APPLICATION OF VARIANCE ESTIMATION METHODS ON RAINFALL, TEMPERATURE AND MOSQUITO POPULATION

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ABSTRACT

The paper examined some variance components such as Analysis of variance (ANOVA), Maximum likelihood estimate (MLE) and Restricted maximum likelihood estimate (RMLE) to estimate Rainfall, temperature and number of mosquitoes in 10 apartments near some health centre in Ijebu north local government of Ogun State, Nigeria. It was observed that there is significant difference between rainfall, temperature and number of mosquitoes in the local government. The findings show that RMLE method seems to give a better estimate than ML and ANOVA because the variances are relatively small compared to that of ML and ANOVA for a balanced one-way model.

Keywords: Analysis of variance, Maximum likelihood estimate, Restricted maximum likelihood estimate

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INTRODUCTION

Variance components is a method often used in population genetics and applied in animal breeding. It was introduced by Anderson & Bancroft [1]. The variance components include Analysis of variance (ANOVA), Maximum likelihood estimate (MLE), Restricted maximum likelihood estimate (RMLE) and Quasi-maximum like hood estimate (QMLE). In this study, ANOVA, MLE and RMLE was considered to estimate Rainfall, temperature and mosquito population in Ijebu north local government of Ogun State, Nigeria. The work of Ajah *et al*. [2] using Analysis of variance method results indicated that the effect of grazing livestock on cowpea and soybean production significantly varied from one area to another with Kwali area council as the most affected while Abaji was the least. Also, the work of Mouhamadou [3] indicated that there is a statistically significant relationship with strong effect size between safety and security index and human development using ANOVA. The findings of Olasupo *et al*. [4] examines the semi average methods to estimate the trend of malaria cases in Nigeria. The trend analysis indicated that the rate of malaria reported cases is increasing as the year is moving gradually.

MATERIALS AND METHODS

The three variance estimation methods considered in this work include analysis of variance, maximum likelihood estimates and restricted maximum likelihood estimate.

Analysis of variance

Analysis of variance is used to check if the means of two or more groups are significantly different from each other.

The model of one-way ANOVA can be given as

$$y_{ij} = \mu_i + \varepsilon_{ij} \qquad (1)$$

Where $i = 1,2,\dots k$ and $j = 1,2,\dots n$, ε_{ij} is normally distributed with mean μ and variance σ^2

The sum of square total (SST) is the sum of the square deviations from the grand mean and can be calculated using the formula:

$$SST = \sum_{i=1}^{k}\sum_{j=1}^{n} X_{ij}^2 - \frac{T^2}{N} \qquad (2)$$

Sum of square treatment (SSt) is the deviation of the treatment means about the grand mean and is given as:

$$SSt = \frac{1}{n_i}\sum T_i^2 - \frac{T^2}{N} \qquad (3)$$

Sum of square error is the defined as the deviation of X_{ij} from the treatment means. It is the experimental error of a given experiment and can be calculated as the difference between the sum of square total and sum of square of the treatment.

$$SSE = SST - SSt \qquad (4)$$

Maximum likelihood estimate (ML)

This method is commonly used in statistics in estimating parameters of a distribution. The maximum likelihood estimators maximizes the likelihood of the parameters given the density functions and the data $y_{ij} = \mu_i + \varepsilon_{ij}$ *where* $i = 1,2,\dots k$ *and* $j = 1,2,\dots n$, ε_{ij}

The maximum likelihood estimates are;

$$\hat{\sigma}_{\varepsilon}^2 = \frac{SSE + SSt}{k(n-1)} \qquad (5)$$

$$\sigma_{\mu}^2 = \frac{1}{n}\left(\frac{SSt}{K} - MSE\right) \qquad (6)$$

Restricted maximum likelihood

$$\widehat{\sigma}_{\varepsilon}^{2} = \frac{SSE+SSt}{kn-1} \quad (7)$$

$$\boldsymbol{\sigma}_{\mu}^{2} = \frac{1}{n} = \left[\frac{SSt}{k-1} - \text{MSE}\right] = \frac{1}{n}[MSt - MSE] \quad (8)$$

RESULTS AND DISCUSSION

Table 1: Rainfall, Temperature and Number of Mosquitoes

No of mosquitoes	**75**	**80**	**113**	**102**	**121**	**111**	**108**	**58**	**98**	**136**	**163**	**151**
Temperature (average)	**28.4**	**27.4**	**26.4**	**25.3**	**26.7**	**27.7**	**28.5**	**30.3**	**28.7**	**29.3**	**29.9**	**29.2**
Rainfall	**208**	**268**	**247**	**225**	**201**	**203**	**70**	**14**	**17**	**35**	**17**	**130**

Performing the Analysis of Variance (ANOVA) in Table 1 we have

Using 5% level of significance

$$SST = \sum_{i=1}^{k}\sum_{j=1}^{n} X_{ij}^{2} - \frac{T^{2}}{N}$$

$$75^{2} + 80^{2} + \cdots + 130^{2} - \frac{(75 + 80 + \cdots + 130)^{2}}{36}$$

$$SST = 195872.57$$

$$SSt = \frac{1}{n_i}\sum T_i^{2} - \frac{T^{2}}{N}$$

$$\frac{1316^{2}}{12} + \frac{337.8^{2}}{12} + \frac{1635^{2}}{12} - \frac{(75 + 80 + \cdots + 130)^{2}}{36}$$

$$SSt = 76149.002$$

$$SSE = SST - SSt$$

$$SSE = 119723.57$$

Source of Variation	Degree of freedom	Sum of Square	Mean square	F ratio
Treatment	2	76149	38074.5	10.49
Error	33	119723.57	3627.99	
Total	35	195872.57		

H_0 : There is no significant difference between rainfall, temperature and number of mosquitoes

H_1 : There is significant difference between rainfall, temperature and number of mosquitoes

Test Statistics = F_{cal} = 10.49

Critical Value = $F_{\alpha, 2, 33}$ = 3.32

Decision Rule: we accept H_1 if $F_{cal} > F_{tab}$. Since $F_{cal} > F_{tab}$ i.e. 10.49 > 3.32.

Conclusion: There is significant difference between rainfall, temperature and number of mosquitoes

To estimate the variance components σ^2_{ε} and σ^2_{μ}.

σ^2_{ε}= Mean square error = 3627.99

$$\sigma_\mu^2 = \frac{(MSt - MSE)}{N}$$
$$\sigma_\mu^2 = 956.8$$

Performing Maximum Likelihood Estimator in Table 1.1, we have

$$\widehat{\sigma}_\varepsilon^2 = \frac{SSE + SSt}{k(n-1)}$$
$$\widehat{\sigma}_{\mathrm{MLE}}^2 = 1865.45$$
$$\sigma_\mu^2 = \frac{1}{n}\left(\frac{SSt}{K} - MSE\right)$$
$$\sigma_\mu^2 = 604.31$$

Restricted Maximum Likelihood Estimator in Table 1.1, we have

$$\widehat{\sigma}_\varepsilon^2 = \frac{SSE + SSt}{kn - 1}$$
$$\widehat{\sigma}_\varepsilon^2 = 1865.45$$
$$\boldsymbol{\sigma}_\mu^2 = \frac{1}{n}[MSt - MSE]$$
$$\boldsymbol{\sigma}_\mu^2 = 604.31$$

CONCLUSION

Table 2: Estimate of ANOVA, ML and RMLE

Estimates	σ_ε^2	σ_μ^2
ANOVA	3627.987	956.847
ML	1865.45	21755.013
RMLE	1865.45	604.306

Table 2 above shows that the ANOVA method has 3627.99 as its variance for error and 956.847 as its variance for mean. It also shows that the ML and REML has their variances for error to be 1865.45 and the variances for mean of ML is 21755.013 and that RMLE as 604.31.

The following deductions can be made from the estimates obtained using the ANOVA, ML and RMLE methods

1. The estimates of the RMLE seems to be the best
2. The estimates of the three methods of estimating variance component used are not within the parameter space.
3. The findings shows that RMLE method seems to give a better estimate than ML and ANOVA because the variances are relatively small compared to that of ML and ANOVA for a balanced one-way model.

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