Journal of Animal Research: v.13 n.05, p. 781-788. October 2023

DOI: 10.30954/2277-940X.05.2023.20

Performance of Growth Traits in Punganur Cattle

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Received: 28 Aug., 2023 **Revised:** 26 Sept., 2023 **Accepted:** 29 Sept., 2023

ABSTRACT

Present investigation comprehends the study of the effect of non-genetic factors and estimation of heritabilities, genetic correlation of body-weight traits in Punganur cattle. Data consisted of a total of 562 progeny records of 169 cows and 53 bulls over a period of 22 years (2000 to 2022) maintained at Livestock Research Station, Palamaner, Chittoor district, Andhra Pradesh. Over all least- squares means for birth weight, 6-month weight and 12-month weight were 11.5± 0.089, 43.126±0.073, 61.296± 0.064 kg respectively. Body weight traits were significantly affected by period of birth, whereas season of birth has not influenced the similar traits. There is a significant ($p \leq 0.01$) difference between males and females for 6-month body weight, 12-month body weight except birth weight. Heritability estimates of birth weight, 6-month weight, 12-month weight were 0.171± 0.107, 0.600± 0.001 and 0.001 ± 0.048 respectively indicated that birth weight and 12- month weight has been less affected by additive gene action. Strong and positive direct genetic correlation between 6-month and 12-month weight traits was 0.788 ±0.162 indicated that selection of one trait might improve the other trait and low genetic correlation observed between birth weight and 12-month weight was 0.043± 0.697. The average estimated breeding values of birth weight, 6-month weight and 12-month weight were 0.176, 0.087 and 0.000 kg respectively. The positive trend for 6-month body-weight was observed in present study implies efficiency in selection based on phenotypic performance.

HIGHLIGHTS

- This article describes growth traits in Punganur cattle.
- First report over a period of 22 years of growth traits data in Punganur.
- The study highlights the importance of selection in small cattle like Punganur.

Keywords: Body weight, Breeding value, Genetic correlation, Genetic trend, Heritability, Phenotypic correlation

Selection of animals for breeding primarily based on performance of growth traits like body weights at different ages in livestock. Body weight is an economic trait and accurate estimation of body weight has scientific importance in the development of livestock research. Among body weights, birth weight of calves is easily measured and correlated with number of other performance traits. The main activities of zootechnics such as nutrition, management, genetics, health and environment were major aspects in domestic animals to identify weight control (Ozkaya, 2013). The monitoring of animal performance through the assessment of weight gain is important for the process of genetic improvement of herds. Live body weight is one of the most important assets to harvest maximum output from milch animals implies fair idea about future performance of calves and plays an important role in reproductive performance of dairy animals. Body weight can be used in determine the health status of an animal when measured in relation to its age, to find out the correct amount of feed fed to an animal

How to cite this article: Bharathi, G., Thiagarajan, R., Karthickeyan, S.M.K., Tirumurugaan, K. and Sesh, P.S.L. (2023). Performance of Growth Traits in Punganur Cattle. *J. Anim. Res.,* **13**(05): 781-788.

Source of Support: None; **Conflict of Interest:** None

to avoid underfeeding or over feeding, to decide the worth of the live animal in relation to the market price, to fix the weaning time of an animal. The most commonly used method to ascertain the weight of animal was electronic scale. Punganur cows of Andhra Pradesh (Vinod *et al.*, 2019), Vechur cows of Kerala (Bindhya and Sosamma, 2010) are extremely small in size, i.e. weighing around 130 to 200 kg. Heritability and genetic correlations of growth traits of Vechur cows reported by (Bindhya and Sosamma, 2010), where as there is no reported literature on heritabilities and genetic correlations of Punganur. The most common method used for estimation of heritability in cattle was Paternal half-sib correlation. There have been extensive development of statistical procedures and softwares for estimation of variance components in last two decades. The animal mixed model using REML procedure is now being used extensively for analysis of data which allowed the estimation of additional variance components such as maternal heritability, permanent environmental effects and correlations between direct and maternal genetic effects for important economic traits. Further, accurate estimates of genetic parameters are essential for correct estimation of breeding values. As genetic studies on growth performance in Punganur cattle are lacking, the study was under taken to evaluate the non-genetic factors affecting the growth traits, heritabilities, correlations and breeding values of body weights with available data that can be further used for formulation of breeding plans in bringing the genetic improvement of the breed.

MATERIALS AND METHODS

The body weights of Punganur cattle reared at Livestock Research Station, Palamaner were utilized for the present study. A total of 562 Punganur calves sired by 53 Punganur bulls' data were obtained from birth weight register maintained at the farm. Data on normal births were used for the study. Punganur calves particulars such as date of birth, sex, birth weight of calves, 6-month weight, 12-month body weight and its sire number, its dam number were recorded from registers. The data of calf birth weight, 6-month weight, 12- month weight were classified according to period of birth, season of birth and calf sex and separate codes were assigned for statistical analysis. Different seasons were classified as Winter (December to March), Summer (April to June), Rainy (July to September) and Autumn (October to November). Normalisation of data has been done by removing the outliers with performance over and below 3 standard deviation from arithmatic mean. A statistical model for body weight traits as follows.

$$Y_{ijkl} = \mu + P_i + Q_j + R_k + e_{ijkl}$$

Where,

Y_{ijkl} = Observation on the trait of the l^{th} animal belonging to i^{th} period of birth, j^{th} season of birth, k^{th} sex.

μ = over all mean

P_i = i^{th} period of birth (I = 1 to 6)

P_1 = 2000 to 2003, P_2 = 2004 to 2007, P_3 = 2008 to 2011, P_4 = 2012 to 2015, P_5 = 2016 to 2019 and P_6 = 2020 to 2022

Q_j = effect of j^{th} season of birth (j = 1 to 4)

S_1 = February to April, S_2 = May to July, S_3 = November to January and S_4 = August to October

R_k = effect of k^{th} sex of calf

Male:1, Female:2

e_{ijkl} = Random error associated with each observation, NID (0, σ_e^2).

Single trait analysis was done by fitting a general linear model (GLM) to study the effects of fixed effects on growth traits using SPSS (v.26.0) software. Pair wise comparison for sub-class means within each fixed effect was done by Duncan's Multiple Range Test (Kramer, 1957).

Estimation of covariance components and genetic parameters

(Co) variance components for different growth traits were estimated by Restricted Maximum Likelihood method (REML) using the WOMBAT program of Meyer (2007), by fitting an animal model for all traits. Animal genetic/ direct genetic effect, maternal genetic effect and maternal permanent effects were considered as random effects in addition to significant fixed effects, as obtained from the GLM.

Statistical model and analysis

The models 1,2,3,4 were used for estimation of co(variance) components required for the computation of heritability, genetic correlation.

$$Y = Xb + Z_a a + e \text{ (Model 1)}$$

$$Y = Xb + Z_a a + Z_m m + e \text{ (Model 2)}$$

$$Y = Xb + Z_a a + Z_p k + \mathrm{e} \text{ (Model 3)}$$

$$Y = Xb + Z_a a + Z_m m + Z_p k + \mathrm{e} \text{ (Model 4)}$$

Where, 'Y' is a NX1 vector of records, 'b' denotes the fixed effects in the model with association matrix X, 'a' is the vector of direct genetic effect with the association matrix Z_a, 'm' is the vector of maternal genetic effect with the association matrix Z_m, 'k' is the vector of permanent maternal environmental effect with the association matrix Z_p, and 'e' denotes the vector of residual (temporary environment) effect. Additive direct and maternal genetic effects were assumed to be normally distributed with mean zero and variance $A\sigma_a^2$ and A_m^2 respectively, where A is the additive numerator relationship matrix, and σ_a^2 and σ_m^2 are additive direct and maternal genetic variances, respectively. Maternal Permanent environmental effect, and residual effects were assumed to be normally distributed with mean zero and variances, $I\sigma_k^2$, and I_e^2 respectively. Where, I is an identity matrix, and k^2 and e^2 are maternal permanent environment, and residual variances, respectively.

Starting values of variance components for the iterations were decided based on the total phenotypic variation and the estimates are available for the population in literature. The convergence criterion for REML iterations were based on change in loglikelihood ($<5\times10^{-4}$), change in vector of parameters ($<10^{-8}$) and norm of gradient vectors ($<10^{-3}$), the details of which are provided by Meyer (2007) etc. Models 1,2,3 and 4 were used for growth traits.

Log-likelihood ratios tests (LRT) was applied for significance of random effects and choosing the most appropriate model for birth weight. Suitability of the model was considered when a significant ($p<0.05$) increase in the log likelihood occurred when adding additional random maternal effect.

Estimates of breeding value (EBV) for different productive traits were obtained by Best Linear Unbiased Prediction (BLUP) method. Henderson's mixed model equations (Henderson, 1975) were solved to obtain Best Linear Unbiased Estimates (BLUE) of fixed effects and BLUP values of EBV. The variance components used for estimation of breeding value were obtained from the best univariate model determined by LRT for traits in which maternal effects were included. The analyses were carried out by choosing the BLUP option in WOMBAT program.

RESULTS AND DISCUSSION

The descriptive statistics of body weight traits in Punganur was detailed in Table 1. The birth weight of calves is most important for faster growth of heifer to show oestrous as early as possible. The least square mean for birth weight of Punganur males and females were 11.608 ± 0.125 and 11.393 ± 0.123 kg, respectively (Table 2) which is almost the similar to the findings of Bindya and Sosamma (2010) in Vechur cows, where as Singh *et al.* (2008) reported 8.56 ± 0.44 kg in Malanad Gidda, Selvan *et al.* (2018) found 19.92 ± 0.18, 20.91 ± 0.25 kg in Sahiwal and Tharparkar. The period of birth was highly significant ($p\leq0.01$) on birth weight while, season of birth and sex had non-significant on birth weight of calves. However, significant effect of season of birth-on-birth weight was reported by Wakchaure and Meena (2010); Atashi *et al.* (2012) and Aksakal *et al.* (2012). Among periods, the least square means of birth weights ranged from 10.897 ± 0.218

Table 1: Descriptive statistics of Body weight (kg) traits in Punganur

Trait	N	Range	Mean±S.E.	Variance	Standard deviation	Coefficient of variation (%)
Birth weight	562	12	11.404± 0.087	4.31	2.076	18.2
6-month weight	553	9	43.092 ±0.777	3.342	1.828	4.2
12-month weight	553	10	61.247 ±0.101	5.734	2.3945	3.9

N = Number of observation.

Table 2: Least square means (±S. E) of body weights (kg) in Punganur cattle

Effects	Birth weight		6-month weight		12-month weight	
	n	Mean ±S.E.	n	Mean± S.E.	n	Mean± S.E.
Overall mean	562	11.5± 0.089	553	43.126±0.073	553	61.296± 0.064
Period of birth	**		**		**	
P1 (2000-2004	61	12.242^{a}±0.262	60	43.056^{bc}±0.217	60	61.869^{a}±0.191
P2 (2005-2008	74	11.830^{ab}± 0.237	73	43.523^{ab}±0.195	73	61.345^{ab}±0.172
P3 (2009-2012)	88	10.897^{c}±0.218	87	42.676^{c}±0.174	87	61.556^{a}±0.153
P4 (2013-2016)	114	11.292^{abc}± 0.191	113	43.171^{ab}±0.15	113	61.045^{ab}± 0.132
P5 (2017-2020)	131	10.929^{c}±0.178	129	42.984^{ab}± 0.138	129	60.931^{b}± 0.121
P6 (2021-2024)	94	11.812^{ab}± 0.213	91	43.347^{a}± 0.184	91	61.021^{ab}± 0.162
Season of birth		NS		NS		NS
Winter (December- March	120	11.617 ±0.189	119	43.040 ±0.161	119	61.385± 0.142
Summer (April - June)	134	11.412± 0.178	133	43.133 ±0.150	133	61.276± 0.132
Rainy (July - September)	153	11.408 ±0.167	151	43.171 ±0.137	151	61.285 ±0.121
Autumn (October - November)	155	11.564± 0.164	150	43.161± 0.132	150	61.236 ±0.117
Sex		NS		**		**
Male	283	11.608 ±0.125	281	43.887^{a}±0.106	281	63.266^{a}± 0.093
Female	279	11.393± 0.123	272	42.366^{b}± 0.100	272	59.325^{b}± 0.088

**P<0.01; NS-Not significant; Means with at least one common superscript within classes do not differ significantly (p>0.05/P>0.01); N-Number of observations.

(period 3 -2009 to 2012) to 12.242 ±0.262 kg (period-1 -2000 to 2004). During summer season, least square mean of birth weight is minimum (11.412± 0.178 kg) and maximum in winter season (11.617 ±0.189 kg). However, calves born during S1 (winter) season had highest birth weight, whereas lowest birth weight was observed in calves born in rainy (Sahiwal) and autumn (Tharparkar) as per findings of Selvan *et al.* (2018).

The overall least square mean of 6-month body weight in Punganur males and females were 43.887 ± 0.106 and 42.366 ± 0.100 kg. The period of birth and sex had significant influence on 6-month body weight, whereas season of birth had no influence on 6-month body weight. Bindhya and Sosamma (2010) estimated almost synonymous findings at 6-month body weight as 44.2 ± 0.8 kg for the males, 43.3 ± 0.8 kg for females in Vechur cows. The overall least square mean of 12-month body weight in Punganur males and females were 63.266±0.093 and 59.325 ± 0.088 kg. The period of birth and sex had significant influence on 12-month body weight, whereas season of birth had no influence on 12-month body weight. Bindhya and Sosamma (2010) reported 12-month body weight as 76.1 ± 1.9 kg for the males, 69.5 ± 1.2 kg for females in Vechur cows. The reasons for low birth weight in Punganur might be due to several variables that affect birth weight included breed, genetics of sire and dam, length of gestation, age of dam, sex of calf, environmental factors, nutrition and health of dam.

Variance components and Heritability estimates

Each body weight trait was analysed with four single trait animal models, as described by Meyer (1992) to assess the importance of different maternal effects. The co(variance) components and heritability estimates inclusive of direct animal genetic (h^2), maternal genetic (m^2), and maternal permanent effects (mp^2) for body weight traits in Punganur cattle were presented in Table 3. The model 3 with direct/animal genetic, and maternal permanent effects was the best model selected through log likelihood ratio test (LRT) for birth weight, model 2 with direct /animal genetic and maternal genetic effects was best for 6-month body weight and model 1 with direct/animal genetic effect was best for 12-month body weight.

Table 3: Variance components and Heritability of body weights in Punganur cattle

Model	σ_a^2	σ_m^2	σ_{mp}^2	σ_e^2	σ_p^2	h^2 +S. E	m^2 +S. E	k^2 +S. E	Log L
Birth weight									
a	0.695902	—	—	3.46426	4.13692	0.163± 0.081	—	—	-685.185
a+m	0.707406	0.001	—	3.44661	4.15502	0.17± 0.107	0.000 ±0.044		-686.145
a+mp	0.708998	—	0.001	3.44485	4.15485	0.171± 0.107	—	0.000 ±0.044	-686.115
a+m+mp	0.710326	0.001	0.001	3.45033	4.16265	0.171 ±0.107	0.000 ±0.000	0.000 ±0.044	-686.120
6-Month body weight									
a	1.25935	—	—	2.13728	3.39663	0.371 ±0.105			-21001500
a+m	2.0501	0.671671	—	0.671671	3.35836	0.600± 0.001	0.200± 0.000		-20075417
a+mp	1.67508	—	1.00505	0.6700341	3.35017	0.500± 0.000	—	0.300 ±0.000	-21001400
a+m+mp	1.67508	0.670034	0.670034	0.335017	3.35017	0.500± 0.000	0.200 ±0.000	0.200± 0.000	-22908599
12-Month Body weight									
a	0.001	—	—	1.94426	1.94526	0.001 ± 0.048	—	—	-473.788
a+m	0.001	0.001	—	1.95267	1.95467	0.001 ± 0.053	0.001± 0.036	—	-473.812
a+mp	0.001	—	0.001	1.93967	1.94167	0.001 ± 0.053	—	0.001± 0.036	-473.797
a+m+mp	0.001	0.001	0.001	1.96918	1.97218	0.001 ± 0.053	0.001± 0.000	0.001 ± 0.036	-473.865

σ_a^2- additive direct variance; σ_m^2- maternal genetic variance; σ_{mp}^2-maternal permanent environmental variance, σ_e^2- error variance; σ_p^2 -Phenotypic variance; h^2-direct heritability, m^2- maternal heritability; k^2-maternal permanent environmental variance ratio, log L-log likelihood, Model in bold letters indicate best model for respective traits.

The direct heritability obtained through best model for birth weight, 6-month weight and 12-month weight in Punganur were 0.171 ± 0.107, 0.600 ± 0.001 and 0.001 ± 0.048 respectively. Bindhya and Sosamma (2010) reported that the heritabilities of birth weight, 6-month weight and 12-month weight in Vechur as 0.01 ± 0.25, -0.17 ± 0.74 and 0.28 ± 0.36 which indicated heritability values differed due to feeding, management, number of observations etc. The high heritability at 6-month body weight can be attributed to the good maternal care and nutrition. The calves get during this age which in turn results in proper expression of their genetic makeup. Maternal heritability (m^2) estimated from best model for 6-month body weight was 0.200 ± 0.000. As the maternal genetic effect of 12-month body weight was almost negligible, the direct heritability estimate i.e., 0.001 ± 0.048 obtained through model with only additive genetic effect considered. This low value could be due to the high environmental variance arising from feeding and management, since these age groups were not individually fed, but managed in groups. The competitive animal behaviour in the herd caused some animals to dominate and others to get pushed back from the feed ration. However, there is no available literature on heritabilities of growth traits in small cattle like Malnad Gidda and Nattukuttai.

Genetic and phenotypic correlations

Direct genetic and phenotypic correlation for body weight traits were estimated from a bivariate animal model considering two traits at a time. The estimates of direct genetic and phenotypic correlations between birth weight, 6-month weight and 12-month weight traits are shown in Table 4. The direct genetic correlations among traits in the present study were higher than the corresponding phenotypic correlations except for birth weight with 6-month weight that have observed negative values in both genetic and phenotypic correlation. The direct genetic correlations only evaluate how both traits were influenced by a common set of genes of an animal while the phenotypic correlations were evaluating the influence of both common genetic and environmental effects of two traits (Zeleke Tesema, 2019). Except birth weight with 6-month weight, the remaining phenotypic correlations between body weight traits were positive. Bindhya and Sosamma (2010) reported high value of phenotypic

Table 4: Genetic and phenotypic correlations between body-weights in punganur cattle

Trait	Birth weight	6 -month weight	12- month weight
Birth weight	—	-0.003± 0.000	0.007± 0.0075
6 -month weight	-0.168± 0.633	—	0.254± 0.064
12- month weight	0.043± 0.697	0.788 ±0.162	—

Phenotypic correlations above the diagonal; Genetic correlations below the diagonal.

Table 5: Breeding values of body weights for Punganur cattle

Trait	Direct Genetic EBV				Maternal genetic EBV			
	Mean	S. D	Minimum	Maximum	Mean	SD	Minimum	Maximum
Birth weight	0.176	0.219	-0.963	1.060	0.054	0.084	-0.468	0.373
6-month weight	0.087	0.152	-0.203	0.332	-86.985	46.087	-715.501	660.296
12-month weight	0.000	0.000	-0.001	0.000	—	—	—	—

DGEBV- Direct genetic estimated breeding value; MGEBV-Maternal genetic estimated breeding value.

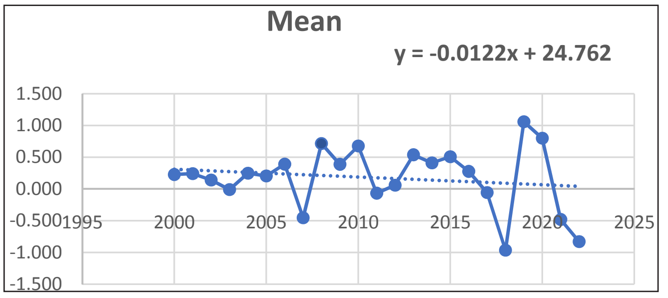
correlation between birth weight and 12-month body weight (0.446 ± 0.121) and also weight at 6-month had significant association with weight at 12-month. The direct genetic correlations between body weight traits in the present study ranged from negative to positive genetic correlations. Negative direct genetic correlation between birth weight and 6-month weight (-0.168) was observed. The negative direct genetic correlations of these traits showed that genes influenced these traits separately or the value of these traits were the result of separate gene action. Strong and positive direct genetic correlation between 6-month and 12-month weight traits was 0.788±0.162, but low genetic correlation observed between birth weight and 12-month weight was 0.043±0.697. Bindhya and Sosamma (2010) observed negative genetic correlation between 6-month weight and 12-month weight (-1.595). However, there is no available literature on phenotypic and genetic correlations in other small cattle breeds like Malnad Gidda and Nattukkuttai.

Breeding value

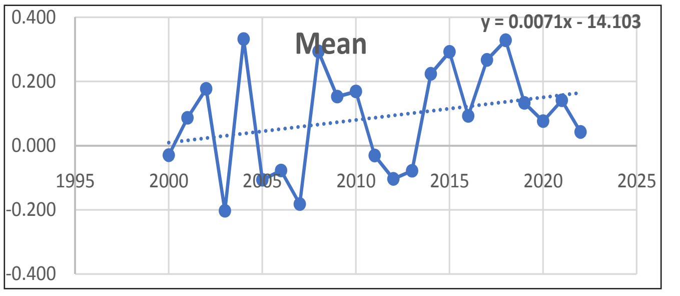
Estimated breeding value (EBV) can be defined as the total genetic ability of an animal for a given trait. Therefore, estimated breeding value refers to the value of animal's additive genetic effects in breeding program for a particular trait of interest. The average estimated breeding values of birth weight, 6-month weight and 12-month weight were 0.176, 0.087 and 0.000 kg respectively. This implies that positive breeding values for birth weight traits tend to be associated with above average performance. The maternal genetic estimated breeding values for birth weight, 6-month weight and 12-month weight were 0.054, -86.985 and 0.000kg respectively. This implies that dams' genetic contribution of birth weight and 6-month weight to their progeny was 0.054 and -86.985. Negative breeding value for 6-month weight associated with below the average performance. Therefore, select bulls with above average 6-month weight maternal breeding values to breed daughters with good maternal ability that could wean better calves in future. There is no available literature on breeding values of other dwarf cattle of South India for growth traits.

Genetic trend

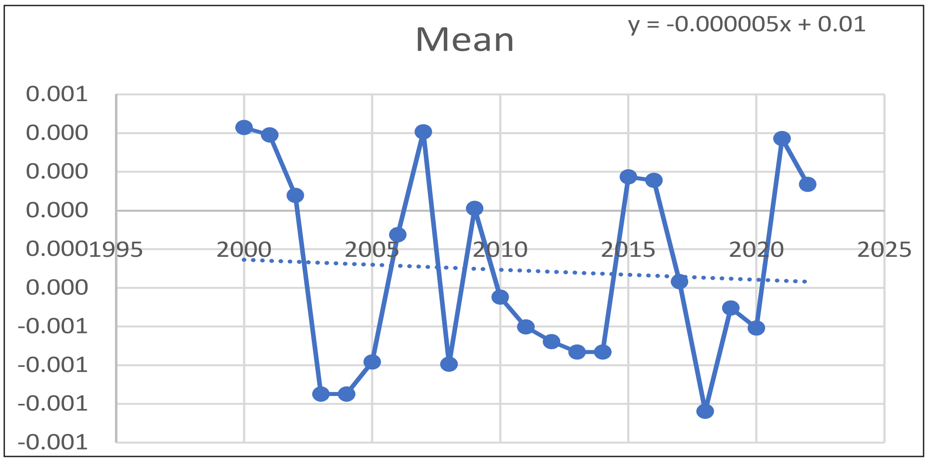
The genetic trend was depicted using the breeding values for birth weight, 6-month weight and 12-month weight traits in Punganur. Breeding values predicted from the best model were fitted in a univariate fixed model with year of birth as the only fixed effect. The least-squares solutions of breeding values for different years were plotted against the year of birth to depict the genetic trend for periodical body weights. Positive genetic trend was observed in 6-month weight whereas negative genetic trend was observed in birth weight and 12-month weight in Punganur. There is



Birth weight-Genetic trend



6-month weight-Genetic trend



12-month weight

Fig. 1: Genetic trend of birth weight, 6-month weight and 12-month weight

no reported literature in small cattle like Vechur, Malnad Gidda and Nattukuttai on genetic trends of growth traits.

CONCLUSION

The heritability, genetic correlation, breeding values and genetictrend of body weight traits might be important for selection within Punganur population. Selection of dam and sire within population should be very important for the achievement of better genetic gain. Further, improvement of management and feeding in the farm simultaneously could make great effort to achieve the additive genetic variance and ultimately improve these low heritability, correlations and breeding values of herd. The low maternal heritability for birth weight in Punganur suggest that maternal genetic effect is important and need to be considered along with additive effect to reach optimum genetic progress by selection.

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