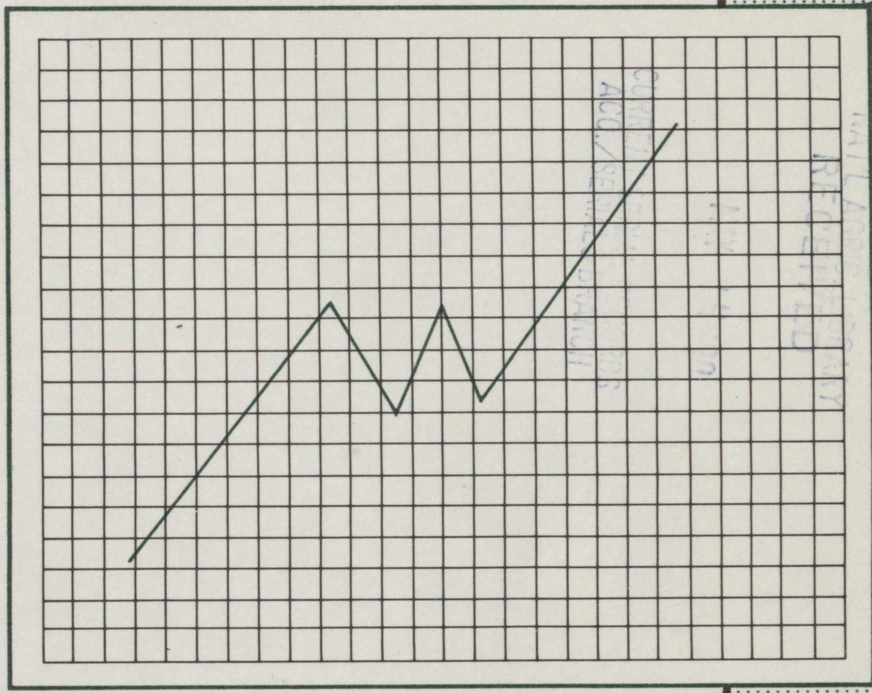

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ANNOUNCEMENTS, COMMENTS AND NOTES

COMMENT

TESTING FOR STOCHASTIC DOMINANCE

Reply to comment (research note) by J. van Zyl and J.A. Groenewald*

INTRODUCTION

In a research note with respect to testing for stochastic dominance Koen & Daniel (1988) conclude that the results of the computer program of Anderson *et al.* (1977) are unnecessarily pessimistic: the set of undominated options may be considerably smaller than that given by the program. This conclusion is reached as a result of an analysis in which they compared the results of Van Zyl & Groenewald (1986) with respect to maize cultivar selection under conditions of risk with results obtained by an alternative computer program developed by themselves (Koen & Daniel 1988). In nature the research note is thus a comment on the article by Van Zyl & Groenewald (1986) rather than independent research.

In this reply, the contentions (allegations) of Koen & Daniel (1988) are critically evaluated with respect to their assumptions, methodology and conclusions. This is done by specifically referring to the elements of approximation and judgement in the comparison of derived functions, the data source used by Koen & Daniel (1988) and a comparison of results obtained with the program of Koen & Daniel (1988) and that of Anderson *et al* (1977) if the same data are used. In conclusion, some allegations/contentions of Koen & Daniel (1988) are evaluated.

ELEMENTS OF JUDGEMENT AND APPROXIMATION IN THE COMPARISON OF DERIVED FUNCTIONS

According to Van Zyl & Groenewald (1986) an element of judgement and approximation is necessary in the comparison of derived functions irrespective of whether the method of integration is numerical or analytical in nature. Koen & Daniel (1988) again, are of the opinion that such a statement ignores the fact that one is dealing with statistical data sets. They contend further that arbitrary approximations are not allowable if the data are to be acceptable representations of the underlying population.

This contention does not recognise the nature and character of research. Research involves testing of hypotheses. Hypotheses are based on theory as it has developed over a long time. Heady (1949) states that the role of theory can hardly be restricted as a guide for empirical research and the interpretation of results. Theory is indispensible for the creation of a model, the logics used, the hypotheses and the construction of a research pattern (Heady, 1949).

Theory, in its turn, consists of a set of definitions and statements concerning relationships among defined characteristics. These statements also indicate expected changes in one set of variable characteristics in response to changes in another set of variable characteristics. Different types of statements exist (Groenewald, 1973; Halter & Jack, 1961).

The importance of definitions cannot be underrated in the practice of science. What is a triangle? It is the definition of a triangle that gives substance to it. Even if a triangle would not exist in reality, it still has substance to the mathematician, since it has the defined characteristics of a triangle and not those of a circle (Descartes, 1960) (note that Descartes lived in the seventeeth century). Thus, for example, unreal numbers, e.g. $(-16)^{1/2}$ have meaning to the mathematician.

In drawing up hypotheses, researchers often encounter problems with definitions as established by theory. Instruments to provide measurements of the theoretical (nominal) definitions are necessary. Measurement problems, however, cause researchers to use operational definitions. The operational definitions may correspond completely with nominal definitions. It can also have a smaller, more comprehensive or overlapping content (Groenewald, 1973; Zetterberg, 1954). The choice of operational definitions and *mutatis mutandem* data series, are thus clearly left to the judgement of the researcher. Different choices can lead to differences in results. The closer the correspondence of the operational definition with the nominal definition, the closer results can correspond with reality. As will be shown later, Koen & Daniel (1988) used different operational definitions from those used by Van Zyl & Groenewald (1986), and identical answers would not necessarily follow even with the same methods.

Researchers also use judgement in their choice of data, given their operational definition. No experimental design, sampling or data gathering

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takes place without prior judgement on the part of a researcher. The same is true with the choice of a statistical model or the shape thereof. In many cases the general hypothesised form of a relationship is known, but not the precise shape (Boulding, 1958). This often leads to the performing of different statistical fits, followed by a choice of one after evaluation of results. Sometimes, for example, the "best" statistical fit is accepted. There is also judgement in the choice of acceptance or rejection criteria. There is, for example, nothing intrinsic in the choice of significance levels (1 %, 5 %, 10 %, etc.). This is merely a subject of subjective judgement on the part of the researcher.

In the interpretation of results theory and judgement also play an indispensable role; the researcher must be guided by already existing knowledge. Only by this is the constancy of natural laws guaranteed (Schroedinger, 1935). The generalisation of knowledge, and thus the conclusions are part of the intellectual environment in which the researcher finds himself; it is not grounded in the nature of things, but in the reaction of the researcher (Schroedinger, 1935; Parsons 1949).

It must also be kept in mind that almost no data set is perfect. Sampling errors, errors of measurement and calibration problems are as old as empirical research itself. Here judgement plays a deciding role. The handling of outliers is only one situation about which sharp controversies occur at times. Therefore, to state, as was done by Koen & Daniel (1988) that arbitrary approaches are not permissible if data should be acceptable presentations of a population, is not realistic. No empirical research is possible without some level of arbitration; the decision on whether the data is acceptable is already arbitrary. Their own choice of a data series was already an arbitrary one.

At this stage it is necessary to first examine the data sets more closely. Maize cultivar yield at four experiment locations for nine cultivars over a period of fourteen years form the basis of the analyses (at this stage this is assumed to be true - the difference between yields and margins is explained later). The first question is whether the data are acceptable representations of the underlying population. Koen & Daniel (1988) are obviously of the opinion that this is indeed the case, and they furthermore also apparently make the arbitrary assumption that yield distributions of maize cultivars are discrete.

Because the concerned observations are based on data of only 14 years, it may however be that the data are not acceptable representations of the underlying population. Anderson (1974a) writes as follows in this regard: "Obviously, chances of success (in that an estimated CDF will be very similar to the parent) increase as sample size increases, but even with a "good" size of a dozen or so, estimates are sometimes quite wide of the mark; although in the absence of any other historical or subjective information, they are still the best one can do." Such a CDF is therefore nothing more than an approximation of a scarce data situation and consequently a degree of subjectivity is relevant. Test sample errors may be present. Anderson *et al* (1977) conclude the following in this regard: "As for any subjective probability, different judgements will be made by different analysts... At any rate sparse data CDFs will be a better stochastic representation than those obtained by assuming, for example, that the few observations represent an exhaustive equally likely discrete listing of states."

Several excellent programs for determining stochastic dominant selections from discrete distributions are available, also for comparison with other decision-making criteria (Porter, 1973; Porter *et al*, 1973; Porter & Gaumnitz, 1972; Levy & Sarnat, 1971). The program of Koen & Daniel (1988) is probably an addition to this list. However, it must again be accentuated that only 14 observations for each cultivar were available and that these observations in no way represent a representative sample of the underlying population, or in any way make such a claim. The underlying distribution of cultivar yields anyway tends to be continuous rather than discrete and often, as in this case, the mathematical form is unknown. It is however statistically possible to fit a function, but this is also only an approximation because only a "best fit" is obtained and such an approach is often subjective in nature.

In the approach used by Van Zyl & Groenewald (1986) (and also Anderson, 1974b) the subjective nature and limited reliability of any method under the above conditions are acknowledged, and therefore a mathematical approximation is used that is suitable for efficiency analysis by representation of the CDF by linear segments that represent equal segments of probability. Although it is continually explicitly stated that this method represents an approximation of the CDF (Van Zyl & Groenewald, 1986), it avoids the pitfall of an implicit assumption that the small number of available observations represent an exhaustive set of discrete outcomes with an equally likely chance of occurrence. The method of Koen & Daniel (1988) apparently relies heavily on this assumption and thus also includes similarly to Van Zyl & Groenewald (1986), elements of judgement and subjectivity, although it is not explicitly mentioned and largely ignored. The authors of this reply are therefore of the opinion that the approach of Koen & Daniel (1988) exhibits certain inherent deficiencies and the approach of Anderson (1974b) is a better representation of reality, irrespective of the explicitly subjective nature thereof. Van Rooyen (1983) and Hough (1986) also share this opinion in that both use the same method for the determination of stochastic dominance.

In this respect it also appears that Koen & Daniel (1988) assume that one has to do with absolute certainty of results. This is however not the case. The following quotation from Steel and Torrie (1960) illustrates the principle: "Objective evaluation of a hypothesis poses problems. Thus it is not possible to observe all conceiveable events and, since laws of cause and effect are generally unknown, variation will exist among those which are observed ..... The only thing we can muster by way of proof is *proof beyond a reasonable doubt*." The choice of a significance or reliability level is, as already mentioned, subjective in nature. Spurr, Kellogg & Smith (1961) have the following opinion about this: "In practice, the final choice of the value of critical probability represents some compromise between two risks. It must be arrived at by balancing consequences of a Type 1 error against the possible consequences of a Type 2 error." Griffin (1962:47) supports the subjective nature of this balancing of consequences. With respect to a choice of significance level, Manderscheid (1965) remarks that it is a conscious choice grounded in the principles of management and statistical theory. These limited examples illustrate the subjective nature of hypothesis testing and accentuate the uncertainty in results.

DATA SOURCES

Koen & Daniel (1988) used their program to select stochastic dominant cultivars. These results were consequently compared with the results reported by Van Zyl & Groenewald (1986). The first-mentioned selection was done with respect to yield data as provided by Van Zyl *et al* (1986). The comparison was made under the assumption that these yield data formed the basis of the "above average management" calculations in the analysis of Van Zyl & Groenewald (1986).

This assumption is however completely wrong. Van Zyl & Groenewald (1986) repeatedly mention that gross margins of the respective cultivars are used as basis for their calculations. It is indeed also shown in the table where stochastic dominant cultivars were listed, a table which was also published by Koen & Daniel (1988). The purpose of another article by Van Zyl *et al* (1986) was indeed to determine differential optimum fertilisation levels for different cultivars in order to use gross margins for decision-making under conditions of risk. Different maize cultivars react differently to fertilisation; differential fertilisation levels thus potentially have a large effect on profit from maize and also on optimal cultivar selection. By evaluating only yield sub-optimal cultivar selections (in an economic sense) may well be made (Van Zyl *et al*, 1986; Anderson *et al*, 1977). It is important to note that the use of gross margins reduces differences between cultivars; a higher yield also does not necessarily represent a higher gross margin; on the contrary, in several cases a cultivar with a higher yield yields a lower gross margin because of higher fertiliser application. The gross margins on which the results of Van Zyl & Groenewald (1988) are based, were not published.

From the above discussion it appears that the results of Van Zyl & Groenewald (1986) and those of Koen & Daniel (1988) are in no way comparable because they are based on completely different data series. Stated in the terminology used above, different operational definitions were used. We contend that the definition of Van Zyl & Groenewald (1986) complies better with the nominal definition which is concerned with profitability. The comparison of results as in Table 1 of Koen & Daniel (1988) is thus irrelevant. The conclusions derived therefrom are incorrect and misleading.

COMPARISON OF METHODS

The methods of Anderson (1974b) and Koen & Daniel (1988) can be compared only if applied to the same data series. In Figures 1 and 2 of the research note by Koen & Daniel (1988) a comparison of the

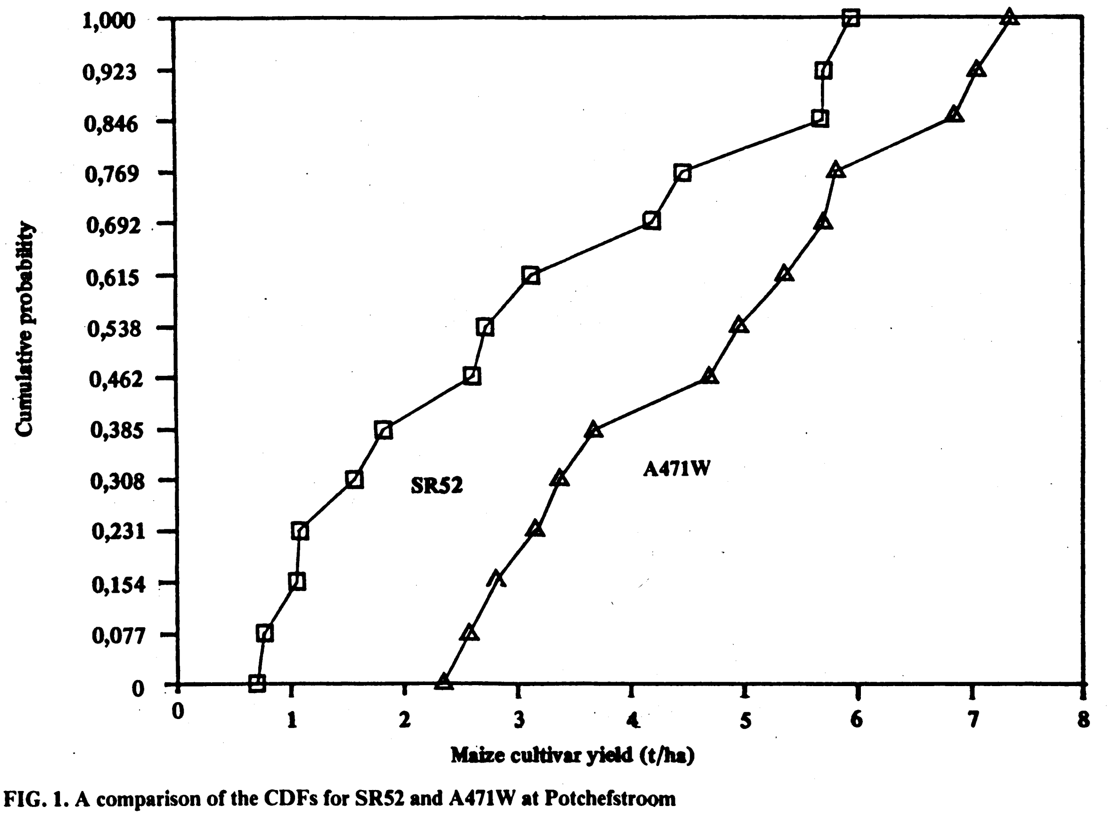

FIG. 1. A comparison of the CDFs for SR52 and A471W at Potchefstroom

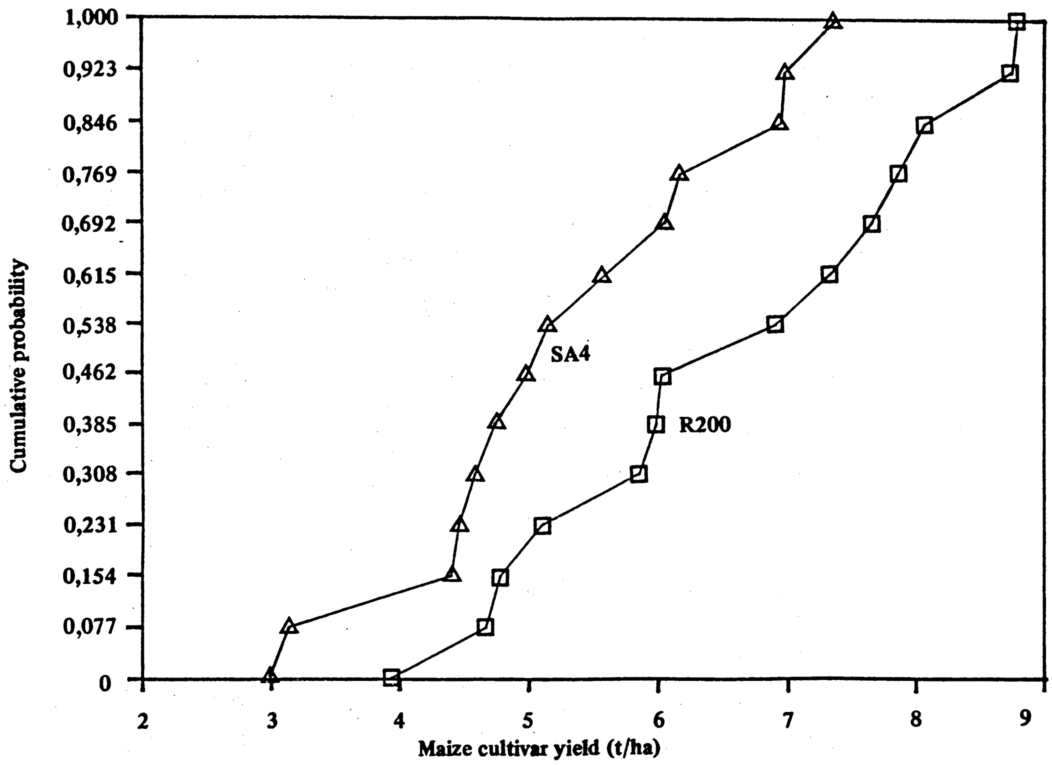

FIG. 2. A comparison of the CDFs for SA4 and R200 at Cedara

CDFs for SR52 and A471W at Potchefstroom and R200 and SA4 at Cedara, is made.

In order to obtain comparable results, the same figures are also drawn with the use of the method of Anderson (1974b). In both cases the yield data provided by Van Zyl *et al*, (1986) are used. The results are shown in Figures 1 and 2, and are directly comparable with the corresponding figures of Koen & Daniel (1988).

According to Figures 1 and 2 it appears that the two methods do indeed yield different results. The CDFs of Koen & Daniel (1988) have a stepwise shape because of the already mentioned implicit subjective assumptions; the key characteristic of the method of Anderson (1974b) is the representation of the CDFs by linear segments that represent equal intervals of probability. What is of more importance, is that if the same data source is used, the results obtained with the respective methods correspond with regard to stochastic dominance in these cases. It is however also clear that two methods can, at higher degrees of dominance, thus where CDFs intersect once or more, sometimes yield different dominant selections. However, this is the exception rather than the rule. In these cases the present authors still prefer the results obtained with the method of Anderson (1974b) because, as has already been mentioned, it is probably a better approximation of the underlying continual yield population.

CONCLUSION

The purpose with this reply was to critically evaluate the allegations of Koen & Daniel (1988) with reference to their assumptions, methodology and conclusions. It appears from the previous discussion that their method, as indeed practically any empirical approach, contains implicit subjective assumptions. In their case, these assumptions largely ignored the underlying population characteristics with respect to cultivar selection. The methodology followed is also wrong and shows a lack of insight in the scientific method. Repeated assumptions and the specified methodology were completely missed or ignored and incomparable results were compared. Their conclusions are therefore irrelevant and misleading. The contribution of this research note to the existing literature on stochastic dominance is thus limited. What it does however illustrate is the value of knowledge concerning the application of theoretical principles. Before theoretical principles can be used in agriculture, a basic knowledge of realities in agriculture, as well as knowledge of the basic concepts of agricultural economics (for example gross margin), is necessary.

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NOTE

THE DENDROGRAM: AN EXPLORATORY TECHNIQUE FOR ANALYSIS OF QUANTITATIVE AND QUALITATIVE DATA SETS

Research note by J. Behr*, C.F. Smit and J.A. Groenewald****

ABSTRACT

Dendrograms can be utilised to order data sets and to identify structural relationships. Automatic interaction detection routines are available for situations with qualitative (categorical) predictors and quantitative (continuous) response variables. The XAID routine was successfully used to construct a dendrogram in order to determine which factors (predictors) make the most important contributions to the percentage revenue (response) farmers derive from game farming activities.

INTRODUCTION

In some situations, researchers are confronted with the problem to order data patterns and to identify structural relationships among variables. The problem is sometimes particularly difficult in situations which have not been examined previously and where previous results can therefore not be used as guide. It is, in addition, often necessary to accommodate quantitative and qualitative data simultaneously.

The construction of dendrograms can in such situations be used as an exploratory technique. A dendrogram is constructed by a so-called AID procedure ("Automatic Interaction Detection") according to which the outcome of a dependent variable Y (response) can be predicted, based on those independent variables (predictors) which have the largest effect on variation in Y.

Two situational types occur: The dependent variable may be qualitative (categorical) or quantitative (continuous). The independent variables are categorical in either case.

When both the dependent and independent variables are qualitative in nature, the CHAID computer routine, as developed by Prof G.W. Kass of the University of the Witwatersrand (Du Toit *et al.*, 1986) can be used. An example could be an opinion survey in which respondents may give a response of "Yes", "No" or "Don't know" and where the opinion may be influenced by educational level, sex and population group.

If the independent variables are qualitative and the dependent variable is quantitative (continuous), the XAID routine, as developed by C. Heyman of the CSIR (Du Toit *et al.*, 1986) is suitable for the purpose.

In both the CHAID and XAID routines the data set is subdivided into subgroups according to the extent to which each independent variable contributes to the explanation of variation in the dependent variable. The division occurs at different levels, and the independent variable which statistically has the most significant effect on the dependent variable, segregates data into subgroups at

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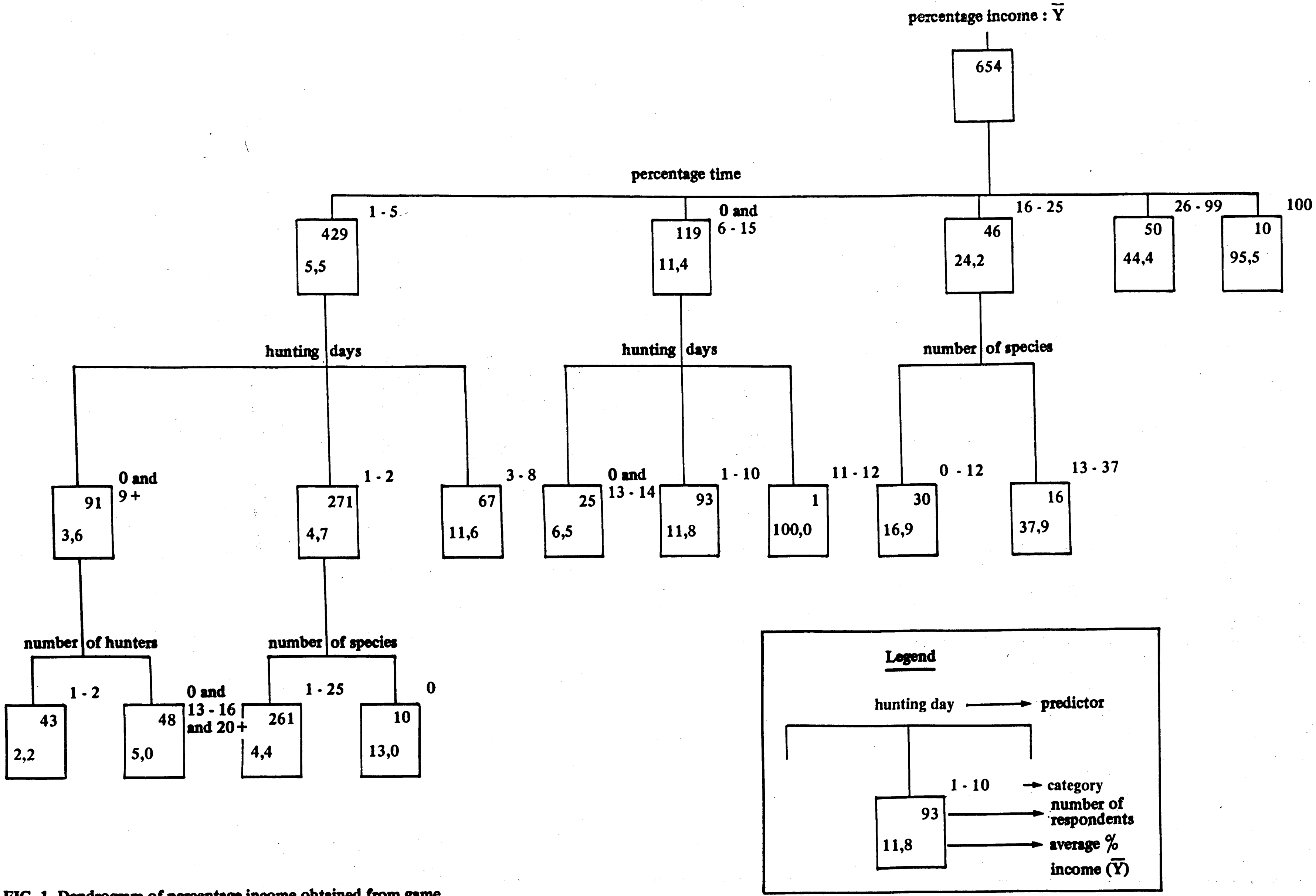

FIG. 1. Dendrogram of percentage income obtained from game

the first division level. The process is continued by segregating each first level subgroup according to the most significant independent variable among the remaining variables. Each division level therefore brings about further branching. The technique is continued at all branches until no further significant segregation is possible. Figure 1 provides a schematic presentation of the process.

A XAID APPLICATION

XAID was applied to a sample of 654 game farmers who responded to a mail questionnaire. An effort was made to determine which independent variables made the largest contributions to the percentage of gross income derived from game farming (dependent variable). The following were considered as possible independent variables:

Percentage of operator's management time devoted to game

Number of game species on farm

Number of hunters handled at a given time

Farm size, divided into categories (size groups according to hectares)

Number of hunting days per hunting reservation.

Subgroups of each predictor are formed as follows:

Each category of a predictor initially forms a subgroup and t tests are used to determine which subgroups may be added together to form homogeneous subgroups. The process is continued until all subgroups consist of categories in which mean Y values do not differ significantly within groups, but do so among groups.

The procedure is computationally intensive and was executed on the main frame computer of the University of Pretoria with the aid of the program developed by C. Heyman (Du Toit *et. al.*, 1986). A dendrogram was constructed from the computer printout (Figure 1).

The dendrogram shows the following concerning percentage of gross income derived from game:

- Percentage of time devoted by the farmer to game farming is the most important predictor. A reasonably monotonic increasing relationship exists between percentage time and percentage income. The more time the farmer devotes to his game enterprise, the higher the percentage contribution from that to the income (see first division level of the dendrogram).
- Hunting days, number of species and number of hunters are also significant variables in decreasing order of importance (second and subsequent division levels).
  - There is an interaction between time and the most important remaining variables on the second level (see also last • below).
  - An interaction also exists at the lowest category of time bestowal between hunting days and the most important remaining variable on the third level. Different groupings of hunting days have different significant subdivisions.
  - In the upper middle income group ($\overline{Y}$=24,2) an increasing relationship exists between number of species and percentage income.
- In the two lower income percentage groups ($\overline{Y}$<11,4) and where 15% or less of time is spent on game farming, the diagram gives the impression that an optimum relationship exists between hunting days and income contribution; there are upper and lower limits to hunting days. The following is noticed in particular:
In the groups with the smallest mean percentage time ($\overline{Y}$=5,5%) the optimum point occurs between 3 and 8 days with an estimated mean income contribution of 11,6%. If sojourn exceeds 8 days, income contribution may decline to an estimated 3,6%. The same tendency is observed in the middle group ($\overline{Y}$=11,4%). In this case the optimum number of days is however between 1 and 10 days with a mean revenue contribution of 11,8% and the revenue contribution declines to an estimated 6,5% if days increase to 13 or 14. It must however be mentioned that in the last case there is only one observation for hunting days between 11 and 12, and this observation may realistically be ignored.

CONCLUSION

It appears that the XAID routine was successful to determine, in the case of game farming, which factors made the most important contributions to relative income contributions from game.

This investigation was exploratory in nature and further analyses can be based thereupon provided data are available. The XAID analysis creates a framework within which such subsequent analyses can be made.

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