



## Estimation of reduction in milk yield due to different diseases in buffaloes by using sampling methodology

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### ABSTRACT

Milk production is an important aspect of the dairy animals. The present study was conducted to estimate the effect of different diseases on per day milk yield in the buffaloes. Data from a sample of 1,214 livestock owners in two divisions of Uttar Pradesh namely Agra and Aligarh were collected. The value of reduction in per day milk yield due to different diseases under two different situations, viz. when strata weights were known and when strata weights were not known was estimated. The estimated value of reduction in milk yield under the situation when strata weights were known was 4.28 kg with variance 0.014 kg<sup>2</sup>. Mastitis is a disease which has a large impact on milk yield in buffaloes. But under the situation when strata weights were unknown and were estimated by double sampling, post stratification and published sources, the estimated value of average reduction in per day milk yield due to different diseases were 4.33 kg, 4.33 kg and 4.35 kg with variance 0.015 kg<sup>2</sup>, 0.017 kg<sup>2</sup> and 0.012 kg<sup>2</sup> respectively. In buffaloes, the best estimated value of average reduction in milk was provided by double sampling estimator.

**Keywords:** Double sampling, Milk reduction, Post-stratification, Relative efficiency

Livestock productivity is a very important factor which plays an important role in income, livelihoods and survival of entire populations. The livestock production depends on the health of the livestock. Numerous factors affect livestock production and productivity. Diseases and parasites are among the most severe factors that affect livestock production and productivity globally. Mastitis is one of the important disease causing huge production losses in livestock affecting dairy animals worldwide (Lightner *et al.* 1998, Kanenne and Hurd 1990, Miller *et al.* 1993, Kossabati *et al.* 1998, Bilal *et al.* 2004, Chishty *et al.* 2007). The simplest estimator of population mean is the sample mean obtained from simple random sampling, when there is no additional information available on the auxiliary variable. While conducting surveys in Animal Sciences there are certain variables like, disease occurrence about which information is not available before the survey. Hence it is not possible to estimate the parameters by using the proper sampling procedure because of lack of sampling frame. To overcome this problem, post sampling procedures (post stratification) and two phase sampling can be used. The information about auxiliary variable can also be obtained from the previous published sources such as census, journals, papers, theses, etc.

### MATERIALS AND METHODS

**Data:** To collect the information on effects of different

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diseases on production (milk yield) in buffaloes, a sample of 1,214 livestock owners was randomly selected from two divisions of Uttar Pradesh namely Agra (consists of four districts; Agra, Mathura, Mainpuri and Firozabad) and Aligarh (consists of two districts; Aligarh and Hathras). From each of six districts, information were collected randomly at village level by using pre-tested questionnaire specifically prepared for the study.

By taking different diseases as strata, whole sampled buffalo population was stratified in different strata for estimation purpose. The effect of diseases on milk yield was estimated in two different situations.

**Case-I (When strata weights were known):** The sample population of buffaloes in different strata was stratified on the basis of auxiliary variable (herd size per household). When stratum size  $N_h$  were known, then sample was selected from each stratum and the population mean of the different response variable estimated. The strata sample sizes were known such that

$$n = \sum_{h=1}^L n_h$$

The estimator of the population means  $\bar{Y}$  is given by (Cochran 1977)

$$\bar{y}_{pst} = \sum_{h=1}^L W_h \bar{y}_h \quad \dots (1)$$

The estimated variance of  $\bar{y}_{st}$  is given by

$$\hat{v}(\bar{y}_{st}) = \sum_{h=1}^L \frac{W_h^2 S_{hy}^2}{n_h} - \sum_{h=1}^L \frac{W_h S_{hy}^2}{N} \quad \dots (2)$$

When the stratum size total  $N_h$  are not known exactly, in that situation,  $w_h$  is measured instead of  $W_h$ , then the sample estimate is biased and the bias is given by (Cochran 1977)

$$\text{Bias}(\bar{y}_{st}) = \sum_{h=1}^L (w_h - W_h) \bar{Y}_h \quad \dots (3)$$

The accuracy of the estimate is measured by its mean square and mean square error is calculated as

$$\text{MSE}(\bar{y}_{st}) = \sum_{h=1}^L \frac{W_h^2 S_{hy}^2}{n_h} (1 - f_h) + \left[ \sum_{h=1}^L (w_h - W_h) \bar{Y}_h \right]^2 \quad \dots (4)$$

(Stephen 1941)

*Case-II (When strata weights were not known):* When strata weights  $W_h$  were not known, strata weights were estimated by using the following three methods:

*Strata weights  $W'_h$  estimated by the post sampling:* A random sample of fixed size  $n$  was taken from the sample population of sized  $N$  and after that the sample units were stratified in different strata (disease categories) according to desired criteria of stratification (Post stratification). The strata weights  $W'_h$  were estimated as follows:

$$W'_h = \frac{n'_h}{n} \quad \dots (5)$$

where,  $n = \sum n'_h$

In post sampling procedure, the stratum size  $N_h$  may not be known exactly. In this case usually  $w_h$  is used instead of true stratum weight  $W_h$ .

The sample estimate of  $\bar{Y}_{pst}$  is given by

$$\bar{y}_{pst} = \sum_{h=1}^L W_h \bar{y}_h \quad \dots (6)$$

The estimator of the variance of  $\bar{y}_{pst}$  is given by

$$\hat{v}(\bar{y}_{pst}) = \sum_{h=1}^L \frac{W_h^2 S_{hy}^2}{n_h} \quad \dots (7)$$

An estimator to estimate the variance of  $\bar{y}_{pst}$  is given by (Sarjinder 2003)

$$v(\bar{y}_{pst}) = \frac{(N-1)}{(N-n)} \hat{v}(\bar{y}) - \sum_{h=1}^L \frac{W_h}{n_h} \sum_{i=1}^{n_h} y_{hi}^2 + \bar{y}_{pst}^2 \quad \dots (8)$$

where

$$\hat{v}(\bar{y}) = \sum_{h=1}^L \frac{W_h}{n_h} \sum_{i=1}^{n_h} y_{hi}^2 - \bar{y}_{pst}^2 + \sum_{h=1}^L W_h^2 \frac{S_{hy}^2}{n_h}$$

*Strata weights  $W'_h$  estimated by the double sampling:* A large sample was drawn from the sample population to get the strata weights and the mean of the auxiliary variable. The sampling units were stratified in different strata  $N'_h$  (disease categories) according to desired criteria of stratification. Now a sample of size  $n_h$  units was selected randomly from each selected stratum of size. The stratum weight was estimated as follow:

$$W'_h = \frac{N'_h}{N'} \quad \dots (9)$$

where,

$$N' = \sum N'_h$$

This gives the double sampling stratified estimator of the mean.

*Strata weight  $W'_h$  estimated from the published sources:* The stratum size  $N'_h$  was taken from the available published sources and the stratum weight  $W'_h$  was estimated as follows:

$$W'_h = \frac{N'_h}{N'} \quad \dots (10)$$

where,

$$N' = \sum N'_h$$

After estimating the strata weights  $W'_h$  and selecting the sample of sized  $n_h$  from each selected stratum, the all remaining procedures to estimate the parameter (population mean) were followed in usual manner.

The relative efficiency of the two estimators ( $E_1$ ) and ( $E_2$ ) in different post sampling procedures was measured by the ratio of the reciprocals of their variances.

When  $E_1$  and  $E_2$  are unbiased estimators then percentage relative efficiency is given by

$$\text{RE}(E_1/E_2) = \frac{V(E_2)}{V(E_1)} \times 100 \quad \dots (11)$$

When  $E_1$  and  $E_2$  are biased estimators then percentage relative efficiency is given by

$$\text{RE}(E_1/E_2) = \frac{\text{MSE}(E_2)}{\text{MSE}(E_1)} \times 100 \quad \dots (12)$$

## RESULTS AND DISCUSSION

Information on incidence of morbidity and effects on production (milk yield) due to different diseases in buffaloes were collected from a sample of total 1,214 households in divisions of Uttar Pradesh namely Agra and Aligarh Divisions. From each of two divisions, information were collected randomly at village level by using pre-tested questionnaire specifically prepared for the study. After data collection, data were stratified by taking diseases as strata. To estimate the effect of various diseases on milk yield in buffaloes, a sample of size 74 buffaloes was taken through proportional allocation from sampled population of 186 buffaloes. In situation when strata weights were known then the estimated value of milk reduction in buffaloes under stratified sampling was 4.28 kg with variance 0.014 kg<sup>2</sup>. It was observed that mastitis had a large impact on milk yield in dairy animals and daily milk yield reduction due to mastitis was 2.09 kg with variance 0.005 kg<sup>2</sup>. Whereas diarrhoea had a small effect on milk yield (Table 1). Bilal *et al.* (2004) and Chishty *et al.* (2007) also observed that mastitis is one of the important disease causing huge production losses in livestock affecting dairy animals worldwide. But under the situation that the strata weights were unknown and estimated by using double sampling procedure, the estimate value of average reduction in milk yield due to different diseases was 4.33 kg with variance 0.015 kg<sup>2</sup> (Table 2). In buffaloes, milk fever also caused

the reduction in milk yield per day as compared to healthy animals. Dohoo and Martin (1984), Erb *et al.* (1985) reported a significant positive effect on the lactation yield in animals affected with the milk fever. Whereas the estimated value of average reduction in milk yield due to different diseases in buffaloes in post sampling procedure and in the cases of strata weights calculated by using published sources (Sharma and Verma 2013, Sharma *et al.* 2013) were 4.33 kg and 4.35 kg with variance 0.017 kg<sup>2</sup> and 0.012 kg<sup>2</sup> respectively (Tables 3 and 4).

*Efficiency comparison:* Estimates of per day reduction in milk yield due to different diseases were obtained under two situations (i) When strata weights were known; (ii) When strata weights were not known and estimated by using double sampling, post stratification and published sources. In this case efficiency was computed with stratified sampling ( $w_h$  known) with double sampling, post sampling and published sources.

In buffaloes, the best estimated value of average reduction in milk yield was provided by double sampling estimator (Table 5). The relative efficiency of double sampling estimator with stratified sampling estimator (when strata weights were known) was 139%. However the post sampling

estimator was less efficient as compared to other estimators.

The present study was conducted to estimate the per day reduction in milk yield in buffaloes due to different diseases. The results of the study indicated that the estimated value of reduction in milk yield under the situation when strata weights were known was 4.28 kg with variance 0.014 kg<sup>2</sup>. Mastitis is a disease which has a large impact on milk yield in buffaloes. When the strata weights were unknown and estimated by double sampling, post sampling and published data in that situation the estimator based on double sampling was more efficient. Hence reduction in per day milk yield in buffaloes based on double sampling estimator was 4.33 kg with variance 0.015 kg<sup>2</sup>.

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Table 1. Estimation of reduction in milk yield per day in buffaloes, when strata weight were known

Disease	$N_h$	$W_h$	$n_h$	$\bar{y}_h$	Variance $S_h^2$	Mean $W_h \cdot \bar{y}_h$	$v(\bar{y}_{str})$
Diarrhoea	22	0.12	9	3.56	1.78	0.42	0.001
FMD	34	0.18	13	4.77	2.1	0.87	0.002
HS	18	0.1	7	4.71	0.95	0.46	0
Mastitis	92	0.49	37	4.22	1.75	2.09	0.005
Milk fever	20	0.11	8	4.13	9.41	0.44	0.005
Total	186		74			4.28	0.014

Table 2. Estimation of reduction in milk yield per day in buffaloes, when strata weight were unknown and estimated by double sampling

Disease	$N_h$	$W_h$	$n_h$	$\bar{y}_h$	Variance $S_h^2$	Mean $W_h \cdot \bar{y}_h$	$v(\bar{y}_{str})$
Diarrhoea	22	0.15	11	3.27	1.22	0.49	0.001
FMD	29	0.2	14	4.21	3.1	0.83	0.004
HS	10	0.07	5	4.4	0.3	0.3	0
Mastitis	72	0.49	36	4.42	1.68	2.15	0.006
Milk fever	15	0.1	8	5.63	5.7	0.57	0.004
Total	148		74			4.33	0.015

Table 3. Estimation of reduction in milk yield per day in buffaloes, when strata weight were unknown and estimated by post sampling

Disease	$N_h$	$W_h$	$n_h$	$\bar{y}_h$	Variance $S_h^2$	Mean $W_h \cdot \bar{y}_h$	$v(\bar{y}_{str})$
Diarrhoea	22	0.19	9	3.86	2.75	0.73	0.003
FMD	34	0.22	13	4.25	2.6	0.92	0.003
HS	18	0.11	7	3.88	0.7	0.42	0
Mastitis	92	0.34	37	4.15	1.82	1.4	0.003
Milk Fever	20	0.15	8	5.82	9.16	0.86	0.007
Total	186		74			4.33	0.017

Table 4. Estimation of reduction in milk yield per day in buffaloes, when strata weight were unknown and estimated from published source

Disease	$N_h$	$W_h$	$n_h$	$\bar{y}_h$	Variance $S_h^2$	Mean $W_h \cdot \bar{y}_h$	$v(\bar{y}_{str})$
Diarrhoea	22	0.12	9	3.56	1.78	0.43	0.001
FMD	34	0.32	13	4.77	2.1	1.53	0.004
HS	18	0.08	7	4.71	0.95	0.38	0
Mastitis	92	0.43	37	4.22	1.75	1.8	0.004
Milk Fever	20	0.05	8	4.13	9.41	0.22	0.003
Total	186		74			4.35	0.012

Table 5. Bias and MSE of estimates of milk reduction in buffaloes under different estimation procedures

Disease	$W_h$ known	$W_h$ estimated by double sampling	$W_h$ estimated by post sampling	$W_h$ estimated by published source
Diarrhoea	0.1183	0.1486	0.1892	0.1200
FMD	0.1828	0.1959	0.2162	0.3200
HS	0.0968	0.0676	0.1081	0.0800
Mastitis	0.4946	0.4865	0.3378	0.4267
Milk fever	0.1075	0.1014	0.1486	0.0533
Bias	-0.004	0.0173	0.0415	-0.021
MSE	0.02085	0.0150	0.0372	0.0208
Relative efficiency	100%	139%	56.04%	100%

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