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RESEARCH ARTICLE

# CUM DUAL PRODUCT ESTIMATOR FOR THE POPULATION MEAN USING RANKED SET SAMPLING

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**ABSTRACT**

It has been shown that Ranked Set Sampling (RSS) is highly beneficial to the estimation based on Simple Random Sampling (SRS). There has been considerable development and many modifications were done to this method. The problem of estimating the population means is an integral aspect of a scientific survey. The estimators were examined for cum-dual products under Ranked Set Sampling (RSS), while the first-order approximation to the bias and Mean Square Error (MSE) of the proposed estimators were obtained. The numerical illustration of the comparisons was carried out to support the claim that the proposed estimators are more efficient than some existing estimators. Data were simulated for study variable y and auxiliary variable $x$ using $R$ software for the analysis to support the claim. The result shows that MSE of the proposed estimators, $\bar{y}^*_{pd,RSS}$ is smaller than the MSE of the existing estimators $\bar{y}^*_{pd}$,$\bar{y}^*_{Rd}$, $\bar{y}^*_{R,RSS}$,$\bar{y}^*_{RSS,MM1}$ and $\bar{y}^*_{RSS,MM2}$ and $\bar{y}^*_{RSS,MM3}$ at $\rho = -0.1, -0.2, 0.1, 0.2$, hence, the proposed estimator performed better than the existing estimators. While the MSE of the proposed estimator $y\bar{y}^*_{pd,RSS}$ is greater than the MSE of the existing estimators $\bar{y}^*_{pd}$ and $\bar{y}^*_{Rd}$ at $\rho$ = -0.3 and 0.3. However, the proposed estimator $\bar{y}^*_{pd,RSS}$ does not perform better than the estimators, $\bar{y}^*_{pd}$,*and* $\bar{y}^*_{Rd}$ at $\rho$ = -0.3 and 0.3. It was concluded that the proposed estimator was more efficient than a class of regression estimators and four existing ratio-type estimators based on RSS.

**KEYWORDS**

Ranked Set Sampling, Ratio Estimator, Product Estimator, Auxiliary Variable, Coefficient of Variation.

## 1. INTRODUCTION

MacIyntre originally proposed a Ranked Set Sampling (RSS), another method of collecting data that has been revealed to enhance simple random sampling (SRS) (MacIyntre, 1952). Judgment ranking of a feature of interest was used by RSS to enhance the estimation of a population parameter. The usefulness of this method is when the variable of interest is highly difficult or costly to measure but the ranking can be easily done at a cost of negligibility. RSS has numerous improvements and modifications and becomes a well-applicable method whenever a ranking mechanism can be found. RSS is useful such that the sampling units ranking is easily carried out and sampling is much more affordable than the variable of interest measurement. Particularly, it is useful in the following situations: (1) certain concomitant variables are available and easy to obtain.

Variables that are correlated with the variables of major interest are referred to as concomitant variables. These situations are numerous in practice. Regardless of how ranking is done, the efficiency of RSS is expected to be more than Simple Random Sampling (SRS), this is because intuitively more information is contained in RSS than a simple random sampling of the same size since a ranked set sample contains the information carried by the ranks not only the information carried by the measurements on the variables of interest. The variable of interest Y is difficult to measure and to rank in some cases in the practical situations but a concomitant variable X can be easily ranked if it is highly correlated with Y which can be used for sampling units ranking. This idea was initially considered (Stokes, 1977). In numerous fields, like agriculture, medicine, biology, and the environment, it is not easy to measure study variables, but it is cheap and cost-free to carry out the ranking.

In real situations, RSS was applied to generation surveys in direct-seeded areas to longleaf pine (Evans 1967). The means based on both RSS and SRS methods were not different significantly, but there is a much difference in the computed variances of the means. The mean of grassland, forest, and other vegetation resources was estimated using RSS (Johnson et al., 1993). The procedure of RSS was used for estimating shrub phytomass in Application Oak forests (Martyin et al., 1980). Four experiments were conducted to investigate the performance of RSS relative to SRS for heritage mass estimation in clover content in nixed grass-clover and of herbage mass and pure grass swards (cobby et al., 1985). The condition under which the RSS becomes a cost-effective sampling method for environmental and ecological field studies was roughed but cheap measurement has a cost. The introduction of formula for the total cost for both RSS and SRS was carried out by them and presented cost ratios for a real data set consisting of the physically measured stream and judgment estimated (Mode et al., 1999).

The use of RSS in estimating the median and mean of a population using the production of crop data set shows that the mean estimation using RSS has a better-gained efficiency for symmetric distribution, and otherwise in the case of median estimation (Husby et al., 2005). The RSS estimation was

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used in milk production, an average of Olives yields, consumer surveys and market, weights of browse and herbage, and population mean and the ratio using a real data set on body measurement (Halls and Dells, 1966; Al-saleh and Al-shrafat 2001; Al-Saleh and Al-Omari 2002; Kowaalezyk 2005; Ganeslingnam and Ganesh, 2006). The Best Linear Unbiased Estimators (BLUEs) of the location and scale parameters of the location-scale family of distributions based on ordered SRS or order statistics were obtained by Lloyd by using the generalized least-squares approach (Lloyd, 1952). While the Simple Linear Regression Model (SLRM) based on RSS was developed (Muttlak, 1995).

Samawi and Muttlak defined the ratio estimator for the population means as (Samawi and Muttlak, 1996)

$$\bar{y}_{R,RSS} = \bar{y}_{(n)}\left(\frac{\bar{x}_{(n)}}{\bar{X}}\right) \quad (1)$$

Motivated by suggested a ratio-type estimator for $\bar{Y}$using RSS, when the population coefficient of the auxiliary variable $C_x$ is known as (Sisodia and Dwivedi, 1981; Mandowara and Nitu Mehta (Ranka), 2013):

$$\bar{y}_{RSS,MM1} = \bar{y}_{(n)}\left(\frac{\bar{X}+Cx}{\bar{x}_{(n)}}\right) \quad (2)$$

Many authors including Adebola and Nurudeen proposed a class of regression estimator with cum-dual product estimator as an intercept for estimating the population means $\bar{Y}$ given (Adebola and Nurudeen (2015).

$$\text{as } \bar{y}^{*}_{pd} = \bar{y}\frac{\bar{X}}{\bar{x}^{*}} + \alpha\,(\bar{X} - \bar{x}^{*}) \quad (3)$$

Where $\alpha$ is a suitable scalar.

A group researchers also proposed a class regression estimator with cum-dual ratio estimator as intercept for estimating population mean $\bar{Y}$. (Adebola et al., 2015).

$$\bar{y}^{*}_{Rd} = \bar{y}\frac{\bar{x}^{*}}{X} + \alpha\,(\bar{X} - \bar{x}^{*}) \quad (4)$$

The technique of simple random sampling has some shortcomings like an inconvenience in administration, less efficiency in case of heterogeneous populations, and different sections of the population with less representative. Literature reveals that regression estimator with cum-dual product and cum-dual ratio using ranked set sampling performs better than regression estimator with cum-dual product cum-dual ratio in simple random sampling under certain conditions. In this paper, we proposed an estimator which was compared with the existing estimator to stimulate the data for the study variable y and auxiliary variable $x$ using $R$ software. The simulation of this analysis was carried out on a finite population that is relatively large with a sample size, n = 100, where m = 10 and r =10.

## 2. THE PROPOSED ESTIMATOR

A group researchers proposed a class of regression estimator with dual product cum as the intercept for estimating the population mean using ranked set sampling $\bar{y}_{pd,RSS^*}$ is given as (Adebola et al., 2015):

$$\bar{y}^{*}_{pd,RSS} = \bar{y}_{(n)\varphi} + \alpha\left(\bar{X} - \bar{x}^{*}_{(n)}\right) \quad (5)$$

Recall $\varphi = \frac{X}{\bar{x}^{*}_{(n)}}$

NOTE: To obtain Bias and MSE of $\bar{y}^{*}_{pd,RSS}$, we set $\bar{y}_{(n)} = \bar{Y}\,(1 + \mathcal{E}_0)$ and $\bar{x}_{(n)} = \bar{X}\,(1 + \mathcal{E}_1)$ and $\bar{x}^{*} = \frac{N\bar{X} - n\,\bar{x}_{(n)}}{N-n}$

By substituting values of $\bar{y}_{(n)}, \bar{x}_{(n)}$and $\bar{x}^{*}_{(n)}$ in equation (1), we have

$$Bias(\bar{y}^{*}_{pd,RSS}) = \bar{Y}\,g\left(\left[g\theta C_x^2 - W^2_{x(i)}\right] - \left[\theta\rho_{xy}C_xC_y - W_{xy(i)}\right]\right) \quad (6)$$

$$MSE(\bar{y}^{*}_{pd,RSS}) = \bar{Y}^2\left(\theta C_y^2 - W^2_{y(i)}\right) + 2g\bar{Y}(\theta\rho_{xy}C_xC_y - W_{xy(i)})(\bar{Y} - \alpha\bar{X}) + g^2\left(\theta C_x^2 - W^2_{x(i)}\right)(\bar{Y} - \alpha\bar{X})^2 \quad (7)$$

*Since*

$$Var(\bar{y}^{*}_{pd,RSS}) = MSE(\bar{y}^{*}_{pd,RSS}) - \left[Bias(\bar{y}^{*}_{Rd,RSS})\right]^2 \quad (8)$$

Therefore

$$Var(\bar{y}^{*}_{pd,RSS}) = MSE(\bar{y}^{*}_{Rd,RSS}) - \left[Bias(\bar{y}^{*}_{Rd,RSS})\right]^2\ Var(\bar{y}^{*}_{pd,RSS}) = Var\bar{Y}^2\left(\theta C_y^2 - W^2_{y(i)}\right) + g^2\left(\theta C_x^2 - W^2_{x(i)}\right)(\bar{Y} - \alpha\bar{X})^2 + \bar{Y}^2g^2\left[g\theta C_x^2 - W^2_{x(i)}\right]\left[2\left(\theta\rho_{xy}C_xC_y - W_{xy(i)}\right) - \left(g\theta C_x^2W_{x(i)}\right)\right]\bar{Y}g\left(\theta\rho_{xy}C_xC_y\ W_{xy(i)}\right)\left[2(\bar{Y} - \alpha\bar{X}) - \bar{Y}g\left(\theta\rho_{xy}C_xC_y - W_{xy(i)}\right)\right] \quad (9)$$

### 2.1 Optimality of $\alpha$

Optimality value of $\alpha$ to minimize the $MSE(\bar{y}^{*}_{Rd,RSS})$ can easily be found as follows: $\frac{\partial MSE(\bar{y}^{*}_{pd,RSS})}{\partial\alpha} = 0$

$$\alpha^{**} = \frac{2W^2_{x(i)}\bar{Y} - g^2\theta C_x + 2g\bar{Y}\left[\theta\rho_{xy}C_xC_y - W_{xy(i)}\right]}{2W_x^2\bar{X}} \quad (6)$$

Where we replace $\alpha$ with $\alpha^{**}$ in equation, we obtained the minimum MSE of the proposed estimator as follows:

$$MSE_{min}(\bar{y}^{*}_{Rd,RSS}) = \bar{Y}^2\left(\theta C_y^2 - W^2_{y(i)}\right) + 2g\bar{Y}\left(\theta\rho_{xy}C_xC_y - W_{xy(i)}\right)(\bar{Y} - \alpha^{**}\bar{X}) + g^2\left(\theta C_x^2 - W^2_{x(i)}\right)(\bar{Y} - \alpha^{**}\bar{X})^2 \quad (10)$$

### 2.2 Efficiency Comparison

#### *2.2.1 The comparison of $MSE(\bar{y}^{*}_{pd,RSS})$ with $MSE(\bar{y}^{*}_{pd})$*

In this section, we compared the MSE of the proposed estimator $\bar{y}^{*}_{pd,RSS}$ with the MSE of regression estimator with cum dual ratio estimator $\bar{y}^{*}_{pd}$*under simple random sampling given as:

By comparing $MSE(\bar{y}^{*}_{pd,RSS})$ and MSE $\bar{y}^{*}_{pd}$

$$MSE(\bar{y}^{*}_{pd,RSS}) = \bar{Y}^2\left(\theta C_y^2 - W^2_{y(i)}\right) + 2g\bar{Y}(\theta\rho_{xy}C_xC_y - W_{xy(i)})(\bar{Y} - \alpha\bar{X}) + g^2\left(\boldsymbol{\theta C_x^2} - W^2_{x(i)}\right)(\bar{Y} + \alpha\bar{X}) \leq MSE(\bar{y}^{*}_{pd}) = \left(\frac{1-f}{n}\right)\ (\bar{Y}^2C_y^2 + 2g\rho\bar{Y}C_xC_y(\bar{Y} - \alpha\bar{X}) + 2g^2\boldsymbol{C_x^2}(\bar{Y} - \alpha\bar{X})^2)$$

And since

$$-\bar{Y}^2W_y^2 - 2g\bar{Y}W_{xy} + g^2W_x^2\bar{X}(\bar{Y} - \alpha\bar{X}) - g^2W_x^2(\bar{Y} - \alpha\bar{X}) \leq 0$$

Therefore,

$$MSE(\bar{y}^{*}_{pd,RSS}) < MSE(\bar{y}^{*}_{pd}) \quad (11)$$

#### *2.2.2 The Ratio Estimator for The Population Mean Defined By Samawi and Muttlak (1996) is Given Below*

In this section, the MSE of the proposed estimator $\bar{y}^{*}_{pd,RSS}$ with the MSE of the usual ratio estimator $\bar{y}_{R,RSS}$

Based on ranked set sampling as explained below:

$$\bar{Y}^2\left(\theta C_y^2 - W^2_{y(i)}\right) + 2g\bar{Y}\left(\theta\rho_{xy}C_xC_y - W_{xy(i)}\right)(\bar{Y} - \alpha\bar{X}) + g^2$$

$$(\bar{Y} + \alpha\bar{X})^2 \leq \bar{Y}^2\left(\theta C_x^2 - 2\theta\rho_{xy}C_xC_y + 2W_{x(i)}W_{y(i)} - W^2_{x(i)}\right)$$

And since

$$\bar{Y}2\theta C_{xy}[\mathrm{g}(\bar{Y} + \alpha\bar{X}) + \bar{Y}] - 2\bar{Y}^2W_{xy(i)}[g-1] - g^2(\bar{Y} - \alpha\bar{X})^2$$

$$\left[W_{x(i)} - \theta C_x^2\right] - 2g\bar{Y}\bar{X}\alpha\left[W_{xy(i)} - \theta C_{xy}\right] < 0$$

Therefore, the $MSE(\bar{y}^{*}_{pd,RSS}) \cong MSE(\bar{y}^{*}_{R,RSS})$ (12)

This shows that the MSE of the proposed estimator is always smaller than the MSE of the estimator, as suggested (Samawi and Muttlak, 1996). As a result, we show that the proposed estimator is more efficient than the ratio estimator in (Samawi and Muttlak, 1996).

#### *2.2.3 Ratio-Type Estimator for $\bar{Y}$ Using Ranked Set Sampling*

$$\bar{Y}^2\left(\theta C_y^2 - W^2_{y(i)}\right) + 2g\bar{Y}\left(\theta\rho_{xy}C_xC_y - W_{xy(i)}\right)(\bar{Y} - \alpha\bar{X}) + g^2\left(\boldsymbol{\theta C_x^2} - W^2_{x(i)}\right)(\bar{Y} + \alpha\bar{X})^2 < \bar{Y}^2\left(\theta\left(C_y^2 + \lambda_1^2\boldsymbol{C_x^2} - 2\lambda_1\rho_{xy}C_xC_y\right) - \left(W_{y(i)} - \lambda_1W_{x(i)}\right)^2\right)$$

And since,

$$-2\bar{Y}W_{xy(i)}[g\bar{Y} + \lambda_1\bar{Y} + g\alpha\bar{X}] + +g^2(\bar{Y} + \alpha\bar{X})^2[\boldsymbol{\theta}C_x^2 - g^2W_x^2]$$

$-\bar{Y}^2\theta\lambda_1 C_x + 2\bar{Y}\theta C_{xy}[g\bar{Y} + \bar{X}\alpha g - \bar{Y}\lambda_1] + \lambda_1^2 W_1^2 \bar{Y}^2 < 0$

Therefore, $MSE(\bar{y}^*_{pd,RSS}) \cong MSE(\bar{y}^*_{RSS,MM1})$ (13)

which shows that the MSE of the proposed estimator is smaller than the MSE of the estimator, suggested (Mandowara and Nitu Mehta, 2013)

### 2.2.4 Ratio-Type Estimators Considering Both Coefficient of Variation and Kurtosis Using Ranked Set Sampling

$MSE(\bar{y}^*_{pd,RSS}) = \bar{Y}^2(\theta C_y^2 - W_{y(i)}^2) + 2g\bar{Y}(\theta\rho_{xy}C_xC_y - W_{xy(i)})(\bar{Y} - \alpha\bar{X}) + g^2(\boldsymbol{\theta C_x^2} - W_{x(i)}^2)(\bar{Y} + \alpha\bar{X})^2 < MSE(\bar{y}^*_{RSS,MM3}) = \bar{Y}^2\left(\theta(C_y^2 + \gamma_1^2\boldsymbol{C_x^2} - 2\gamma_1\rho_{xy}C_xC_y) - (W_{y(i)} - \gamma_1 W_{x(i)})^2\right)$

And Since

$-W_{y(i)}^2(\bar{Y}^2 - 1) + 2\bar{Y}\theta C_{xy}(g\bar{Y} + \gamma_1\bar{Y} + g\alpha\bar{X}) - 2W_{xy}(\gamma_1 + g\bar{Y}(1 + \alpha\bar{X}))$

$-\bar{Y}^2\boldsymbol{\theta C_x^2}((\gamma_1^2) - g^2) - \mathbf{2}g^2\bar{Y}\bar{X}\alpha(W_{y(i)}^2 - \theta C_y^2) - g^2\boldsymbol{\alpha^2}\bar{X}^2(W_{x(i)}^2 - \boldsymbol{\theta} C_x^2)$

$-W_{x(i)}^2(g^2 - \gamma_1^2) < 0$

Therefore,

$MSE(\bar{y}^*_{pd,RSS})$ is better than $MSE(\bar{y}^*_{RSS,MM3})$

Since $MSE(\bar{y}^*_{pd,RSS}) < MSE(\bar{y}^*_{RSS,MM3})$ (14)

### 2.2.5 Ratio-Type Estimators By Changing The Place of Coefficient of Kurtosis and Coefficient of Variation Using Ranked Set Sampling

$MSE(\bar{y}^*_{pd,RSS}) = \bar{Y}^2(\theta C_y^2 - W_{y(i)}^2) + 2g\bar{Y}(\theta\rho_{xy}C_xC_y - W_{xy(i)})(\bar{Y} - \alpha\bar{X}) + g^2(\boldsymbol{\theta C_x^2} - W_{x(i)}^2)(\bar{Y} + \alpha\bar{X})^2 < MSE(\bar{y}^*_{RSS,MM4}) = \bar{Y}^2\left(\theta(C_y^2 + \gamma_2^2\boldsymbol{C_x^2} - 2\gamma_2\rho_{xy}C_xC_y) - (W_{y(i)} - \gamma_2 Wx_{x(i)}^2)\right)$

And since

$-W_{y(i)}^2(\bar{Y}^2 - 1) + 2\bar{Y}\theta C_{xy}(g\bar{Y} + \gamma_2\bar{Y} + g\alpha\bar{X}) - 2W_{xy}(\gamma_2 + g\bar{Y}(1 + \alpha\bar{X}))$

$-\bar{Y}^2\boldsymbol{\theta C_x^2}((\gamma_2^2) - g^2) - \mathbf{2}g^2\bar{Y}\bar{X}\alpha(W_{x(i)}^2 - \theta C_x^2) - g^2\alpha^2\bar{X}^2(W_{x(i)}^2 - \boldsymbol{\theta} C_x^2)$

$-W_{x(i)}^2(g^2 - \gamma_2^2) < 0$

Therefore,

$MSE(\bar{y}^*_{pd,RSS})$ is better than $MSE(\bar{y}^*_{RSS,MM4})$

Since $MSE(\bar{y}^*_{pd,RSS}) < MSE(\bar{y}^*_{RSS,MM4})$ (15)

## 3. Numerical Experiments

The numerical illustration of the comparisons was carried out to support the claim that the proposed estimators are more efficient than some existing estimators. Data were simulated for study variable y and auxiliary variable $x$ using $R$ software for the analysis to support the claim. Where study variable $y$ and auxiliary variable $x$ are highly correlated. Data obtained were normally distributed.

The simulation of this analysis was carried out on a finite population that is relatively large with a sample size, n = 100, where m = 10 and r =10.

**Table 1:** This Table Shows The Performances of The Proposed Estimators $\bar{y}_{pd,RSS}$ Over Other Existing Estimators Between The Range Of $P$ = -1 To 1.

| Estimators | -0.1 | -0.2 | -0.3 | 0.1 | 0.2 | 0.3 |
|---|---|---|---|---|---|---|
| $\bar{y}^*_{pd,}$ | 0.004047833 | 0.003925172 | 0.003720736 | 0.004047833 | 0.003925172 | 0.003720736 |
| $\bar{y}^*_{Rd}$ | 0.004047833 | 0.003925172 | 0.003720736 | 0.004047833 | 0.003925172 | 0.003720736 |
| $\bar{y}^*_{pd,RSS}$ | **0.003782917** | **0.003775454** | **0.003768061** | **0.003798055** | **0.00380573** | **0.003813475** |
| $\bar{y}^*_{R,RSS}$ | 0.006477894 | 0.007040894 | 0.007603893 | 0.005351894 | 0.004788894 | 0.004225895 |
| $\bar{y}^*_{RSS,MM1}$ | 0.006175774 | 0.006737065 | 0.007298355 | 0.005053192 | 0.004491902 | 0.003930611 |
| $\bar{y}^*_{RSS,MM\ 3}$ | 0.006196744 | 0.006760823 | 0.007324903 | 0.005068584 | 0.004504504 | 0.003940424 |
| $\bar{y}^*_{RSS,MM4}$ | 0.00433385 | 0.004565428 | 0.00479747 | 0.0038693 | 0.004637258 | 0.003905216 |

## 4. Description of The Results

In this paper, the efficiency of the proposed estimator has been investigated. Since the MSE of the proposed estimators, $\bar{y}^*_{pd,RSS}$ is smaller than the MSE of the existing estimators $\bar{y}^*_{pd}$,$\bar{y}^*_{Rd}$, $\bar{y}^*_{R,RSS}$,$\bar{y}^*_{RSS,MM1}$and $\bar{y}^*_{RSS,MM2}$and $\bar{y}^*_{RSS,MM3}$ at $\rho$ = −0.1,−0.2,0.1,0.2, respectively, therefore, the proposed estimator performed better than the existing estimators. While the MSE of the proposed estimator $y\bar{y}^*_{pd,RSS}$ is greater than the MSE of the existing estimators $\bar{y}^*_{pd}$and $\bar{y}^*_{Rd}$ at $\rho$ = -0.3 and 0.3. Therefore, the proposed estimator $\bar{y}^*_{pd,RSS}$ does not perform better than the estimators, $\bar{y}^*_{pd}$,*and* $\bar{y}^*_{Rd}$ at $\rho$ = -0.3 and 0.3. Our new proposed product ranked set sampling performed better in numerical illustration as displayed very clearly in Table 1.

## 5. Conclusion

We have proposed a cum dual product estimator for the population means using ranked set sampling. The optimality of the proposed estimator was also obtained. Theoretically, we have proven that the proposed estimator was more efficient than a class of regression estimators and four existing ratio-type estimators based on RSS. Numerical validation of the proposed estimator was carried out to show the superiority of the proposed estimator over the estimators based on simple random sampling and ranked set sampling.

## References


Adebola, F.B., Adegoke, N.A., and Ridwan, S., 2015. A Class of Regression Estimator with Cum-Dual ratio Estimator as Intercept. Global Journal of Science Frontier Research, mathematics and decision Sciences.

Adebola, F.B., and Adegoke, N.A., 2015. A Class of Regression Estimator with Cum-Dual Product Estimator as Intercept. International Journal of Probability and Statistics, 4 (2), Pp. 42-50.

Al–Saleh, M.F., and Al–Omari, A.I., 2002. Multistage ranked set sampling. Journal of Statistical Planning and Inference, 102, Pp. 273–286.

Al–Saleh, M.F., and Al–Shrafat, K., 2001. Estimation of milk yield using ranked set sampling. Envirometrics, 12, Pp. 395–399.

Cobby, J.M., Bassett, P.J., and Large R.V., 1985. An investigation into the use of ranked set sampling on grass and grass-clover swards. Grass and Forage Science, 40, Pp. 257–63.

Evans, M.J., 1967. Application of ranked set sampling to regeneration, Surveys in areas direct seeded to long leaf pine. Unpublished paper, Master Thesis, school for Forestry.

Ganeslingam, S., and Ganesh, S., 2006. Ranked set sampling versus simple random sampling in the estimation of the mean and the ratio. Journal of Statistics and Management Systems, 2, Pp. 459–472.

Halls, L.S., and Dell, T.R., 1966. Trial of ranked set sampling for forage yields. Forest Science, 12 (1), Pp. 22–26.

Husby, C.E., Stansy, E.A., and Wolfe, D.A., 2005. An application of ranked set sampling for mean and median estimation using USDA crop production data.Journal of Agricultural, Biological, and Environmental Statistics, 10 (3), Pp. 354–373.

Johnson, G.D., Paul, G.P., and Sinha, A.K., 1993. Ranked set sampling for vegetation research. AbstractaBotanica, 17, Pp. 87–102.

Kowalezyk, B., 2005. Alternative sampling designs some applications of qualitative data in survey sampling. Statistics in Transition, 7 (2), Pp. 427–443.

Lloyd, E.H., 1952. Least-squares estimation of location and scale parameters using order statistics. Biometrika 39 (1/2), Pp. 88-95.

Mandowara, V.L., and Mehta, N., 2013. efficient generalized ratio-product type estimator for finite population means with ranked set sampling. Austrian Journal of statistics, 42 (3), Pp. 137-148.

McIntyre, G.A., 1952. A method of unbiased selective sampling, using ranked sets. Australian J. Agricultural Research, 3, Pp. 385–390.

Mode, N.A., Conquest, L.L., and Marker, D.M., 1999. Ranked Set Sampling for ecological research: accounting for the total costs of sampling. Environ metrics, 10, Pp. 179-194.

Muttlak, H.A., 1995. Parameters estimation in a simple linear regression using rank set sampling. Biometrical Journal, 37 (7), Pp. 799-810.

Samawi, H.M., Muttlak, H.A., 1996. Estimation of ratio using ranked set sampling. Biometrical Journal, 38, Pp. 753-784.

Sisodia, B.V.S., and Dwivedi, V.K., 1981. A modified ratio estimator using coefficient of variation of auxiliary variable. Journal of the Indian Society of Agricultural Statistics, 33, Pp. 13-18.

Stokes, S.L., 1977. Ranked set sampling with concomitant variables, communication in statistics-Theory and methods, 69 (12), Pp. 1207-1211.