] (Cont'd)

Countries by continents	Census year	Total number of holdings	Total area of holdings (ha.)	Average size (ha.)	Median size for number (ha.)	Median size for area (ha.)	Concentration index	Estimated σ	Classifying area as % of total area [2]
Italy	1970	3 607 262	25 064 218	6.9	1.9	28.3	0.75	1.62	100
Portugal	1968	811 656	4 974 157	6.1	1.4	57.3	0.79	1.77	100
United Kingdom	1970	326 698	17 992 312	55.1	20.5	146.5	0.69	1.41	100
OCEANIA									
Australia	1971	249 485	497 223 700	1 993.0	137.5	...	0.89	2.31	100
Guam	1970	1 121	10 586	9.4	1.1	...	0.90	2.35	100
American Samoa	1970	1 923	4 212	2.2	...	3.8	0.53	1.02	100
Fiji	1968	33 521	...	...	3.7	...	...	...	...
New Zealand	1972	62 789	19 030 369	303.1	89.0	1307.0	0.75	1.62	100
Pacific Islands (Trust Territory)	1970	3 857	39 647	10.3	4.1	41.5	0.69	1.43	100

1/ Data are derived from the distribution of number and area of holdings by size of total area unless otherwise specified in footnotes.
2/ See page 2 for explanation.
3/ Classification by land under crops.
4/ Data relate to traditional sector only.
5/ Excluding 9 200 ha. of fallow land.
6/ Data relate to small holdings, and exclude 11 010 holdings of size not reported.
7/ Classification by agricultural area.
8/ Excluding 47 173 holdings without land.
9/ Excluding 10 092 holdings without land.
10/ Farm households only, and classification by cultivated area (land under crops and cultivated pastures).
11/ Classification by cropland.
12/ Excluding government holdings.
13/ Classification by arable land.
14/ Classification by productive land (agricultural land and wood or forest land).

ANNEX 2

SUMMARY OF SYMBOLS, NOTATION, TERMS AND DEFINITIONS

Definition of a lognormal distribution

Lognormal distribution is the distribution of a variate whose logarithm obeys the normal law of probability. A lognormal variate X is completely defined by two parameters: the mean μ and the variance σ^2 of the normal distribution Y = Log X. We then say that Y is $N(\mu, \sigma^2)$.

The variate Log X - μ is normally distributed with mean 0 and variance σ^2.

Median and mean of a lognormal distribution

The median of the variate X is the value x_m of X for which $P\{X < x_m\} = 0.5$ where P denotes the probability of the event $\{X < x_m\}$. It corresponds to Log $x_m - \mu = 0$, i.e., $x_m = e^{\mu}$.

Considering this relation, a lognormal distribution X can be assumed to be completely specified by the median of X and the variance of Y = Log X.

Definition of lognormal scales

The scales are said to be lognormal when the horizontal axis is logarithmically graduated and the vertical axis is graduated according to the distribution function of the normal law of probability (0 to 100 percent).

Graphic properties of a lognormal distribution

On lognormal scales, the points representing the distribution function of a lognormal variate lie on a straight line. The slope of the line is an inverse function of the parameter σ.

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