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Genetic Parameters and Annual Trends for Birth and Weaning Weights of a Northeastern Thai Indigenous Cattle Line

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ABSTRACT : Records of a Northeastern Thai indigenous cattle line population were used to estimate genetic parameters and annual trends for calf weights. The data set comprised records of 1,922 and 1,489 animals for birth and weaning weight, respectively born from 1993 to 2004. A bivariate analysis was carried out for variance and covariance components estimations using average information restricted maximum likelihood procedure. Average estimated breeding value and maternal breeding value of the animals born in 1993 were set to zero as a base group. Genetic trends of each trait were calculated by regressing average estimated breeding values and maternal breeding values on birth year of calves. Phenotypic trends for each trait were calculated by regressing the yearly adjusted weight on birth year of calves. The results revealed that the estimate of direct heritability, maternal heritability and maternal permanent environmental variance as a proportion of phenotypic variance for birth and weaning weight was 0.40, 0.14 and 0.04; 0.27, 0.05 and 0.23, respectively. Direct heritability was moderately heritable and genetic improvement through selection can be achieved. The estimate of phenotypic, direct genetic, maternal genetic and maternal permanent environmental correlation between birth and weaning weight was 0.48, 0.65, 0.98 and 0.73, respectively. The phenotypic trend, genetic trends of estimated breeding value and maternal breeding value for birth weight was 0.18, 0.04 and 0.01 kg/year, respectively. The phenotypic trend, genetic trends of estimated breeding value and maternal breeding value for weaning weight was -1.36, 0.32 and 0.03 kg/year, respectively. As maternal genetic effect was considerably less important than direct genetic effect, selection for improved weaning weight of this Northeastern Thai indigenous cattle line can place more emphasis on the direct genetic effect. (**Key Words** : Thai Indigenous Cattle, Genetic Parameters, Annual Trends, Calf Weights)

INTRODUCTION

Thailand has a total beef cattle population of 5.5 million heads. This number includes 3.6 million heads of Thai indigenous cattle, which account for about 65% of the total (Department of Livestock Development (DLD), 2003). The distribution of Thai indigenous cattle is predominantly in the Northeastern part of Thailand. The production system centers mainly on suckler herds and could be referred to as backyard, subsistence production, involving smallholders in remote areas. In 1992, DLD presented the plan and implemented a genetic improvement program for a Northeastern Thai indigenous cattle line to improve the economic situation of small Thai beef cattle producers; secure a base supply of beef for Thai people from within the country; utilize the adapted genotype of Thai beef cattle and conserve biodiversity in Thai beef cattle.

Growth traits such as birth weight and weaning weight are of primary economical importance in cow-calf production system. They are known to be influenced by the direct genetic effect of the calf and the maternal genetic effect (Koch, 1972; Garrick, 1990; Meyer, 1992). The primary goal of animal breeders is to maximize the rate of genetic improvement. Knowledge of the nature and magnitude of population parameters (i.e. variance components and heritabilities) for a Northeastern Thai indigenous cattle line is needed to effectively design breeding programs and to estimate breeding values for traits of relevance to beef producers.

In order to achieve optimum progress in the selection program for cow-calf production system both direct and maternal genetic effect should be taken into account, especially if an antagonistic relationship between them

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Table 1. Characteristic of the data structure of a Northeastern Thai indigenous cattle line

Item	Northeastern line
Data structure	
No of animals in pedigree	2,291
No of sire	48
No of dam	584
1 calf	84
2 calves	158
3 calves	165
4 calves	56
5 calves and higher	121
Age of dam* (in years)	4.8±1.4
Birth weight	
No of records	1,922
No of dam with own record	230
Average birth weight* (in kg)	16.7±2.5
No of contemporary group at birth**	50
Weaning weight	
No of records	1,489
No of dam with own record	221
Average weaning weight* (in kg)	91.6±19.4
No of contemporary group at weaning**	42
Age of animal* (in days)	201.9±16.7

* Mean±standard deviation.

** cg = contemporary group (herd×year×seasons of calving).

exists. Apart from this, annual trends for calf weights should be monitored over time to check the validity of the predictions made and to investigate direction of genetic change and whether the selection strategies implemented could reach a selection limit or have unexpected other effects. Therefore the present study was conducted with the following objectives: 1) To estimate (co)variance components and genetic parameters for birth and weaning weight of a Northeastern Thai indigenous cattle line 2) To estimate direct and maternal genetic effect for birth and weaning weight of a Northeastern Thai indigenous cattle line and 3) To measure phenotypic and genetic trends for birth and weaning weight of a Northeastern Thai indigenous cattle line.

MATERIALS AND METHODS

Animal management

Records of birth and weaning weight of calves of a Northeastern Thai indigenous cattle line born between 1993 and 2004 were obtained from the Department of Livestock Development. The animals were raised in three stations (Chaiyapoom, Ubonrachatani and Udonthani Livestock Research and Breeding stations) which are located in Northeastern part of Thailand. Natural mating was used at a ratio of 1 bull per 25-30 cows and calving occurred all year round. Calves were weighed within 24 hours after birth and stayed with their dams until weaning (approximate 7 months of age). All calves were identified at birth with tattoo, dehorned and treated against internal parasites and vaccinated for food and mouth disease at 3-4 month of age. The cattle in each station were allowed to graze on pasture during the day and were confined in large pens at night. Hay or silage was fed *ad lib.* and supplemented with 0.5 kilogram of 14% crude protein concentrate during the dry season (January to May). Dry lick mineral blocks and drinking water were available *ad lib.* for each herd in the large pens. During the rainy season (June to December), the animals were kept on improved pasture (6 animals/acre) without supplementation. The pasture were reestablished every three years by using ruzi grass (*Brachilia ruziziensis*) and verano stylo (*Stylosanthes spp.*).

The calves were weaned four times a year (24 March, 5 June, 23 September and 5 December). Bulls and heifers were selected for replacement based on structural soundness and weight ratio using the expression of animal's performance for adjusted-weaning weight relative to contemporary group average. Bulls and heifers were selected if they had adjusted weaning weight ratio above the contemporary group average. The selected bulls from each station were assigned to mate with dams in all stations in order to establish genetic linkage.

Data management

The pedigree and data file were edited to the same standard protocol. Only weaning age between 120 to 300 days were included. Records outside three standard deviations from the overall mean would be checked and eliminated using SAS (1996). Other basic editing involved consistency checks for sex, age at weighing and age of dam including pedigree validation. For a small proportion of animals (584 out of 1,922 records), age of dam could not be obtained due to missing birth date of the dam and was replaced by the mean age of dam in the data set (4.8 years). This occurred mainly in the early years of the project for foundation cows with purchasing parent stock from the farmer.

In order to determine the fixed effects to be included in the model, preliminary analyses were performed using the PROC MIXED in SAS (1996). If effects were not-significant, they were eliminated from the model. Finally, the fixed effects taken into account included contemporary groups, defined as herd (station)-year-seasons of calving (3 seasons, i.e. Summer, March-June; Rainy, July-October and Winter, November-February) and sex of calves. Age of dam and age of animal were fitted as covariate.

The final data set comprised 1,922 and 1,489 records for birth and weaning weight in three stations, calves were by 48 different sires and 584 different dams. Approximately 80% of dams had more than 2 calves and 40% had their

Table 2. Estimates and standard errors of variance component and genetic parameters of a Northeastern Thai indigenous cattle line

Parameter	Birth weight	Weaning weight
σ^2_p, kg^2	5.24±0.23	236.20±11.07
h^2	0.40±0.08	0.27±0.06
m^2	0.14±0.05	0.05±0.05
c^2	0.04±0.04	0.23±0.05
r_{p1p2}	0.48±0.03	
r_{a1a2}	0.65±0.12	
r_{m1m2}	0.98±0.30	
r_{c1c2}	0.73±0.28	
r_{e1e2}	0.25±0.07	

σ^2_p = Phenotypic variance, h^2 = Direct heritability, m^2 = Maternal heritability, c^2 = Maternal permanent environmental variance as proportion of phenotypic variance, r_{p1p2} = Phenotypic correlation, r_{a1a2} = Direct genetic correlation, r_{m1m2} = Maternal genetic correlation, r_{c1c2} = Maternal permanent environmental correlation and r_{e1e2} = Residual correlation.

own birth and weaning weight recorded. Characteristics of the data set are summarized and presented in Table 1.

Estimate (co) variance components, genetic parameters and breeding value

A bivariate analysis was used for estimating variance and covariance components by the average information restricted maximum likelihood (AI-REML) and fitting an animal model using ASREML (Gilmour et al., 2002). The preliminary analyses were conducted for direct-maternal genetic correlation for both traits however the results were close to zero. Therefore these effects were ignored in this study. The models were as follows:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$$+ \begin{bmatrix} W_1 & 0 \\ 0 & W_2 \end{bmatrix} \begin{bmatrix} m_1 \\ m_2 \end{bmatrix} + \begin{bmatrix} S_1 & 0 \\ 0 & S_2 \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

Where

y_1 and y_2 = vector of observations for birth and weaning weight

b_1 and b_2 = vector of fixed effects for birth and weaning weight

a_1 and a_2 = vector of direct genetic effects for birth and weaning weight

m_1 and m_2 = vector of maternal genetic effects for birth and weaning weight

c_1 and $c2$ = vector of maternal permanent environmental effect for birth and weaning weight

e_1 and e_2 = vector of residual effects for birth and weaning weight

X_1 and X_2, Z_1 and Z_2, W_1 and W_2, S_1 and S_2 were incidence matrices relating records of birth and weaning weight to fixed, direct genetic, maternal genetic and maternal permanent environmental effects, accordingly.

The first moment for the models was:

$$E = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$$

The variance and covariance structure were presented as followed:

$$Var = \begin{bmatrix} a_1 \\ a_2 \\ m_1 \\ m_2 \\ c_1 \\ c_2 \\ e_1 \\ e_2 \end{bmatrix} = \begin{bmatrix} A\sigma^2_{a_{11}} & A\sigma_{a_{12}} & 0 & 0 & 0 & 0 & 0 & 0 \\ A\sigma_{a_{21}} & A\sigma^2_{a_{22}} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & A\sigma^2_{m_{11}} & A\sigma_{m_{12}} & 0 & 0 & 0 & 0 \\ 0 & 0 & A\sigma_{m_{21}} & A\sigma^2_{m_{22}} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & I\sigma^2_{c_{11}} & I\sigma_{c_{12}} & 0 & 0 \\ 0 & 0 & 0 & 0 & I\sigma_{c_{21}} & I\sigma^2_{c_{22}} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & I\sigma^2_{e_{11}} & I\sigma_{e_{12}} \\ 0 & 0 & 0 & 0 & 0 & 0 & I\sigma_{e_{21}} & I\sigma^2_{e_{22}} \end{bmatrix}$$

For the second moments, A and I were numerator relationship and identity matrices. σ^2_a was the direct genetic variance, σ^2_m was the maternal genetic variance, σ^2_c and σ^2_e were the maternal permanent environmental variance and residual variance, respectively. The genetic parameters were defined according to Willham (1972) and Falconer and Mackay (1996).

Phenotypic and genotypic trends

Breeding values for birth and weaning weight for individual animals were estimated utilizing all available pedigree and performance information. Average estimated breeding value and maternal breeding value of the year 1993 were set to be zero as a base group. The genetic trend was calculated for each trait by regressing the average estimated breeding values and maternal breeding values that deviated from the base group on birth year of calves. The phenotypic trend was calculated for each trait by regressing the adjusted weight on birth year of calves. Adjusted weights were obtained from a least square analysis.

RESULTS AND DISCUSSION

Genetic parameters

The estimate of variance component and genetic parameters with their standard error are presented in Table 2. For birth weight, both direct and maternal genetic effects played more an important role on birth weight than that of non-genetic, i.e. maternal permanent environmental effect. The estimates of direct and maternal heritabilities were moderate to low, explaining 40% and 14% of the phenotypic variance respectively. The maternal heritability amounted to 35% of that due to direct heritability. Birth weight was affected by maternal permanent environmental effect to a less extent, explaining 4% of the phenotypic variance. As found in other breeds, Meyer (1993) and Robinson (1996) reported that direct heritability, maternal heritability and maternal permanent environment effect were 0.43, 0.10 and 0.09 for Hereford and 0.35, 0.08 and 0.05 for Angus, respectively. The results were agreement with this analysis, identifying birth weight as highly to moderately heritable trait with the maternal heritability amounting to about 23% of that due to direct heritability.

For weaning weight, the estimates of direct heritability and maternal permanent environmental effect played an equally important role, explaining 27% and 23% of the phenotypic variance. The direct heritability was found to be moderate. The maternal permanent environmental effect was the main factor determining weaning weight when compared to that of birth weight. In contrast, the maternal heritability which generally assumed to express the variation in milk production potential indicated a low variation for mothering ability, explaining 5% of the phenotypic variance. The maternal heritability amounted to 18% of that due to direct heritability. Similar results were observed by Meyer (1992), Meyer (1993) and Meyer et al. (1993) who reported that maternal permanent environmental effects in Hereford, Charolais were consistently more important than maternal genetic effect. The estimate of direct heritability in this study was well in agreement with the range of 0.21 to 0.30. Weaning weight was found to be moderately heritable trait and maternal heritability amounted to be average 14% of that due to direct heritability (Meyer et al., 1993; Haile-Mariam and Kassa-Mersha, 1995; Roughsedge et al., 2005). However, the estimates were much higher than the estimate of direct heritability reported for Korean cattle (Choi et al., 2000; Choi et al., 2005).

In a Northeastern Thai indigenous cattle line, the direct heritability for weaning weight was considered moderately heritable trait. It was therefore possible for genetic improvement through selection in this population. The maternal heritability was low and played less an important role than direct heritability which indicated that the improvement of weaning weight should be based on direct genetic effect.

Phenotypic and genetic correlations

The estimate of phenotypic, direct genetic, maternal genetic, maternal permanent environmental and residual correlations between birth and weaning weight are presented in Table 2. The phenotypic and direct genetic correlations were moderately to highly positive, 0.48 and 0.65 respectively. The result indicated that calves with high performance at weaning tended to be heavier at birth. For maternal effects, i.e. the maternal genetic and maternal permanent environmental correlations were found to be unity to highly positive. The residual correlation was lowly positive (0.25), which implied that the relationships between prenatal and postnatal environment were only slightly positive. The surrounding environment experienced by a calf in uterus had little in common with the environment experienced by a calf after birth. On the whole, except for maternal effects, levels of these correlations were comparable to other breeds (Kries et al., 1991; Meyer et al., 1993; Bennett and Gregory, 1996).

As observed by many authors (e.g., Meyer, 1992; Robinson, 1996), allowing for a model with the direct-maternal genetic correlation yielded a large negative estimate for this parameter. The increasing estimate of both direct and maternal heritabilities dramatically augmented the likelihood significantly. The large negative estimate of direct-maternal genetic covariances did not reflect a marked adverse genetic correlation between growth and maternal performance. The negative values were associated with the management practice or environmentally induced negative dam-offspring covariances. For this study, allowing for a model with the direct-maternal covariances included resulted in slightly higher heritabilities for the direct as well as maternal heritability, 0.28 and 0.06 respectively. The direct-maternal genetic correlation was -0.36. However, the

Table 3. Least square means at birth and weaning weight (adjusted 200 day) of a Northeastern Thai indigenous cattle line

Year of birth	Number of calves	Birth weight* (kg)	Weaning weight* (kg)
1993	72	14.90±0.44	101.67±3.73
1994	114	15.80±0.39	95.81±3.35
1995	124	15.91±0.39	92.41±3.33
1996	111	14.75±0.38	87.41±3.23
1997	117	15.30±0.37	77.40±3.15
1998	87	15.34±0.40	83.25±3.32
1999	94	17.68±0.38	105.86±3.14
2000	144	16.95±0.35	80.50±2.95
2001	259	17.01±0.29	86.92±2.63
2002	262	16.34±0.28	85.61±2.42
2003	327	16.78±0.26	82.31±2.36
2004	211	16.69±0.27	79.06±3.64
Phenotypic trend (kg/year)		0.18±0.06 ($p<0.05$)	-1.36±0.67 ($p>0.05$)

* Least square means±standard errors.

Table 4. Average estimated breeding value (EBV) over years 1993 to 2004 for birth and weaning weight of a Northeastern Thai indigenous cattle line

Year of birth	Birth weight* (kg)	Weaning weight* (kg)
1993	0	0
1994	0.40	1.32
1995	0.23	0.48
1996	0.33	1.85
1997	0.19	1.45
1998	0.45	2.81
1999	0.70	2.00
2000	0.42	3.99
2001	0.71	4.17
2002	0.74	4.10
2003	0.68	4.01
2004	0.21	2.27
Genetic trend (kg/yr)	0.04±0.01 ($p<0.05$)	0.32±0.07 ($p<0.01$)

* In 1993, average estimated breeding value of birth and weaning weights are equal to -0.60 and -2.96 kg.

Table 5. Average maternal breeding value over years 1993 to 2004 for birth and weaning weight of a Northern Thai indigenous cattle line

Year of birth	Birth weight* (kg)	Weaning weight* (kg)
1993	0	0
1994	0.32	1.28
1995	0.16	0.65
1996	0.16	0.66
1997	0.13	0.53
1998	0.25	1.06
1999	0.50	2.04
2000	0.07	0.33
2001	0.30	1.22
2002	0.29	1.20
2003	0.31	1.27
2004	0.04	0.21
Genetic trend (kg/yr)	0.01±0.01 ($p>0.05$)	0.03±0.04 ($p>0.05$)

* In 1993, average maternal breeding value of birth and weaning weights are equal to -0.36 and -1.49 kg.

model did not augment the likelihood significantly when compared to that of excluded the two covariances. Therefore, the model with the direct-maternal covariance included was ignored from this study. Considerably more data across generations is required to investigate the negative covariance further.

Phenotypic and genetic trends

The phenotypic and genetic trends for estimated direct breeding values and maternal breeding values for birth and weaning weight were presented in Table 3 through 5.

The phenotypic trend of birth weight was positive, 0.18 kg/year ($p<0.05$). Ranges of least square means for birth weight were ranged from 14.75 to 17.68 kg. In 1999, birth weight were dramatically increased and gradually decreased thereafter.

In contrast to birth weight, the phenotypic trend for weaning weight was found to be -1.36 kg/year ($p>0.05$). Ranges of least square means for weaning weight (adjusted to 200 day weight) were from 77.40 to 105.86 kg, a reflection of variation in the environment and management over the years. The adjusted weaning weight was gradually decreased from 1994 to 1998. In 1999, weaning weight was dramatically increased and thereafter decreased to 79.06 kg in the last year. The reduction in mean weaning weight for calves born in the last five years (2000 to 2004) were mainly due to a larger proportion of calves selected in previous years in order to increase the population. Some bulls and heifers were selected when they had adjusted weaning weight ratio below the contemporary group average. Therefore, to improve phenotypic performance for weaning weight of the herd, improved management strategies are also needed. Changes in management such as pasture improvement, grazing strategies and culling procedures needed to be measured and monitored in order to evaluate the benefit of the change (Allen, 2002).

Estimated breeding values for birth weight have increased since 1994. The averages of estimated breeding values for birth weight ranged from -0.60 to 0.14 kg and the genetic trend averaged 0.04 kg/year ($p<0.05$). The averages of estimated breeding values for weaning weight ranged from -2.96 to 1.21 kg and the genetic trend was positive, 0.32 kg/year ($p<0.05$).

Maternal breeding values for birth weight were also increased from the year 1994. The averages of maternal breeding values for birth weight ranged from -0.36 to 0.14 kg. The genetic trend was positive, 0.01 kg/year ($p>0.05$). The averages of maternal breeding value for weaning weight were ranged -1.49 to 0.55 kg. The genetic trend was positive, 0.03 kg/year ($p>0.05$). The small genetic trend observed in this population points to low level of efficiency of selection for maternal genetic effect in a Northeastern Thai indigenous cattle line, after all the selection was based on within management group ratios only and not on BLUP estimated breeding values, which resulted in lower accuracy and lower intensity of selection.

The estimates of genetic parameters obtained in this study indicated that if genetic improvement through selection for weaning weight of a Northeastern Thai indigenous cattle line is desired, substantial genetic progress can be achieved. Estimated breeding values and maternal breeding values is another tool for cattle breeders to generate animals that are suitable for their cow-calf production system. Similarly, breeders should use various management practices to help achieve this aim as well. Genetic and management are complimentary and both require measurements to achieve results. Estimated breeding values could be used not only to select superior animals genetically for the primary traits of interest, but also to monitor secondary traits that are of little current interest but might become more important later on. In this study, selection for higher weaning weight has caused an increase in birth weight. Therefore, while herds are not experiencing calving difficulty at present, monitoring birth weight while selecting for higher weaning weight is a good insurance policy.

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