ABSTRACTS OF PAPERS PRESENTED AT THE 27th ANNUAL CONFERENCE HELD IN NEW DELHI IN APRIL, 1974

1. On Replicated Samples Drawn with Rao, Hartley and Cochran's Scheme

By

RAVINDRA SINGH AND BALJINDER SINGH

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The efficiency of the estimate (Y_e) of population total based on equal sized replicated samples of the primary stage units drawn with Rao, Hartley and Cochran's (1962) sampling procedure has been compared with the estimate (Y_u) based on replicated samples of unequal sizes and drawn with the same selection procedure. A condition for the estimate Y_u to be more efficient than the estimate Y_e, has been obtained. The case considered by Koop (1967) is shown to be a particular case of this investigation. For single-stage sampling the estimate Y_u is shown to be always more efficient than the estimate Y_e.

2. On a Class of Probability Sampling Schemes

By

SUKHDEV SHARMA

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In this paper, a new class of sampling schemes has been developed. This scheme is similar to an ordinary systematic sampling with a difference that for an integer k, such that $N=nk$, a random start r_0 between 1 and k is selected ; then we bring in a decision criterion d at each of the units r_0+qk, $q=0, 1, \ldots \ldots n-1$. The decision criterion either suggests (*i*) the selection of that unit, or (*ii*) the selection of any of the previous $k-1$ units. Assuming that the population units are arranged on a circle, we have obtained the estimator of the population mean and its variance under the scheme. In this class, the variance is always estimable except for two members of

which the first one is infact, the systematic sampling where d is such that the probability of (i) is 1, and the other one corresponds to the case where the probability of (ii) is zero. An attempt has, therefore, been made to estimate the variance of systematic sampling estimator as limiting case of the estimators of variance under the new class of schemes.

3. Pre-harvest Forecast of Forage Production in a Pasture of Dicanthium Annulatum

By

R. K. BOHRA

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Methods for indirect assessment of pasture production are extremely useful for range management and animal production. Various techniques for such assessments have been described by the research workers for different types of pastures. (Wilm et, al. (1944); Pastro et. al. 1957 ; Evans and Jones, 1958 ; Bohra et. al. 1969). To evolve a suitable method for assessing the production potential of the grasses of arid and semi-arid regions in India, a study on the inter-relationship between various growth characters and foraget yield of a parental grass *Dicanthium Annulatum* has been made. The present paper deals with 2 main aspects of the study, *viz.* (i) selection of the physical characters of the plants which are highly correlated with forage yield, and (ii) description of a simple method based on Experiment Evidence, to forecast the forage yield. The study has revealed that measurements on plant height and number of tillers on a random sample of these plants are sufficient enough for pre-harvest forecasting of the forage yield in such pastures with sufficiently high degree of reliance.

4. A Sampling Scheme with Varying Probability without Replacement

By

PADAM SINGH AND R. SINGH

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In the present paper a varying probability without replacement sampling scheme has been suggested. The selection procedure under

the suggested scheme consists of the following steps :

Step I : Select a sample of size n_1 by usual P. P. S. systematic sampling.

Step II : Select a sample of size $n_2(=n-n_1)$ from the remaining $N-n_1$ units of the population by simple random sampling without replacement.

The new scheme is not only very convenient and simple to operate but in addition fulfils many of the requirements of an ideal sampling scheme. Firstly, it is possible to compute a set of revised selection prababilities so that the inclusion probability of each unit will be proportional to the corresponding size measure. Secondly, inclusion probability for every pair of units under this scheme is positive and thus ensures unbiased estimation of sampling variance. Thirdly, the Yates-Grundy estimate of variance of the Horvitz-Thompson estimator of the populated total takes positive value in most of the situations usually met in practice. The superiority of the suggested scheme to the usual P. P. S. systematic and P. P. S. with replacement sampling has been examined with the help of a numerical example.

5. Use of PPS with 3-P Sampling Procedures

By

R. SETHUMADHAVI AND M. RAJAGOPALAN

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3-P sampling procedure is recommended when information on the auxiliary character to be used for selection of the sampling units is not available in advance of selection. The procedure briefly consists in visiting every unit of population to record the auxiliary information and selecting the units according to a procedure similar to PPS selection for simultaneous recording of information of the character under study. The auxiliary information not included in the 3-P sample could be used for drawing a PPS sample to build up a suitable estimator.

6. On the Efficiency of the Combined ratio Estimator under a Simple Size Stratification and its Application to Successive Sampling on two occasions

By

PRANESH KUMAR AND M. S. AVADHANI

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The efficiency of the combined ratio/regression estimator under the simple size stratification suggested by Avadhani (1952) was worked out depending on whether the 'size' character is discrete or continuous and compared with some of the well known strategies. It is found that the simple stratified ratio strategy under reference is more efficient than that of Midzuno-Sen ratio, and the PPS sampling strategies of Hertley and Rao (1962), Rao et. al. (1962) and Hanurav (1967) in many a situation. Also, the applicability of the former stratified ratio strategy to sampling on two successive occasions for estimating :

(*i*) the mean on the second occasion, and

(*ii*) difference, or sum, of means of the two occasions separately and also jointly,

has been investigated.

7. Some Contributions to the Theory of Sampling in Stages

By

G. SADASIVAN AND M. V. GEORGE

I. A. R. S., New Delhi-12

The theory of three-stage sampling has been developed for variable sizes of first and second stage units and different estimates for a continuous character have been given. There are mainly two estimates for a continuous character namely an unbiased estimate and a ratio estimate. In the present paper we are discussing a variant of the unbiased estimates, the bias introduced in the estimate due to change in the weights as well as change in the estimated variance. Further some regression type of estimators have also been developed along with their variances and estimated variances. The results are demonstracted by using the data of a survey conducted at the Central Plantation Crop Research Institute, Kasargod, Kerala, India.

8. On the Non-existence of Second and Higher Order Necessary Best Estimators in T_4, T_5 and T_6 Classes of Linear Estimator Under Mzuno-Sen Sampling

By

P. C. GUPTA AND A. K. YOGI

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The authors have proved in an earlier paper (1973 to appear in The Journal of Indian Soc. of Ag. Stat.), the non-existence of second and higher order Necessary Best Estimators in the T_4, T_5 and T_6 classes of linear Estimators. They have also shown that the first order Necessary best Estimators, however, exists in all these classes and is the same as the well known Horvitz and Thompson estimator.

In the present paper the non-existence of second order Necessary Best Estimators T_4, T_5 and T_6 classes of linear estimators using Midzuno Sen sampling scheme have been investigated. The Necessary best estimator of order one, however, exists in these classes and is the same as Horvitz and Thompson estimator.

9. Efficiency of SRC over Snowball Sampling for the Estimation of Number of '*s*' Step '*k*' Direction Relationships in the Population

By

S. K. AGARWAL

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Present study has been carried out by using *s.r.s.* and forming different stages. The lower and upper limits of the probabilities of an individual entering in the stages has been obtained and comparison of these probabilities with the probabilities formed by Goodman has also been done. In certain range of probabilities *s.r.s.* is found to be more efficient than snowball sampling.

10. Estimation of Sub-Population Means on Successive Occasions

By

S. K. P. SINHA AND T. P. TRIPATHI

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We consider the problem of estimating sub-population means of a character on two successive occasions. A procedure of partial replacement of units on two occasions has been adopted and a suitable estimator is proposed.

The situations in which partial replacement of units is better than complete replacement and no replacement and in which optimum replacement (in the sense of minimizing the variance of the proposed estimator) is better than 100%, 75%, 50%, 25% replacements and no replacement have been investigated under very general conditions. The relative gains in precision of optimum per cent of the sample units to be replaced over no replacement, 25%, 50%, 75% and 100% replacement of units are given in a table and the results are discussed. Interestingly we find that we can either replace the units completely or match completely or can replace 75% sample units (under the situation mentioned) without bothering for optimum replacement.

11. Optimum Points of Stratification in Multi-Dimensional Populations

By

G. SADASIVAN AND R. AGARWAL

I.A.R.S., New Delhi

Dalenius (1950) has given the equations to find out optimum points of stratification for the univariate case by minimising the variance of the estimate when the same variate is used as the basis for construction of strata. Dalenius and Gurney (1951) have considered the problem of finding out the optimum points of stratification, when the stratification is done on the basis of some auxiliary variate. As these equations gave strata boundaries in terms of strata parameters, approximate solutions were found out.

The present work is concerned with the optimum points of stratification with two variables under study. Here we have tried to extend the exact equations given by Dalenius to two-variate case, with the same variables as the basis of stratification. Minimising the generalised variance we have got sets of equations giving optimum points of stratification in two cases (*i*) when correlation coefficient

between the variables is constant from stratum to stratum, (*ii*) when ρ is not constant from stratum to stratum.

Working on the same lines as Ekman, we have given the approximate solutions to find out points of stratification, under the assumption that there are numerous strata so that the higher powers of stratum width can be omitted. We have also tackled the problem when there is only one variate under study and two auxiliary variates and we obtained general equations giving exact points. Also equations have been given under the linear model.

The result presented can be extended to K dimensions. The efficiency of stratification achieved can be studied empirically in particular cases. The model with two auxiliary variables can be extended to the case of proportional allocation.

12. Sampling Technique in the Study of Changing Attitudes of Farming Community from Farming to Education

By

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and

S. K. AGARWAL

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Immense progress in the field of agriculture and spread of education in the recent years, has generated the curiosity to know as to how the outlook of the farming community towards agriculture is changing with the increase in education among them. A study of this nature may give a clue, about the future prospects of agriculture in the country.

One such study was conducted in the Aligarh District U. P., which is also one of the Districts covered under IADP. The approach of snowball sampling was made use of for the study.

The average number of identical views for and against education and agriculture was estimated. The average number of identical views on education was 102.27 (83 82 for and 18.45 against) and on agriculture, 92.65 (43.33 for and 49.32 against). It has been found that a majority of the farmers and their sons were more inclined towards education than agriculture which is an indication that there is a tendency among the farmers to deviate away from agriculture. The average number of identical views was also estimated by classifying the village according to various factors such as (*i*) distance of village from the nearest city ; (*ii*) irrigation and educational facilities ; (*iii*) Literacy of the farmers, and (*iv*) availability of agriculture inputs and labour in the villages. Measure of association, test of independence and preference for education over farming were also calculated.

13. Some Contributions to Post Cluster Sampling

By

G. SADASIVAN AND M. SRINATH

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In cluster sampling, the lack of information relating to the composition of clusters is a difficulty that is often faced. But post cluster sampling which overcomes this difficulty has been coined first by T. Dalenius in his book "Sampling in Sweden." In this procedure the clusters can be built up on the basis of an initial random sample and final sampling is done with these clusters as sampling units. Sakti P. Ghosh (1963) has given a stochastic model for analysis of post cluster sampling. With the help of this model he built up several estimates of a population characteristic along with their variances. He also gives an optimum sampling design for "post cluster sampling."

In the present work an improved estimator of the population characteristic alongwith its variance is given. A comparison of this estimate with that of Sakti P. Ghosh is made and a set of conditions for its superiority over the latter is given. Also, its behaviour under random population is studied. In addition to this, post cluster sampling has been compared with cluster sampling and it is found that the latter is always more efficient than the former.

Finally, post cluster sampling is extended to a three-stage designs. An estimate of population mean alongwith its variance is found out. This method of sampling has been compared with simple random sampling and a condition for its superiority over the latter is given. In addition to this, the behaviour of post cluster sampling in a three-stage design under random populations is studied. It is shown that under random populations simple random sampling is always more efficient than post cluster sampling for the three-stage design as well.

14. Some Empirical Studies on Comparing Sample Mean, Ratio and Regression Estimators of Mean of Finite Populations Through Monte-Carlo Methods

By

VINOD KUMAR GUPTA

I.A.R.S., New Delhi

In the available literature on sampling theory, it is suggested that if ρ, the co-efficient of correlation is greater than zero, then regression estimator is always superior to sample mean estimator. Also ratio estimator is said to be more efficient than samples mean

estimator if the first order condition viz : $\rho > \frac{1}{2} C_x/C_y$, derived on the basis of approximate formula of variance of ratio estimator is satisfied. In the present investigation, comparisons between these estimators viz. regression versus sample mean and regression versus ratio have been made with reference to data taken from crop estimation surveys on vegetables. The data comprise village-wise area under four different crops in Talukas of Poona district. These four crops, termed as characters, are taken to be four populations under study. The area under all the vegetable crops, reported by patwaris two years earlier, for all these villages is taken as an auxiliary character. It is found that the co-efficient of correlation, between the auxiliary and study character is very poor, ranging from 0·056 to 0·184. The comparisons are made with the help of Monte-Carlo Method. According to this method, 150 repeated samples are drawn out of (N_n) possible samples. For each sample, the population mean is estimated by each of the three methods of estimation. The estimates of true variances of each estimator could be worked out on the basis of mean squares between the estimated values from each sample. On comparison, it is found that regression is always less efficient than sample mean. Also comparing regression with ratio, it is seen that in some cases, regression is less efficient than ratio. However, if the estimator is biased (as ratio and regression estimators are and for the population under study the bias in these estimators is found to be fairly high) the comparisons are made on the basis of Mean Square Errors (MSE). The relative bias shows a decreasing trend with increase in the sample size. Also the degree of bias in regression is comparatively smaller than that in ratio estimator. A comparison on the basis of MSE reveals that the efficiency of regression is less than that of sample mean and is found to increase with the increase in sample size. Also, comparing regression with ratio, in some cases ratio turns out to be superior to regression. Here also, the efficiency shows an increasing trend with sample size. These investigations have given indication that the comparison of ratio and regression estimators on the basis of approximate formulae as given in the standard books on sampling is not justified when sample size is not very large. It has been also demonstrated that in certain populations regression estimator could be quite inefficient as compared to sample mean even though ρ be positive.

15. Prices Response and Short-term Projections of some Important Crops in M.P. : An Econometric Investigation

By

S.P. PANT and B.N. TRIPATHI

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The problem of 'incentive prices' to agricultural producers is a problem of response behaviour of farmers. At a time when the country shows signs of approaching self-sufficiency in wheat but *P*

likely to remain deficient in pulses, oil seeds and fibres resulting in changes in prices ratios in favour of crops in which the State of M.P. possesses distinct advantage a study of price response of M.P. farmers is essential for formulation of effective policy.

The study was directed to estimate the short-run elasticities of price and some non-price variables of some selected crops and to project the acreage under them in M.P. in the year 1975-76. The crops selected are rice, wheat, maize, gram, groundnut and cotton. The period covered is 1956 to 1971.

The emphasis in the study was to identify the variables and starting with the simplest equation with only own price as the explanatory variable additional variables were added till all the variables considered important as *a priori* grounds were incorporated. This gave 12 equations which were then grouped into 4 groups. Own price, relative price, lagged own and relative prices, lagged yield, lagged acreage and time trend have been used. In addition an index of relative variability of gross revenue was also used. The form of the equations used was of the Cobb-Douglas type.

Results

Rice. In case of rice own price rather than the relative price was found to exercise significant influence on acreage. Lagged prices do influence acreage decisions of farmers, the decisive price being one year lagged price. Lagged yield, own or relative and lagged acreage bear little influence on determination of current acreage. The coefficient of variability of relative income bears a negative sign indicating that 1 per cent increase in relative income variability results in over 4 per cent decrease in acreage under rice.

Wheat. With respect to wheat crop we find that own or relative price as well as lagged prices with or without time trend explain very little of the variation in acreage under wheat. The inclusion of lagged yield, lagged relative yield and lagged acreage as well as relative income variability though increase the explanatory power of the equations yet turns the price or relative price coefficients negative.

Gram. Own price, relative price, own yield, relative yield, lagged prices all with or without time trend seem to bear little influence on current acreage. The own price coefficient turns out to be highly significant in company with the variable denoting relative income variability.

Maize. All the variables and equations turn out well in the case of maize crop. Own price, relative price, lagged price, lagged yield with or without time trend turn out to be significant and explain a substantial proportion of variability in the current acreage.

Groundnut. In case of groundnut we have obtained statistically significant own or relative price coefficients. But the distributed price

lags yield relatively poor equations. Similary, Own yield or relative yield do not seem to yield any positive influence on acreage decisions as is the case with previous years acreage. The relative income variability coefficient though insignificant suggests that one per cent increase in income variability reduces groundnut acreage by 3.8 per cent.

Cotton. Contrary to expectations own price or relative price coefficient has turned out to be singularly insignificant variable in all the twelve equations. The lagged prices too are not significant. Similarly, lagged influence of own yield or relative yield too are not significant though lagged acreage coefficient is significant. The relative income variability coefficient, however, is significant and states that one per cent increase in income variability decreases current acreage by as much as 13 per cent.

The analysis suggests that prices, own or relative, bear good influence on groundnut, gram and rice but had little influence in the case of cotton and wheat which seem to be influenced more by lagged acreage. The impact of relative income variability was more pronounced on cotton, rice and gram.

Despite the fact that most equations bore an unsatisfactory fit and that the historic conditions are likely to change rapidly projections for the year 1975-76, were made. The broad conclusion derived is that the acreage under rice, wheat, maize and groundnut is most likely to increase being in wheat and lowest in rice. On the other hand acreage under cotton shows potential for large decreases. Area under gram may remain stagnant.

16. A Study of Quality of Statistics of Slaughter in Registered Slaughter Houses and Estimation of Annual Meat Production Through Random Sampling Techniques

By

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AND

G.S. BASSI

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Meat comes mainly from registered slaughter houses maintained by municipalities in different cities/towns and a small portion comes from the butcher houses, which are unregistered and households in villages (private slaughter). Although data on the number of animals slaughtered in each registered slaughter house are maintained daily by the staff provided therein, yet doubts are expressed in regard to the quality and accuracy of such data. The Institute of

Agricultural Research Statistics conducted pilot investigations for developing an integrated technique for estimation of major livestock products and study of attendant animal husbandry practices in the Northern Region which comprises Punjab, Haryana and Himachal Pradesh during the period 1969-72, and in the year 1971-72 stress was laid on wool and meat for detailed study. During this survey data on the number of animals slaughtered privately was recorded in selected villages while from a sample of registered slaughter houses, information on the number of animals slaughtered on the day of visit of the enumerator and as counted by him was recorded, in addition to the data on meat production of a sample of selected animals slaughtered in the slaughter house on the day of visit. A comparative study of the data on the number of animals slaughtered and that recorded in the survey showed that the two figures differed significantly at 5% level in the case of sheep, while in case of goats and pigs the respective differences were not significant. A further study of the data on sheep has revealed that the official figures maintained in the registered slaughter houses are less than the survey estimates by 9·4 per cent. Using this result, a revised estimate of the number of sheep slaughtered in the registered slaughter houses during 1971-72 was obtained and is seen to be 2·36 lakhs. Estimates of number of animals slaughtered privately in villages, annual meat production and per capita availability of meat have also been worked out.

17. On Two-Stage Sampling on Successive Occasions with p (p>1) Auxiliary Variates

By

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In a sample survey, besides the main variate under study, information is usually collected on a number of related variates also. If the population values of the related variates X_i's are not known, they will have to be estimated first by taking a larger sample of units from the population. An estimator of the population mean of the main variate Y under under study on the current occasion may then be obtained by suitably taking into consideration, the correlation, the between the main variate and the related variates.

Let n be the number of psu's in the sample (each consisting of m ssu's) drawn on the first occasion on which X_i's alone were observed and n_1 the sub-sample drawn out of n on which X_i's and Y were observed. On the second occasion, n_1' psu's out of n psu's are retained for X_i's and these are supplemented by drawing n'_2 new units from the population. Out of n_1 units for Y on the first occasion, n_1'' units are retained on the second occasion which are supplemented by

n_2'' new units which may be drawn (*i*) either out of the n_2' units for X_i's on the second occasion or (*ii*) drawn afresh from the population. It is assumed that $n_1<n_1'$. It is further assumed that selection of psu's in the sample is done with varying probabilities with replacement and of ssu's within them is done with equal probability without replacement.

A ratio-type composite estimator is first built for each of the p auxiliary variates and of the main variate utilising information available on these p variates. Following Olkin (1958), an overall estimator for the Y variate mean on the second occasion is then obtain by suitably combining the ratio-type composite estimators so obtained.

18. A Model for Rank Analysis in Traid Comparisons

By
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In sensory test, the number of samples a judge can assess is often limited by sensory fatigue. The difficulty of obtaining satisfactory quantitative measures of treatment effects usually entails assessment by ranking in paired or triad comparisons. The present paper deals with the method of analysis for the ranking of t treatments in sets or sub-sets of the possible (t_3) triple comparisons.

A mathematical model for the analysis of experiments involving ranking in triad comparisons has been developed. Treatment parameters are postulated and estimated by the method of maximum likelihood. The likelihood function obtained under the model is

$$L=\frac{\prod_{i=1}^{t} \pi_i^{\frac{3n}{2}(t-1)(t-2)-\sum_{p=1}^{n}\sum_{i<j<k=1}^{t} r_{ip,\,jk}}}{\prod_{i<j<1} (\Delta_{ijk})^n}$$

where n is the number of repetitions, $r_{ip,\,jk}$ is the rank of T_i in triplet having T_i, T_j and T_k in p-th comparison and $\Delta_{ijk}=(\pi_i+\pi_j)(\pi_i+\pi_k)(\pi_j+\pi_k)$ where π_i, π_j, π_k, are non-negative parameters associated respectively with T_i, T_j and T_k.

The test procedures are also derived. The nature of the test statistics for small and large number of repetitions is presented. Tests are provided for hypotheses on (*i*) treatment effects, (*ii*) treatment by group interactions, and (*iii*) the appropriateness of the model used. A numerical illustration was also presented.

19. On the Formation of Clusters

By

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The procedure of cluster sampling is widely used in sample surveys. More often we come across situations in which clusters exist in a natural way. However, sometimes the clusters have to be formed artificially by combining two or more elementary units. The available procedures for formation of clusters can be divided into two categories, *viz.*, (*i*) clustering before sampling (*CBS*) and (*ii*) clustering after sampling (*CAS*). The procedures mentioned by Sethi (1965), Sukhatme (1970) and adopted by Jessen (1938) and Asthana (1950) fall in the first category. The procedures adopted by Mahalanobis (1940), Panse *et. al.* (1964, 66), Singh, Murty and Goel (1970) and Singh, Rajagopalan and Maini (1970) fall in the second category. The anthors have considered the problem purely from the point of view of efficiency or operational convenience. While forming clusters, it is important to consider both these aspects.

The problem of formation of clusters *viz.* (*i*) what should be the size of the clusters ? (*ii*) whether the clusters should be equal or unequal ? and (*iii*) what should be the criterion for forming clusters ? has been discussed in detail in this paper. The procedure of *CAS* is cheap and convenient as compared to the procedure of *CBS*. Moreover, if used in conjunction with some good criterion, *CAS* may be more efficient even than sampling of individual elements. The *CAS* procedure, however, may give rise to overlapping clusters or in other words introduce selection bias. Therefore, in this type of cluster sampling the estimate of the population mean based on mean of the cluster means will be biased. An algebraic expression has been derived for bias and nature of bias has also been discussed. Some objective, efficient and convenient criteria have been suggested for cluster formation.

20. A Study of Growth Rate and Trends 1961-72

By

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An attempt has been made in this paper to study the trend in the imports of food and live animals from 1961-72. This is done at a detailed level —3-digit group of Revised Indian Trade classification. This classification is used for recording Indian trade data. A consistent and comparable series of imports at constant prices at such a disaggregative level is not available. The main difficulty in making a comparable time series is the change in the classification system in 1965.

A due correspondence was established and the indext at constant prices of 1961 and 1971 was computed for each group. A deometric average of these two series was computed to get index at coustant prices for each group.

There are 39 groups and they were regrouped according to the trend in their imports over the period 1961-72. Imports of food and live animals has been the main determining factor of the structure of imports. The structure of imports could not undergo radical change because of the fluctuating behaviour of this group.

21. Nutritional Status of Milch Buffaloes under Village Conditions

By

K. C. RAUT

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Feeding is an important factor for enhancing milk production. For formulation of improvement programmes for milch stock it is essential to assess the present level of feeding and their potentiality under village conditions. Studies have been mostly confined to cows maintained under farm conditions both in India and abroad to estimate the potentiality of milk production. Such studies on buffaloes are limited even though the contribution from buffaloes to the total milk production in the country is more than that from cows. Attempts have been made to estimate the level of feeding milch buffaloes and their potentiality of production under village conditions utilising data collected In a large scale survey carried out in Dhulia region of Maharashtra State. Different production functions were fitted to work out the relationship of milk yield with the quantum of feed in terms of their of roughages and concentrates as well as in terms of their nutritive values (*DCP*, *TDN*). Optimum intake of feeds for different production levels has also been worked out.

22. Feeding Animals in Milk under Village Conditions for Economic Returns

By

S. S. PILLAI & K. C. RAUT

Institute of Agricultural Research Statistics New Delhi-12

The animals in the farms are fed according to their requirements keeping in view their maintenance and production ration. In the

villages, on the other hand, the farmers being ignorant of the quantitative aspect of the enterprise, generally feed their animals according to the availability of feeds in the area. Under the conditions prevailing it would be possible to suggest the farmer the extent of input for his animal so as to get maximum return. Studies have been made to work out the relationship of milk yield with costs on feed and labour utilizing data collected in a large scale sample survey carried out in Krishna delta area of Andhra Pradesh. Optimum feeding schedules have also been worked out for different levels of milk production using linear programming techniques. Such studies would help the farmers in minimizing costs incurred on feed and attaining desired milk production.

23. Some Properties in Estimation of true Class Effects in $p \times q$ Classification with Disproportionate Cell Frequencies

By

B. MARUTIRAM

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In the case of $p \times q$ classification with two factors A and B where A has p classes with effects $a_1, a_2 \ldots, a_p$ and B has q classes with effect $b_1, b_2, \ldots, b_q$, the following properties in the estimation of true class effects under the constraints

(*i*) $\Sigma\, a_i = 0, \ \Sigma\, b_j = 0$

and

(*ii*) $\Sigma\, n_i\, a_i = 0 \ \ \Sigma\, n_j\, b_j = 0$

have been observed :

(*i*) The product $[R_{ik}][C_{ip}]$ is a vector whose elements all are equal and depend only on the constraint imposed on the class effects and where $[R_{ik}]$ is the universe of the information matrix after eliminating any effect a_p and $[C_{ip}]$ is the column vector with elements involving the cell frequencies. Further the product is independent of disproportionality of cell frequencies as well as any concomitant variate utilised in the analysis.

(*ii*) The linear contrasts among true class effects, with and without concomitant variate, are invariant of constraints imposed on them in their estimation. The estimates of any true class effect under two constraints differ by the same constant. The estimate of regression coefficient in the case of a concomitant variate is also invariant of the constraint on class effects.

(*iii*) While any given linear constraint on class effects leads to an unique solution, the converse is not true but all the linear constraints resulting in a given set of values for class effects satisfy the same condition.

24. Study of Low Response of High Yielding Varieties of Rice and Wheat to Fertilizers Under Farmer's Conditions

By

S.J. AMDEKAR and S.K. RAHEJA

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Under the scheme of Sample Surveys for Assessment of High Yielding Varieties Programme undertaken by the Institute of Agricultural Research Statistics for estimating the yield rates and area of high yielding varieties of major cereals and extent of adoption of recommended practices under field conditions, the results of 1970-71 showed that application of chemical fertilizers did not show substantial increase in yields in a number of districts. A detailed study of factors responsible for low "response" was made in four districts, two each for rice and wheat, for two consecutive years 1970-71 and 1971-72. The main causes for relatively poor yield obtained from fertilized fields in these districts were higher dose of bulky manures applied to the crop in unfertilized fields and early sowing or longer crop duration in these fields and, sometimes, inadequate doses of N.P.K. A regression analysis to study the effect of delay in sowing on yield rates and doses of NPK applied showed that there was a definite declining trend in yield rates of both rice and wheat when sowing was delayed. There was also a tendency on the part of the farmers gave to larger doses of chemical fertilizers to make up for the loss in yield accruing from delay in sowing.

25. A New Test For Outlying Observations

By

G. SADASIVAN and S. ZACHARIAH

I.A.R.S., New Delhi

In the present work the statistics $\frac{x(n)-\bar{x}}{R_n}$ from a sample of observations is proposed for testing outlying observations. The distribution of the statistic is derived under certain assumptions and tabulated. How the test can be adapted for two sides cased is also discussed. Practical applications of the test as well as adaptation of the test for slippage problems are also investigated.

26. On Inclusion of Some Units in the Sample With Certainty

By

R. SINGH

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New Delhi-12

In situations where the population units vary considerably in size, it is advantageous to select units in the sample with probability proportional to size. But in some situations where population under study is highly skewed, it may be more advantageous and much simpler to have a sampling plan which calls for :

(*a*) the complete coverage of a group of units having extremely large values, and

(*b*) a supplementary sub-sample from the remaining population with probability proportional to size x_i.

In the present paper such a sampling scheme has been considered and the optimum point beyond which to include all the units, has been obtained such that the suggested scheme is more efficient than the usual pps with replacement sampling scheme. Practical examples have also been used to illustrate the usefulness of the new scheme.

27. Analysis of Covariance in Two-Way Classification with Disproportionate Cell Frequencies

By

B. MARUTIRAM

Institute of Agricultural Research Statistic, New Delhi

The problem of analysis of covariance in two-way classification with disproportionate cell frequencies was dealt by Das (1953) who gave explicit solution in a simple form suitable for systematic computation. He also provided expressions of estimates of contrasts of class effects together with their standard errors. In applied statistics, particuraly in the fields of agriculture and animal husbandry, relative superiority of a variety or a breed/grade is equally important in decision making and the same is to be necessarily based on the true performance of the variety or breed/grade. The problem of estimation of true class effects and their variances in two-way classification with disproportionate cell frequencies and with concomitant variation has been investigated. Expressions for the true class effects and their variances are obtained under the constraints :

$$(i)\ \sum_i a_i=0,\ \sum_j b_j=0 \quad \text{and} \quad (ii)\ \sum_i n_{i.}a_i=0,\ \sum_j n_{.j}\,b_j=0$$

on class effects. It is observed that, in both the cases, it is possible to obtain estimates of true class effects of one factor by solving the normal equations involving the effects of the second factor alone and there is no constraint imposed on the effects of that factor for which the true class effects are estimated. Alternate expressions have also been presented for the estimation of true class effects and their variances for use in differing situations.

28. On Variance and Covariance Component Models in Triallel Crosses for the Estimation of Genetic Components

By

K.N. PONNUSWAMY

I.S.A.S.

The importance of the genetic components of variance in plant and animal breeding works cannot be overemphasized. Attempts have been made in the past to use the variances and covariances of F_1, F_2 and other advanced generations arising out of a pair of lines, to estimate the Additive and Dominance genetic variances. Of late the Diallel mating design is being extensively used for this purpose. Rawlings and Cockerham (1962*a*, *b*) have shown that the Triallel and Double cross mating designs can provide estimates for Additive, Dominance and some of the Epistatic components of variance, viz., Additive × Additive, Additive × Dominance and Dominance × Dominance. Hinkelmann (1965) extended the genetic analysis to partial triallel crosses (PTC). Ponnuswamy (1971) using a model different from that of Rawling et al, has also provided unbiased estimates for the five genetic variance components.

In this paper, a set of (design) variance and covariance components models for Triallel cross has been investigated for the estimation of the genetic components. It has been shown that the covariance components of the type ∂_{gh}, ∂_{ds}, ∂_{ss} and ∂_{tt} cannot be ignored, if one considers the parametrization of the model proposed by Hinkelmann (1965) and Ponnuswamy (1971). Incidentaly the investigation also brings to the light the need for the development of suitable criterions to determine the best variance and covariance component model for a given situation.

29. Lactation Correlation Factors for Dairy Cattle

By

K.N.S. SHARMA and S.B. AGARWAL

N.D.R.I., Karnal

This paper deals with the statistical evaluation of different methods of estimation of lactation correction factors and to estimate the lactation correction factors for Tharparkar, Sahiwal, Red Sindhi and Brown Swiss crossbred cattle maintained at N.D.R.I., Karnal.

The ratio and linear regression methods of estimation were found to give the estimates of lactation correction factors with almost equal precision. The standard errors being of the same order. The quadratic regression estimates did not provide any additional information over linear regression estimates. The ratio method due to its simplicity and ease of understanding can be used.

First lactation yield provide sufficient information about the production capability in subsequent lactation. The standard errors of estimates of subsequent lactations based on first lactation were of the same order as compared to estimates based on other lactations.

The factors for estimating later records on the basis of first lactation and for converting the later records to first lactation basis have been given.

30. Correlations Between Relatives in Inbred Populations

By

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Institute of Agricultural Research Statistics,
New Delhi-12

In quantitative genetic studies, resemblance between relatives is used for estimating the genetic parameters, such as heritability and genetic correlation. In such cases, it is assumed, that the individuals in the population mate at random. The correlations between common relatives, such as, full-sibs or parent-offspring, take a simple value of half. But, when a regular system of inbreeding such as, for instance full-sib or parent-offspring mating is practised, the correlation is increased. The increase in correlation between relatives depends on the number of generations during which the inbreeding is practised. Of special interest in quantitative genetics, is the case of correlation between one relative and a number of individuals belonging to the particular relationship. For instance, the correlation between one parent and several of its off spring is a major determinant in increasing the response to selection. The behaviour of such correlation in inbred population is not fully known. In this paper, therefore, the correlation between one parent and several of its offspring as well as both the parents and several of their offspring have been studied under the two regular systems of mating viz., full-sib mating and parent-offspring mating.

31. Effect of Preceding Dry Period on Calving Interval

By

K.C. RAUT and SHIVTAR SINGH

Institute of Agricultural Research Statistics, New Delhi

One of the criterion for selecting a milch animal can be its preceding dry period. Hardly any study has been undertaken to know the effect of the preceding dry period of an animal on the calving interval and the next dry period under village conditions. Attempts have been made to study this aspect utilising data collected in a large scale sample survey carried out in Hissar district of Haryana State. Functions were fitted to know the appropriate relationship between preceding dry period and the calving interval as well as between two consecutive dry periods. In case of Murrah buffaloes maintained under village conditions it was worked out that the minimum calving interval would be 396 days when the preceding dry period be 86 days. The lactation length and dry period would be 291 days and 105 days respectively. In the case of Hariana cows it was estimated that for a preceding dry period of 103 days, the next calving interval would be 395 days comprising 256 days of lactation length and 139 days dry period.

32. Performance of Cross-bred Calves in Intensive Cattle Development Project, Dhulia

By

A.D. GODBOLE and G.V. SHIRALKAR

Dhulia

A Survey to study the performance of cross-bred calves in the field condition was undertaken in the I.C.D. Project, Dhulia covering the period January, 1970 to March, 1973. All the cross-bred calves were enumerated and type of beneficiaries for C.B. programme were studied. All the six Regional A.I. Centres were included in the survey. Fifteen A.I. Sub-Centres under each Regional A.I. Centre were classified into good, medium and below average classes on the basis of number of A.I. done and the opinion of local Veterinary Officers. From each group, one A.I. Sub-centre was selected at random and detailed study regarding number of inseminations, causes and age of mortality, age at maturity, etc., was carried out. The results obtained have been discussed in the paper.

33. Triallel Analysis in Barley

By

K.N. PONNUSWAMY and DAS CHAUDHARY

Indian Society of Agricultural Statistics, New Delhi
and
Haryana Agricultural University, Hissar

Data pertaining to 60 three-way hybrids formed out of 6 Barley inbred lines have been subjected to the statistical and genetic analysis proposed by Ponnuswamy (1972), Ponnuswamy and Das (1973). The 'line evaluation' aspects of the analysis shows that the two-line and three-line specific effects are as important as the general line effects in the evaluation of the lines. Superior three-way hybrids can be developed by choosing a proper triplet and crossing them in appropriate order. The 'genetic analysis' shows that the nature of generation is predominantly epistatic and more of additive × dominance, and dominance × dominance type than additive × additive. Indicating thereby, that hybridization should be resorted to improve the yield and other economic traits in Barley. Probably Hallauer's cyclic single cross selection (CSCS) procedure or formation of three-way hybrid may be adopted to fully exploit the genetic potential.

34. Commercial Poultry, Production in Relation to Capital

By

B. MARUTIRAM, U.G. NADKARNI,
L.B.S. SOMAYAZULU & T.B. JAIN

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The success of large scale poultry development programmes would depend, to a great extent, on ensuring profitable returns to farmers engaged in commercial poultry keeping. Towards this end studies in the field of economics of poultry keeping would be of considerable practical value in providing pointers to directions in which economics in the methods of egg production and poultry rearing can be effected and their efficiency improved.

The data collected from about 120 commercial poultry farms under a survey carried out by I.A.R.S. in Tanda-Dasuya area of Punjab for estimation of cost of poultry rearing and egg production were utilised to study the relationship between egg production and working capital and fixed capital. Different functional forms were fitted to the data and it was observed that the quadratic accounts for about 70% of the variation. Isoquants were obtained and a study of the levels of capitals for constant production was made. Optimum combinations of working and fixed capital were determined for varying levels of egg production and for different rates of changes of the two capitals.

35. Best Lactation Production as a Criterion of Selection

By

M. GURNANI, M.K. RAO AND S.K. GUPTA

National Dairy Research Institute, (I.C.A.R.), Karnal

Animal Husbandry workers in India generally select young bulls, for breeding purposes, on the basis of their dams best lactation performance. Controversial reports on the off chiverness of such criterion of selection are available. Copeland (1938) and Graves (1947) found this criterion of selection to be appropriate whereas Berry and Lush (1939), Lush and Schultz (1938) and Lush and M. Gillian (1955) disfavoured it.

Preliminary investigations on Red Sindhi breed of cattle at this Institute suggest that first lactation production is a better criterion of judging the producing ability of animals as compared to the best lactation.

36. On Counter-Examples to a Conjecture of Stanton and Mullin

By

G. M. SAHA

Indian Statistical Institute, Calcutta

Two methods of construction of counter-examples to a conjecture of Stanton and Mullin (1966 A.M.S.) which states that in an irreducible (r, λ)—system, for, $\lambda \leqslant 2$, and perhaps all λ, $\lambda(v-1) = r(r-1)$ implies $v = b$, are presented in this paper. The examples constructed here are also, obviously, partially balanced designs of index λ. A series of counter-examples, different from that of Bhagwandas and Sastry (1972 to appear in Utilitas Mathematica), is also reported.

37. Construction and Analysis of Asymmetrical Qualitative-Cum-Quantitative Experiments

By

S. MOHANTY

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The construction analysis of confounded designs for both symmetrical and asymmetrical factorial experiments involving only

quantitative factors has become simple on account of the work done by Fisher, Yates, Nair and Rao, Krishan and Srivastava, Das and others. But much attention has not been paid for symmetrical and asymmetrical qualitative-cum-quantitative experiments.

Fisher (1935) was the first to tackle this problem and proposed that quality difference may be regarded as proportional to quantity applied. Yates (1937) discussed in detail the analysis of 33 quantitative-cum-qualitative experiments in 9 plot blocks. Kempthrone (1951) discussed a much more general proportional model in which the proportions are not simply quantities applied as proposed by Fisher, but are estimates which provides maximum information from the data. Sardana (1961), Narayan and Sardana (1967) have discussed in detail the possible type of confounding for asymmetrical experiments and presented the analysis of some of them under both the models.

In this present paper, some methods of construction and analysis of some asymmetrical qualitative-cum-quantitative experiments (*i.e.* $3\times3\times2$, $3\times3\times3$, $3\times3\times3\times2$, etc.) have been presented, which are more simple and efficient than those already known.

38. Percentiles from Rainfall Data Direct, As Controls to Decision

By

G. M. PANCHANG

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72 years' (1900-71) daily rainfall data cummulated till different seasonal (or epochal) dates in respect of six raingauge sites in Maharashtra's lower central region of Bhima sub-basin bring out their non-normal character of individual frequency distributions. Rain-gaugewise suitable percentiles therefore directly computed from about 50 years' observed data ending 1971 have been suggested to provide the only fair basis for taking time to time important decisions over implementing the various successive stages of dry farming operations.

39. On the Affine Resolvability of Designs

By

P. U. SURENDRAN

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Shah (1964) has shown that a necessary and sufficient condition for certain types of designs which are resolvable to be affine resolvable is that each of such designs contain a block which has the

same number of treatments common with every block not in its own replication. In the present paper the author has obtained the affine resolvability of the above designs under less restrictive conditions. The following results are established:

A necessary and sufficient condition for each of the following designs to be affine resolvable is that it has one block disjoint with $(u-1)$ blocks, each of the remaining $(b-u)$ blocks having the same number of treatments common with this block where of course, $b=ur$:

(*i*) A *BIB* design.

(*ii*) A semi regular *GD*.

(*iii*) A *PBIB* with two associate classes and having triangular association scheme with

$rk-v\lambda_1=(n/2)\,(r-\lambda_1)$

(*iv*) A *PBIB* with two associate classes and having L_2 association scheme with $(rk-v_1)=s(r-\lambda_1)$

(*v*) A *PBIB* with three associate classes and having rectangular association scheme with $\lambda_1=\lambda_2=0$.

40. Construction of Balanced Ternary Block Design for Even Number of Varieties

By

K. N. AGGARWAL

Cummings Laboratory, I.A.R.I, New Delhi

Tocher (1952) introduced balanced n-ary block design. Recently, Murty and Dass (1968), Rao (1966), Dey (1970), Saha (1972) gave various method of construction of such designs. In the present paper a new design called partially affine resolvable balanced incomplete block designs ('*PAR*' *BIB*) has been defined and it was shown that when block size is two α resolvable *BIBD* is *PAR* only if $\alpha=1$ and v is even. When the blocks of *PAR* are serially numbered then the intersecting blocks of two different sets of *PAR* gives two associated partially balanced incomplete block design with design parameters

$$v^*=\frac{v\,(v-1)}{2},\ b^*=\frac{(v-1)\,(v-2)}{2},\ k^*=2,\ r^*=2\,(v-2)$$

and the following triangular association scheme,

$$v^*=\frac{v\,(v-1)}{2},\ n_1=v-3,\ n_2=\frac{(v-1)\,(v-2)}{2}+1\lambda_1=1\ \lambda_2=0$$

$$P_1 = \begin{bmatrix} v-2 & v-3 \\ v-3 & \frac{(v-3)(v-4)}{2} \end{bmatrix} \quad P_2 = \begin{bmatrix} 4 & 2(v-4) \\ 2(v-4) & \frac{(v-4)(v-5)}{2} \end{bmatrix}$$

where symbols have their usual meanings.

The existence of '*PAR*' *BIB* design with parameters v, b, r, $k=2$, implies the existence of a balanced ternary block design with parameters

$$V=v,\ B=\frac{v(v-1)(v-2)}{2},\ K=4,\ R=2(v-1)(v-2),$$

$$\lambda=5(v-2).$$

The three frequencies in a block are 0, 1, 2 with their number as $v-3$, 2 and 1 respectively.

41. Rectangular Lattice Designs and Associated Asymmetrical Factorial Designs

By

K. KISHEN AND A. N. SHUKLA

Directorate of Agriculture, U. P., Lucknow

Association Schemes for partially balanced incomplete block (*PBIB*) designs involving three or more associate classes have been investigated mainly by Roy (1953-54), Vartak (1959), Raghavarao (1960), Singh and Shukla (1963), Tharthare (1963, 1965), Raghavarao and Chandrasekhararao (1964) and John (1966). In this paper, we have defined the rectangular lattice association scheme involving four associate classes which exist for $v=p(p-1)$, p being any positive integer. *PBIB* designs with this association scheme may be called rectangular lattice designs (*RLDS*), of which the simple rectangular lattice developed by Harshbarger (1946, 1947) and studied by Nair (1951) come out as a special case.

By the use of *RLDs*, we have constructed asymmetrical factorial designs of the types $(2S-1)\times S\times 2$ and $(2S+1)\ XS\times 2$ involving three factors and have developed the analysis of these designs in an elegant form with the help of the characteristic roots and vectors of NN', where N is the incidence matrix of the *RLD*. Of these, the first is a partially balanced asymmetrical factorial (*PBAF*) design and the second a balanced asymmetrical factorial (*BAF*) design. The losses of information on the partially confounded main effects and interactions have been worked out and it has been shown that the total loss of information in these designs is $\frac{v}{k}-1$.

Two replicate *PBAF* and *BAF* designs have also been obtained by the use of two *RLDs*, each involving two replications.

42. Partially Balanced Asymmetrical Factorial Designs of the Classes $St \times S^2$, $(S-1)\, t \times S^2$ and $2t \times S^2$

By

K. KISHEN AND R.B. TRIPATHI

Directorate of Agriculture, U.P., Lucknow

Methods of constructing *PBAF* designs of the classes $q \times 2^2$ and $q \times 3^2$ and all cases reducible to them by use of the associated partially balanced incomplete block (*PBIB*) and pairwise partially balanced (*PPB*) designs have been given by Kishen and Tyagi (1963) and Kishen and Shukla (1972). Also, methods of construction of *PBAF* designs 6×4^2, 8×4^2, 8×5^2 and 10×5^2 by use of trivial *GD* designs have been developed by Tyagi (1966).

In this paper, *PBAF* designs of the classes $St \times S^2$, $(S-1)\, t \times S^2$, and $2\, t \times S^2$, where S is a prime positive integer or a power of a prime and t any positive integer, have been obtained in $S-1$ replications each by the use of trivial *GD* designs. Methods of analysis of these classes of designs have been given and the losses of information on the partially confounded degrees of freedom worked out.

43. On a Method of Construction of Balanced Ternary Designs

By

V.C. SRIVASTVA AND A. DEY

Institute of Agricultural Research Statistics, New Delhi-12

A ternary design, defined by Tocher (1952), is one whose incidence matrix contains three elements 0, 1 and 2. An equireplicate, proper ternary design with V treatments and B blocks is said to be balanced if the inner product of any two rows of its $V \times B$ incidence matrix is a constant λ. The definition of ternary designs was slightly modified by Das and Rao (1968); according to them, a ternary design is one whose incidence matrix contains three integral elements (including zero) P_1, P_2, P_3, where P_i's are not necessarily 0, 1 and 2. Systematic methods of construction of Balanced Ternary (*BT*) designs are given by Das and Rao (1968), Dey (1970), Saha and Dey (1973) and Saha (1972).

In the present paper we give another method of construction of *BT* designs, using *BIB* designs with $\lambda=1$. The parameters of the design obtained are

$V=v$, $B=bk\ (r-1)/2$, $R=rk\ (r-1)$, $K=2k$, $A=(r-1)\ (2k+1)$ where v, b, r, k denote the parameters of the *BIB* design with $\lambda=1$.

44. Balanced and Nearly Balanced n-ary Designs with varying Block Sizes and Replications

By

A.K. NIGAM, S.K. MEHTA AND S.K. AGARWAL

Institute of Agricultural Research Statistics, New Delhi-12

In the present paper we have generalised the method of Kulshreshtha *at al* (1972) to obtain balanced n-ary designs with more than two block sizes and varying replications. We have also suggested nearly balanced design which may serve as a substitute whenever a suitable balanced and partially balanced design is not available for a given number of treatments.

45. Extended Rectangular Lattice Designs and Associated Symmetrical Factorial Designs

By

K. KISHEN AND A.N. SHUKLA

Directorate of Agriculture, U.P., Lucknow

Investigations of association schemes of the partially balanced incomplete block (*PBIB*) designs involving three or more associate classes have been carried out, among others, by Vartak (1959), Raghavarao (1960), Tharthare (1963, 1965), Raghavarao and Chandrasekhararao (1964) and John (1966).

In the present paper, a new association scheme, called the extended rectangular lattice association scheme involving ten associate classes, has been defined which exists for $v=p\,(p-2)$ where p is an even positive integer $\geqslant 8$. *PBIB* designs having this association scheme have been called extended rectangular lattice designs, (*ERLD*s).

Four types of two-replicate *ERLD*s have been constructed and the analysis of *ERLD*s has been indicated. Asymmetrical factorial designs of the types $(2u-1)\times u\times 2^3$ and $(2u+1)\times u\times 2$ have been developed by the use of *ERLD*s for $p=4u$ and $p=4u+2$ respectively and the analysis of these designs has been obtained in an elegant form by the use of the characteristic roots and vectors of NN', where N is the incidence matrix of *ERLD*. The losses of information on the partially confounded main effect and interactions have been worked out and it has been shown that the total loss of information in these designs comes out to be $\frac{v}{k}-1$.

Two replicate *PBAF* and *BAF* designs have also been obtained by use of four *ERLD*s, each involving two replications.

46. Truncated Triangular Designs and Associated Asymmetrical Factorial Designs

By

K. KISHEN AND A.N. SHUKLA

Department of Agriculture, U.P., Lucknow

In this paper, we define a new association scheme called the Truncated Triangular Association Scheme involving five associate classes, which exist for $v=p(p-1)/2$, where p is any even positive integer $\geqslant 8$. For $p=4$, this association scheme degenerates into a two-associate class scheme, and for $p=6$ into a four-associate class scheme. *PBIB* designs having this association scheme may be called Truncated Triangular Designs (*TTD*s).

We have indicated the analysis of *TTD*s. We have also constructed the associated asymmetrical factorial designs of the types $(2U-1)\,X\,U\times 2^2$ and $(2U+1)\times U\times 2^2$ involving four factors A, B, C and D, and have obtained the analysis of these designs in an elegant form by the use of the characteristic roots and vectors of NN', where N is the incidence matrix of the corresponding *TTD*.

Two-replicate *PBAF* and *BAF* designs have also been developed by use of two *TTD*s, each involving two replications.

47. Some Higher Class PBIB Designs and their Applications as Confounded Factorial Experiments

By

K. R. AGGARWAL,

Punjab Agricultural University, Ludhiana

This paper contains a new series of extended group divisible (EGD) designs of Hinkelman [Ann. Math. Statist. 35(1964)] with the parameters

$$v=\prod_{i=1}^{m} s_i,\ b=\prod_{i=1}^{m} s_i(s_i-1),\ r=\prod_{i=1}^{m=1}$$

(s_i-1), $K=s_m$, $\lambda d_1 d_2 \ldots d_m=1$, if all d's are unity; 0, otherwise; where $s_m \leqslant s_i$ $(i=1, 2,\ldots,m-1)$ and s_i's are primes or prime powers. In this series of *EGD* designs, by taking $s_i=s(i=1, 2\ldots\ldots, m)$, we get a hypercubic design of Shah [Ann. Math. Statist. 29(1958)] and Kusumoto [Wakayama Medical Reports, 9(1965)] with the parameters $v=s^m$, $b=s^{m-1}(s-1)^{m-1}$, $r=(s-1)^{m-1}$, $k=s$,

$\lambda_i=0$ $(i=1, 2,\ldots\ldots, m-1)$, $\lambda_m=1$; which is Bose's [Sankhya 8(1947)] symmetrical confounded experiment s^m in $(s-1)^{m-1}$ replications, in which the main effects remain unconfounded, and a complete balance is achieved over interactions of all order, from the first to the $(m-1)$th. The relative loss of information on each degree of freedom of $(i-1)$th order interaction is given by

$$[1+(-1)^i\ (s-1)^{i-1}]/s,\ (i=2, 3,\ldots\ldots,m).$$

Another series of hypercubic designs with the parameters

$$v=(s+1)^m,\ b=(s+1)^{m-1},\ s^{m-1}\ (s-1)^{m-1},\ r=s^{m-1}\ (s-1)^{m-1},\ k=s+1,$$
$$\lambda_i=0\ (i=1, 2, \ldots\ldots,m-1),\ \lambda_m=(s-1)^{m-1},$$

where s is a prime or a prime power, are also given. This series of hypercubic designs can also be taken as symmetrical confounded factorial experiment $(s+1)^m$ without confounding main effects. A complete balance is achieved over all interactions. The relative loss of information on each degree of freedom of $(i-1)$th order interaction is given by

$$[i+(-1)^i\ s^{1-i}]/(s+1)\ (i=2, 3,\ldots\ldots m).$$

48. Some Results on Balanced Designs

By

A. DEY

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A design is said to be balanced if the variance of any elementary contrast among the estimated treatment effects is a constant. It is known that a necessary and sufficient condition for a design to be balanced is that all the non-zero latent roots of the matrix C of the adjusted intra block normal equations are all equal. In the first part of the present paper, we obtain a necessary and sufficient condition for a binary equireplicate design with two block sizes to be balanced.

Next we propose a method of construction of a class of balanced n-ary designs with two unequal block sizes and variable replications.

Finally, some balanced designs with equal block size and variable replications of treatments are also obtained.

49. An Investigation on the Maximum Number of Factors in Confounded Factorials

By

S. H. BIYANI

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Let $m_3(r, s)$ denote the maximum number of factors which can be accommodated in a symmetrical factorial experiment with each factor at s levels, where s is a prime power $= 3$ in blocks of size sr and saving up to 3 factor interactions. It has been established in this paper that,

$$m_3(r, s) \geqslant (s^2+1)\, 2^{r-4} \text{ for } r \geqslant 4.$$

The upper bound for $m_3(r, s)$ has also been slightly improved over the one given by Bose (1947) and it has been shown that,

$$m_3(r, s) \leqslant s^{r-2} + 1 - \frac{s^{r-4}-1}{s-1}$$

where s is an odd prime power, and in general,

$$m_3(r, s) \leqslant s^{r-2} + s^{r-3} + 1$$

where s is any prime power.

50. Confounding in Diallel Experiments

By

K. R. AGGARWAL

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In this paper the author presents the analysis of confounded diallel experiments known as method (1) of Griffing [Aust. J. Bio. Sci. 9 (1956)]. The partially balanced incomplete block (*PBIB*) designs used, for this purpose, are the $L_2(s)$ designs of Bose and Shimamoto [J. Am. Statist. Assn. 42 (1952)]. The total s^2-1 degrees of freedom has been partitioned into orthogonal sets of $(s-1)$, $(s-1)$, $s(s-1)/2$ and $(s-1)(s-2)/2$ degrees of freedom said to belong to general combining ability (*g.c.a.*) effects, maternal effects specific combining ability (*s.c.a.*) effects and residual reciprocal effects. For this class of *PBIB* designs a balance is obtained in the sense of Shah [Ann. Math. Statist. 29 (1958)] over each of the above sets of degree of freedom. The anova table partitioning the total sum of squares for the treatments eliminating blocks into *g.c.a.*, maternal, *s.c.a.* and reciprocal

effects is also given in this paper under two situations when the cross effects are taken as fixed effects and when these taken as random effects. For the $L_2(s)$ design with the parameters

$$v=s^2,\ b=2s,\ r=2,\ k=s,\ \lambda_1=1,\ \lambda_2=0,$$

g.c.a. and maternal effects are partially confounded and other effects are left unconfounded whereas for the $L_2(s)$ design with the parameters

$$v=s^2,\ b=s(s-1),\ r=s-1,\ k=s,\ \lambda_1=0,\ \lambda_2=1$$

the *g.c.a.* and maternal effects are left unconfouned and other effects are partially confounded.

51. On Some Balanced Row-Designs

By

A. K. NIGAM

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In this paper some row-column designs have been considered. These have been shown to become efficiency-balanced when one column has been deleted. These designs are the generalised forms of Youden and *F*-squares :

52. On A Method of Analysis of Confounded Asymmetrical Factorial Designs

By

H. T. TRIVEDI

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In recent years considerable research work has been done in regard to confounded asymmetrical factorial designs. After Yates introduced these designs in 1937, very little work of interest was available in literature till Nair & Rao (1941, 42, 43), Dick (1951), Li (1944), Kishen and Srivastava (1954) and Das (1960), evolved suitable method of construction of such designs. Following this work, several other papers have since appeared to fill up various gaps in constructional problems of these designs. Some of these works can be found in references, Sardana and Das (1961), Das & Rao (1967), Kishen & Tyagi (1971), Sreenath (1970).

In spite of these works, an analysis of unbalanced (in the sense of confounded specifically single replicated asymmetrical factorial designs) has received very little attention in literature. In fact, no satisfactory method of analysis of such designs is available. Here we present a method of analysis of confounded (balanced or not) asymmetrical factorial designs which can be deemed as to the existing methods of analysis but can be claimed as an improved one in sense that one can analyse the unbalanced asymmetrical factorial designs, especially the single replicated designs through this mtehod.

53. Some Incomplete Block Designs for Parallel Line Essays

By

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Das and Kulkarni (1966) proposed two series of incomplete block bio-assay (*I.B.B.*) designs for symmetrical parallel line assays in blocks of size $2k'$ ($K' \geqslant 2$). These designs provide full information on estimate of relative potency. Kulshrestha (1971) proposed three series of modified *I.B.B.* designs for symmetrical parallel line assays with even number of doses of standard and test preparations in blocks of size $4k'$ ($K' \geqslant 2$), which in addition to providing full information on relative potency also provides estimate of parallelism contrast without loss of information.

In this paper we discuss construction of *I.B.B.* designs for symmetrical parallel line assays for even number of doses of standard and test preparation in blocks of $4k'$ plots, which provides full information on estimate of relative potency and parallelism contrast by making use of concept of intra group partially balanced and intergroup balanced designs. Some methods of construction of these (intergroup balanced and intergroup partially balanced) designs are also discussed. These intergroup balanced and intragroup partially balanced designs are useful in getting *I.B.B.* designs for asymmetrical parallel line assays for even number of doses of standard and test preparation,

It is also shown that the loss of information on parallelism constrast from designs proposed by Das and Kulkarni (1966) by using circular designs can be reduced considerably by rearrangement of doses of standard preparation.

54. Multi-stage Generalised Two-way Elimination of Heterogeneity Designs

By

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Research workers in many of the agricultural branches often repeat their experiments to arrive at definite conclusions regarding the treatments under study. Such experiments are called "multistage experiments." The importance of these designs in experimentation and their constructions when the design at each stage is an Youden Square are discussed by Freeman (1957), (1958), (1959); Clarke (1963), (1967) ; Hedayat, Seiden and Federer (1972) Afsarinejad and Hedayat (1972) and Hedayat and Afsarinejad (1973).

In this paper, we give classes of multi-stage designs where at each stage, the designs are generalized two-way elimination of heterogeneity designs [*cf.* Agarwal (1966)] and possess some desirable properties.

55. On a Method of Constructing Group Divisible Incomplete Block Designs

By

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Two-associate-class partially balanced incomplete block designs were classified by Bose and Shimamoto (1952) into five classes among which group-divisible incomplete block designs constitute one of the important classes. Methods of constructing group-divisible designs are given by Bose and Conner (1952), Bose *et. al.* (1953), Freeman (1957), Raghavarao (1959), Sportt (1959) and others. The object of the present paper is to advance a method of constructing group-divisible incomplete block designs. Through this method, several designs which seem to be unknown to data have been obtained.