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Transformation methods for analysis of data on faecal egg count in sheep

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Fecal egg counts remained the most effective way of selecting sheep for parasitic resistance (Woolaston 1992). Factors like sex, age, reproductive status and season of birth of animals affect the resistance to *Haemonchus* infection in sheep. Different sets of transformation of data were used to analyse the fecal egg count data in different sheep breeds (Vanimisetti *et al.* 2004, Yadav *et al.* 2006). The appropriate transformation of data will lead to estimate the parameters more precisely and help to draw the valid conclusions. Hence the present study was carried out to select the appropriate transformation method for precise estimation of the prevalence of *H. contortus* infection and factors influencing the trait.

Adult Muzaffarnagari ewes (270) maintained at CIRG were used. The faecal samples were collected twice from each individual. The fecal egg counts (FEC) were conducted using the modified McMaster Method (Coles 1980) to determine the number of eggs per gram (epg) of faeces, and to obtain the severity of the infection. The FEC of ewes were classified according to the different physiological status (i.e., dry, lactating and pregnant) of ewes. As feacal egg counts were not normally distributed and because of skewed distribution, a set of logarithms transformation was applied to the raw data of fecal egg count (FEC) to correct the heterogeneity of variance and to produce approximately normally distributed data. Different transformations like $\log_{10}$ (FEC+1), $\log_{10}$ (FEC+25), $\log_e$ (FEC+1) and $\log_e$ (FEC+100) were tested for normality using normal probability plot technique. Shapiro-Wilk test (Shapiro and Wilk 1965) was also applied to test the normality of transformed variable by calculating the *W* statistics:

where, $x(i)$ are the ordered sample values ($x(1)$ is the smallest) and the a_i are constants generated from the means, variances and covariances of the order statistics of a sample of size n from a normal distribution. Small values of *W* are evidence of departure from normality. All statistical tests for FEC were applied to all transformed data and raw data. To study the effect of different factors on raw and different sets of transformed data, the mixed model least-squares analysis for fitting constants (Harvey 1990) was applied: $Y_{ijkmn} = \mu + S_i + P_j + A_k + T_m + b(X_{ijkmn}-X) + e_{ijkmn}$; where, $Y_{ijklmnp}$ is the record for the pth animal, μ is the overall mean, S_i is the random effect of the ith sire, P_j is the fixed effect of the jth season of birth (j=1,2), A_k is the effect of the kth physiological status of ewes (k=1,2,3), T_m is the effect of the mth birth status (m=1,2), b is the linear regression coefficient for the age of animal and e_{ijkmn} is the residual error. The results were back transformed by taking anti-logarithms of the least-squares means (LSM) and presented as geometric means (GFEC). Comparison of different sub-groups mean was made by Duncan's multiple range test (DMRT) as described by Kramer (1957).

Preliminary analysis showed distributions of feacal egg counts to have positive skewness and kurtosis in this study. In addition, large differences were recorded in the mean and variances of faecal egg counts. The graphical representations of probability plot technique of raw data and different sets of log-transformed data were depicted in Figs. 1–5. The calculated *W* values were 0.76,0.73, 0.80, 0.73 and 0.84 for raw FEC data, $\log_{10}$(FEC+1), $\log_{10}$(FEC+25), $\log_e$(FEC+1) and $\log_e$(FEC+100) transformed data, respectively. Corresponding figures for the probability plot correlations coefficients were 0.87, 0.85, 0.90, 0.86 and 0.92, respectively. This correlation coefficient, which is close to 1.0, is generally considered as the most suitable transformation method for raw faecal data. Hence, $\log_e$ (FEC+100) transformation of the data set was the most appropriate transformation for this study. The overall least-squares means for raw FEC, $\log_{10}$ (FEC+1), $\log_{10}$ (FEC+25), $\log_e$(FEC+1) and $\log_e$ (FEC+100) during the course of infection has been presented in Table 1. The sires of the animals had only significant ($P< 0.01$) effect

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Table 1. Comparison of least-squares means for faecal egg count (FEC,epg), various log-transformed faecal egg count and geometric mean of (FEC,epg) by seasons of birth, physiological status of ewes and birth status of animals in Muzaffarnagari sheep

Parameters	No. of obs.	FEC	Log_{10} (FEC+1)	Log_{10} (FEC+25)	Log_e (FEC+1)	Log_e (FEC+100)
Overall mean	270	501.03±78.17	1.88±0.16 (74.86)	2.35±0.08 (198.87)	4.35±0.36 (76.48)	5.93±0.13 (276.15)
Season of birth						
May-April	138	623.32±88.54[a]	2.16±0.18[a] (143.54)	2.50±0.09[a] (291.23)	4.07±0.41[a] (57.56)	6.17±0.15[a] (378.18)
October-November	132	378.74±86.19[b]	1.62±0.17[b] (40.69)	2.20±0.09[b] (133.49)	3.73±0.40[b] (40.68)	5.71±0.14[b] (201.87)
Physiological stage of ewes						
Dry	69	461.11±100.51[b]	1.64±0.21[b] (42.65)	2.23±0.11[b] (144.82)	3.77±0.47[b] (42.38)	5.78±0.17[b] (223.76)
Lactating	81	828.84±98.62[a]	2.88±0.20[a] (757.58)	2.87±0.11[a] (716.31)	6.63±0.46[a] (756.48)	6.69±0.16[a] (704.32)
Pregnant	120	213.12±88.62[c]	1.15±0.18[c] (13.12)	1.95±0.10[c] (64.13)	2.65±0.41[c] (13.15)	5.35±0.15[c] (110.61)
Birth status		NS	NS	NS	NS	NS
Single	243	551.66±65.93	1.78±0.13 (59.26)	2.32±0.07 (183.93)	4.11±0.30 (59.95)	5.93±0.11 (276.15)
Twin	27	450.39±124.43	1.99±0.25 (96.72)	2.38±0.14 (214.88)	4.59±0.58 (97.49)	5.95±0.21 (283.75)

Figures in parentheses are GFEC; Means with different superscripts differed significantly ($P<0.05$) from each other; NS, nonsignificant.

on $\log_{10}$ (FEC+25) and $\log_e$ (FEC+100) transformed data of feacal egg count of ewes. Significant sire effect on feacal egg count was also reported by Romjali *et al.* (1997) and Gauly and Erhardt (2001) in different sheep breeds. The season of birth had significant ($P< 0.01$) effect on raw and all transformed feacal data under this study. The animals born in October-November showed significantly lower feacal egg count in their adulthood as compared to adult animals born in the month of March-April. Chauhan *et al.* (2003) reported that the kids born in the autumn (October-November) had significantly lower LFEC as compared to kids born in spring (March-April) at 6 month of age in Jamunapari and Barbari goats. Vanimisetti *et al.* (2004) reported that year, week and year × week interaction influenced the transformed ln(FEC+100) data of ewes. The raw and all transformed FEC of ewes was also significantly ($P< 0.01$) affected by physiological status of animals (i.e., dry, lactating and pregnant) in the present study. The lactating ewes had significantly higher fecal egg count as compared to dry and pregnant ewes. Similar findings of higher fecal egg count in lactating animals were observed in different breeds of sheep (Romjali *et al.* 1997, Baker 1999). Poor nutrition of ewes, stress, lack of antigenic stimulation and hormonal suppression of immunity may be the major causes of the high feacal egg count in lactating ewes. The birth status of animals had no significant ($P>0.05$) effect on FEC of ewes in this study. The

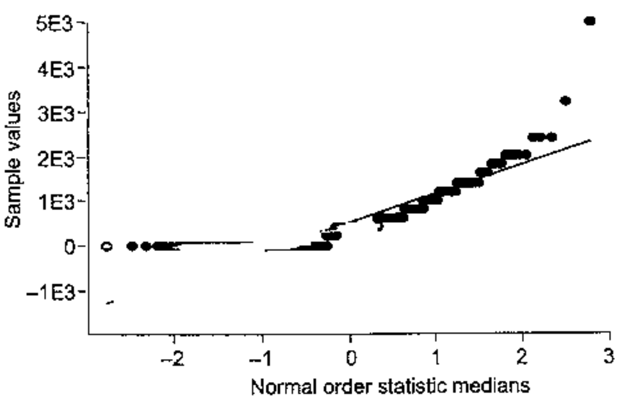

Fig 1. Graphical plotting of raw FEC data

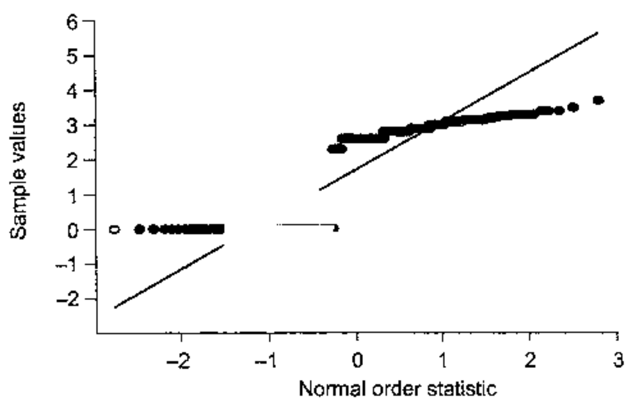

Fig 2. Graphical plotting of Log_{10} (FEC+1) data

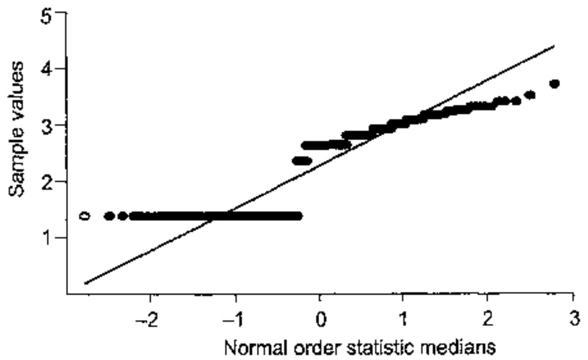

Fig 3. Graphical plotting of Log_{10} (FEC+25) data.

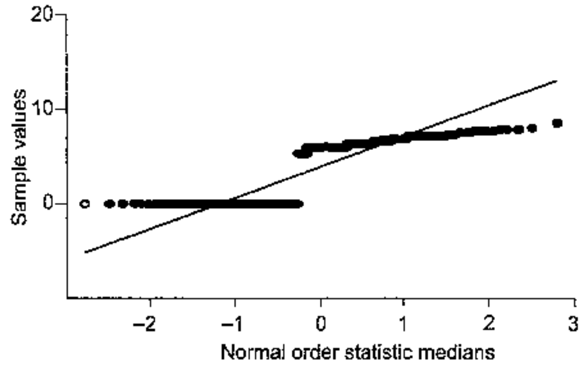

Fig 4. Graphical plotting of Log_e(FEC+1) data.

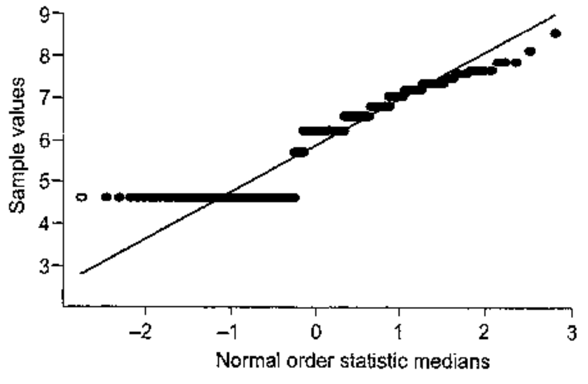

Fig 5. Graphical plotting of Log_e(FEC+100) data.

linear regression effect of the age of ewes on FEC for all data set was negative and significant (P<0.05) in our study. The present findings were in agreement with those reported in other sheep breeds (Romjali *et al.* 1997 and Gauly and Erhardt, 2001).

SUMMARY

The study revealed that $\log_e$(FEC+100) transformation is the most appropriate transformation method for studying the effect of different factors on feacal egg count in a flock of Muzaffarnagari sheep. The feacal egg counts was good indicator of naturally infected nematode infection. The genetic factor like sire of the animal had only significant effect on $\log_{e10}$ (FEC+25) and $\log_e$ (FEC+100) transformed data and non-genetic effects, viz. sex and physiological status of ewes had significant effects on all transformed FEC data.

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