Assessment of Heterogeneity of Residual Variances in an Autoregressive Test-Day Multiple Lactations Model

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Introduction

•Numerous studies (Meuwissen and Van der Werf, 1993; Ibáñez et al., 1999; Rekaya et al., 2000; López-Romero et al., 2003) have reported heterogeneous (HE) genetic, residual and permanent environmental variances for production traits.

•Ignoring heterogeneity of variances may affect genetic progress (Robert-Granié et al., 1999; Ibáñez et al., 1999; Rekaya et al., 2000; López-Romero et al., 2003).

•Most studies using TD animal models recommend that HE sources of variance should be accounted with especial concern to residual variances (Rekaya et al., 2000; López-Romero et al., 2003).

•López-Romero et al, (2003) studying first lactation TD records with a random regression model, found significant reductions in the residual variances (RV) at the beginning and at the end of the lactation when a 5th order polynomial sub model was fitted to the permanent environment (PE) component.

•They concluded that allowing for heterogeneous RV only improves the adequacy of the model to the observed or predicted data for models fitting a low order to the PE sub model.

Objectives

•To assess heterogeneity of RV across L, 5 random samples of the Portuguese Holstein milk database were extracted and analyzed by autoregressive test-day animal (ARTD) models differing on the RV structure (HO vs. HE).

Data

Table 1. Characteristics of the data sets

	Sample				
	1	2	3	4	5
No. of Animals	13,270	10,743	9,509	10,239	9,408
Animals w/records	7,625	5,757	5,156	5,161	4,955
TD observations	127,407	97,342	91,010	78,014	88,163
1st Lactation:					
Animals w/records	6,542	4,843	4,356	4,189	4,257
TD observations	56,811	42,317	37,992	34,657	37,348
Average TD/Animal	9	9	9	8	9
2nd Lactation:					
Animals w/records	5,098	3,868	3,581	3,266	3,513
TD observations	42,916	32,995	30,675	26,614	30,362
Average TD/Animal	8	9	9	8	9
3rd Lactation:					
Animals w/records	3,329	2,644	2,656	2,254	2,441
TD observations	27,680	22,030	22,343	16,743	20,453
Average TD/Animal	8	8	8	8	8

The ARTD Model

•The autoregressive test-day animal model (ARTD) is a class of TD models where the within animal covariance (PE effects) follows 1st order autoregressive processes and are fitted within and across lactations (L) using short (STE) and long (LTE) term environmental effects (Carvalheira et al., 2002).

•STE effects are fitted with HE variance for each L and describe animal correlations between TD within each L.

•LTE effect accounts for the animal correlation across L.

•Results from a previous study suggested that the usual assumption of a homogeneous (HO) residual variance component may not hold (Carvalheira, 2006).

• Multiple lactations single trait animal model,

$$y_{ijLkmn} = HTD_i + Age_{ij} + DIM_{Lk} + a_m + p_{Lm} + t_{Lmn} + e_{ijLkmn}$$

- HTD – Herd TD,
- Age – Age at calving,
- DIM – days in milk (30 classes),
- a – Genetic,
- p – LTE, Long term environmental effects, AR(1),
- t – STE, Short term environmental effects, AR(1),
- e – residuals, Temporary environmental effects.

Results and Discussion

Table 2. Likelihood Ratio Tests (Heterogeneous vs. Homogeneous RV)

Sample	LRT	P
1	77.599	< 0.0005
2	9.510	< 0.01
3	124.879	< 0.0005
4	37.691	< 0.0005
5	62.531	< 0.0005

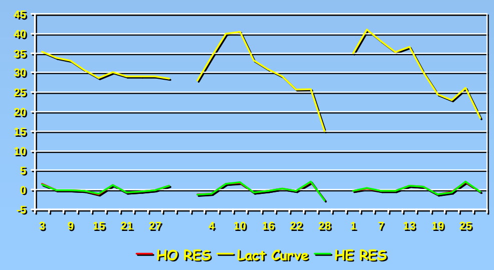
•Likelihood Ratio Tests indicate a better fit for models with Heterogeneous RV.

Table 3. (Co)variance components (kg^2), autocorrelations and heritabilities

Parameter	Average Components	
	Heterogeneous RV	Homogeneous RV
var(G)	7.942	7.901
var(LTE)	<0.001	<0.001
corr(LTE)	<0.001	<0.001
var(e1)	3.572	3.967
var(e2)	4.448	
var(e3)	4.989	
var(STE1)	12.970	12.793
corr(STE1)	0.805	0.823
var(STE2)	25.534	25.837
corr(STE2)	0.834	0.822
var(STE3)	28.862	29.518
corr(STE3)	0.837	0.812
Heritability(L1)	0.324	0.322
Heritability(L2)	0.209	0.211
Heritability(L3)	0.190	0.192

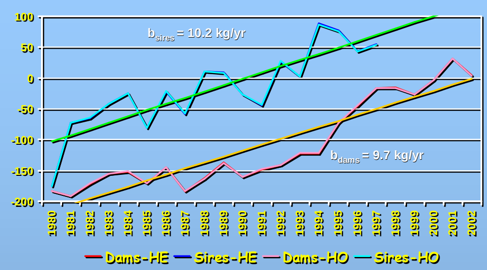
•Heritabilities were similar for the 2 models and the range was within the ones reported in the literature.

Figure 1. First 3 Lactations and Residuals (Heterogeneous vs. Homogeneous RV) for a cow chosen at random



•Residuals in both models never exceeded ±3 kg.

Figure 2. Genetic Progress (Heterogeneous vs. Homogeneous RV)



•Genetic progress was similar between models with sires and dams having a positive and almost parallel slope.

Table 4. Correlations (Heterogeneous vs. Homogeneous RV)

		Heterogeneous			
		EBV	PEV	ACC	Rank
Homogeneous	EBV	0.999	-	-	-
	PEV	-	0.999	-	-
	ACC	-	-	0.999	-
	Rank	-	-	-	0.999

•Correlations between the animal's EBV, PEV, ACC and Rank were high suggesting that HE RV will not change the genetic rank of sires and cows.

Table 5. Average Differences (Heterogeneous vs. Homogeneous RV)

Parameter	N	Mean	STD	P
EBV	53,169	-0.0003	0.0344	= 0.06
PEV	337	-0.0021	0.0077	< 0.0001
ACC	337	0.0009	0.0007	< 0.0001

•Differences between EBV were on average not significant. On the other hand, differences among PEV and ACC favoured the HE RV model, implying greater potential for genetic progress.