PROCEEDINGS OF THE SYMPOSIUM ON 'DESIGNS AND SELECTION PROCEDURES FOR ANIMAL EXPERIMENTS'

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A total of five papers were submitted. These can be divided into two categories (*i*) designs for animal experiments and (*ii*) selection procedures useful in animal experimentation. The papers by Dr. Prem Narain and Dr. A. Dey fell in the first category whereas the papers from Dr. J. V. Deshpande, Dr. Govind P. Mehta and Dr. O.P. Bagai dealt with the problems related with selection procedures.

After the Chairman's opening remarks the speakers presented their papers. The paper by Dr. A. Dey was presented by Dr. A.K. Nigam.

The paper by Dr. Prem Narain presented an excellent account of the status of animal experimentation in the country and proposed various remedial measures for improvement. It was pointed out that about 87 percent of the cases the design adopted was completely randomized design. In over 50 percent of such cases, the coefficient of variation was found to be quite high. This situation did not improve even when randomized block design was used. A remedial measure suggested to deal with this problem is to use *nearest-kin* models. This is based upon using covariance technique by utilising the information on closest relatives. Another measure suggested is to use designs with nested blocks to account for several sources of variation. Use of cyclic and supplemented block designs is also advocated either because of experimental requirement or because, sometimes, it leads to increased precision. The use of gradient analysis of latin square designs is suggested whenever the two cross sources of variation are not at right angles.

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It is further pointed out that the design points of response surface experiments were, in most cases, chosen arbitrarily. Such experiments are useful particularly in feeding trials where the objective is either to find an optimal feeding mix or to explore the possibility of substituting one feed by the other. Majority of the trials conducted were of the former type wherein several feeding mixtures consisting of varying proportions of various forms of concentrates and roughages were tried. A close look into these experiments revealed that neither the designs were properly selected nor these were properly analysed. These experiments should be analysed as mixture experiments which were introduced by Scheffe' in 1958. These are different from the usual response surface experiments in the sense that the regression coefficients of the polynomial models get confound with the general mean effect and with other coefficients of the model.

The paper by Dr. A. Dey reviewed the important work done on change-over designs. His paper was presented by Dr. A.K. Nigam. The review is quite exhaustive and is a good handout for any scientist engaged in this branch of research. A feature of the paper was to highlight the difference between the two commonly misunderstood notions of balance viz., the combinatorial balance and the variance balance.

The paper by Dr. J.V. Despande was the first in the series of two papers on ranking and selection procedures. It was pointed out that the scope of the F-test in the ANOVA of any designed experiment is limited only to testing whether the differences amongst the treatments are significant or not. In most situations, however, the experimenter is interested in ranking the treatments or selecting the treatment with the largest or smallest effect. Two approaches are available in literature to deal with above situations. These are. the subset selection approach and the indifference zone approach The paper by Dr. Deshpande describes the first approach which utilises the available observations and selects all those populations whose sample means are within a specified distance from the largest mean. In the indifference approach, which is described in the paper by Dr. Mehta, it is possible to select the best treatment which is better than the second test by an amount atleast say d*. It is also possible to determine the least number of observations to be taken on each treatment for specified values of d* and P*, the infinum of the probability of correct selection. The methods of both the papers have been illustrated through an experiment involving six treatments each replicated four times.

In both the papers, it is stated that several generalizations to the problem are available in literature. Selection procedures are also known for the location and scale parameters of many distributions other than normal. It is also possible to select some or all the treatments better than a given (known or unknown) treatment.

In the third paper on selection procedures, Dr. O.P. Bagai dealt with the problem of selecting the best population and clustering procedures from amongst k multivariate normal populations. If the overall hypothesis of equality of k mean vectors is rejected, the next course of action could be either to select the best population, or to form clusters of like populations. The best population can be selected based on either a linear combination of means or a Mahalanobis Distance from origin. The two methods are illustrated through data from a study of harmonal induction of lactation in cows.

The presentation of papers was followed by discussion. Dr. B.K. Sinha and Dr. Rahul Mukherjee of I.S.I., Calcutta pointed out that some work was already in progress at ISI on optimiality of serially balanced designs. On selection procedures, Dr. K.C. Seal of C.S.O. raised the problem of choosing an appropriate value of d, which may be robust with regard to the assumptions on the underlying distribution. Dr. G.K. Shukla of I.I.T. Kanpur was of the view that although choosing the treatment with highest mean effect and smallest standard error may be ideal, from farmer's point of view it would be sufficient to choosed treatment even with moderate average effect if it is highly stable.

The detailed summaries of the papers are as follows.

1. Status of Animal Experimentation in India and Remedial Measures for Their Improvement

BY

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Although efforts have been made in the past to introduce the principles of design of experiments in the field of animal husbandry, the impact has been very slow. Animal scientists still hesitate to adopt sound experimental designs and remain content with the simplest design such as completely randomised design. In some areas of animal sciences such as animal sciences such as animal physiology, animal reproduction, epidemiology and disease control, appropriate statistical principles are not necessarily applied. In this paper, therefore, we examine the status of animal experimentation in India with the help of information generated under one of the IASRI Project entitled 'National Index of Animal Experiments'. We also study the extent to which conducted experiments have been able to control experimental errors and suggest possible remedial measures to improve upon them. We do not cover the areas of animal breeding since the impact of statistical methods in this field has been rather substantial. Such experiments are usually long term mostly involving principles of statistical genetics and careful recording of data.

Status of Experimentation

Animal experimentation is carried out in several areas of animal sciences such as animal nutrition, animal physiology, animal reproduction, epdemiology and disease control. However, statistically planned experiments in India seem to have been mostly related to animal nutrition. Here experimentation has proceed mainly on the following types ;

(*a*) Determination of nutrients for growth, production and maintenance—These are mostly non-factorial type and involve designs as C.R.D., R.B.D., Latin Square, Switchover and Switch-back.

(*b*) Determination of optimum proportion of concentrates and roughages to provide the requisite nutrients for growth, production and maintenance—These are essentially feeding trials mostly factorial type and variables.

(*c*) Determination of marginal substitution rates of one ingradient by another in animal feeds. These are mostly factorial experiments and also involve response surface design.

(*d*) Determination of economic rations which are iso-calorie, iso-protein and equi-potent—These are mostly non-factorial and involve conventional designs as in (a).

It is revealed from the past studies that for types (a) and (d) the most widely used design is CRD, there being 86-87 per cent experiments based on such a design. This is the simplest design requiring small number of animals and is very easy to adopt in practice. But it is not efficient. For experiments of type (*b*), factorial experiments with response surface but without any blocking were mostly used. Studies made at IASRI indicate that in 30 per cent of cases, designs adopted were proper so that quadratic response surface with two or three factors could be fitted. For type (*c*) experiments, factorial structure laid out in C.R.D was mostly adopted. IASRI studies indicate that hardly 50 experiments out of about 2,500 experiments conducted were such that response surface could be fitted to estimate the marginal substitution rates of concentrates mixture by another cheap source.

Again, in over 50 per cent of the cases where CRD was used, the C.V. was higher than 15 per cent. The same is true for RBD which shows that blocking had not been effective. It is also found in such cases that power of inference drawn was less than 0.7. Apparently, the situation is far from satisfactory and corrective measures are called for.

Studies made at IASRI further indicate that for characters like growth and milk production, the C.V.'s differ widely when animals of different age or stage of lactation are kept on uniform feeding regime.

To remedy the above situations, suggestions for using nearest-kin models, incomplete block designs, gradient analysis of latin squares designs, and response surface designs, have been put forward. Fruitful collaboration between statisticians and animal scientists is advocated as the way to improve the status of animal experimentation in India.

2. Topics in Change—Over Designs

BY

A. DEY

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Designs in which each experimental unit receives a cyclical sequence of several treatments in successive periods of time are commonly known as *Change—over designs* or *Repeated Measurements* designs. These designs have been used in several fields of research viz., in animal nutrition experiments, in clinical trails in medical research, in psychological experiments, in long term agricultural field experiments and bio-assays. These designs are particularly useful in situations where the experimental units are rather variable or are expensive and scares.

Change—over designs are conveniently divided into two categories :

(*i*) Cyclical types, in which all treatments in a sequence applied to a given experimental unit are different, and

(*ii*) The reveral or switch-back types, in which a treatments appearing early in a sequence appears again in the same sequence at a later period.

In what follows, we deal with the first type of situation in some detail and briefly touch upon the reversal type of experiments.

In experiments, where the treatments are applied in sequence to the same experimental unit (e.g. animal, store, field plot etc,) it is likely that the effect of certain treatments continues even after the application of the treatment is discontinued. That is, the observation in a given period of a sequence may be affected not only by the direct effect of the treatment appearing in that period but also the carry-over of residual effect (*s*) of the previous treatment (*s*) in the same sequence. Residual effects may be of different magnitudes. Residuala, which presist for only one succeeding period are called *First Order Residual Effects* or, simply, First Residual Effects. In general, the k-th order residual sffects is one which persists upto and including k successive periods.

Change—over designs are generally capable of providing treatment comparisons of high precision because they eliminate the difference among experimental units from the error variation. This advantage, of course, is offset by the possible complications that arise in view of the presence of residual effects. One of the ways of getting rid of the complications (in analysis) due to the presence of residual effects is to insert a rest period between successive experimental periods, such that residual effects, if any, may wear out during the rest period. However, it is neither always feasible nor advisable to follow this procedure. Alternatively, provision for the separation of direct and residual effects can be made by suitably designing the experiment, that is, to choose an appropriate set of sequences. This method, although results in some loss in precision, the loss is not serious, especially when the residual effects are small in magnitude and do not persist for more than one succeeding period after application (of Patterson and Lucas, 1962). Consequently, much of the work on Change—over designs has been directed towards finding appropriate treatment sequence which allow the estimation of direct and residual effects, with some degree of *balance.*

The purpose of this communication is to give an account of the important developments that have taken place in the area of design and analysis of change-over trials. The concept of, balancing in change-over designs is discussed and conditions for balance are sent out. One section deals with balanced change-over designs which have as many experimental periods as there are treatments. Obviously, in many experimental situations, it may not be possible to have as many periods as there are treatments, especially if the number of treatments is large. Balance designs in which the number of treatments is larger than the number of periods are also studied. Some other classes of change—over designs are discussed under the terminology of partially—balanced designs. All the designs discussed are suitable for cyclical type of trials. The reversal type of trials and balanced designs for such trials are also discussed (including extra-period designs). In many situations, interactions between treatments and periods might exist. Designs for estimating such interactions with high degree of precision and studied next. Balanced designs in the presence of higher—order residual effects (e.g. first and second order residuals) some other developments are briefly discussed.

3. Simultaneous Inferense and Selection Proceduers-III

BY

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Consider k independent random samples, each of size n, from k normal populations $N(\mu_i^2, \sigma_i^2)$, $i=1, 2, \ldots\ldots, k$. Again the interest is in the population associated with largest mean. A subject selection approach is used, whereby we select a subset (of random size) of the k populations such that it includes the best population with some preassigned probability P^*, $(\frac{1}{k} < P^* < 1)$. With this approach one selects those populations which are close to the best and makes use of the available observations. The cases of equal and known variance; equal but unknown variance; and unequal and unknown variances are discussed. For the case of unknown equal variance, it is seen that one can not only deal with the selection problem but one can at the same time obtain simultaneous confidence intervals for distances of the k populations from the best population. An example demonstrates the use of these selection procedures to data obtained from animal experiments.

4. Simultaneous Inference and Selection Procedures-II

BY

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Suppose k independent samples, each of size n, are available from k normal populations $N(\mu_i, \sigma^2)$, $i=1, 2, \ldots, k$ where σ^2 is assumed to be known. Let us call the populations with the largest mean to be the 'best' population the one with the second largest mean to the second best; and so on. A procedure is discussed to select the best population from the k populations. If the best-population is, in fact, selected, we call this to be a correct selection. The in difference zone approach is followed to achieve a probability of correct selection not less than a preassigned number, P^* $(\frac{1}{k} < P^* < 1)$. An expression for the smallest sample size required to achieve the least probability of correct selection (P^*) is obtained. An extension of this procedure to the case of selecting t (where t is predetermined $1 \leqslant i < k$) best populations is explained. An example illustrates the use of this procedure in a situation dealing with animal experiments.

In case population variances are unknown and equal or unequal two-stage selection procedures are used. The probability of correct selection in this case does not depend upon the unknown population variances.

5. Simultaneous Inference and Selection Procedures-I

BY

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In practice one often faces situations in which one needs to compare many available varieties. These may be varieties of wheat; drugs for the same ailment; different chicken stocks; sires (comparisons in terms of transmitting ability); cows (comparisons interms of lactation yield), etc, etc. Often one uses standard analysis of variance techniques merely to conclude whether these varieties are identical or not. Irrespective of the decision reached by analysis of variance, the varieties are almost never identical and hence the experimentor is still interested in obtaining (simultaneous) confidence intervals for individual population means, for differences between means as well as picking out the best variety.

In this series of lectures we are dealing with such post-ANOVA techniques of data analysis. In this lecture we discuss the procedures of Tukey and of Scheffe for obtaining simultaneous confidence intervals for pairwise differences of means and for differences of means of the treatments from the mean of the control population, in one-way analysis dealing with uni-and multi-variate observations. An illustrative example regarding animal experiments follows to demonstrate the use of these procedures.