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Performance of milk production traits in Punganur Cattle

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Abstract
Data on milk production traits such as total lactation milk yield (TLMY), lactation length (LL), peak milk yield (PMY), milk yield per day of lactation length (MY/LL) and milk yield per day of calving interval (MY/CI) of Punganur reared at Livestock Research Station (LRS), Palamaner, Chittoor, Andhra Pradesh in the course of time 1994 to 2016 were analysed to study the influence of environmental factors on these characteristics. The comprehensive least square averages for aggregate milk yield, lactation length, peak yield, milk yield per day of lactation length, milk yield per day of calving interval were 466.86±2.067 kg, 238.59±0.517 days, 2.72±0.184 kg, 1.96±0.015 kg and 1.032±0.0033 kg respectively. The effects of period, season and parity on the overall lactations production traits was significant ($p \leq 0.01$) except effect of season of calving on peak yield was observed in analysis of variance.

Keywords: lactation length, peak yield, punganur cattle, total lactation milk yield

1. Introduction
Domestic animals play a vital part in the nutritional security of the people and it is integral part of agriculture. The livelihood of more than two-thirds of the rural population depends on livestock. The sum of cattle heads were 192.49 million (35.92% of total livestock population) out of which indigenous cattle population encompassed 142.11 million (20th Animal Husbandry Demographic Statistics, 2019). In milk production, India lined up in the first position with 176.3 million tonnes of total milk produce during 2017-18 in world (BAHS, 2018) [2]. Out of total milk produced in the country, the stake of indigenous cattle is near by 20%. As observational results in Andhra Pradesh state, it attains 5th in total milk production in India with a final outcome of 15.04 million metric tonnes. Although there is an increasing tendency in milk production, the primary disadvantage faced by the milk producers in dairy farming is poor productiveness of native animals based on several reasons.

Production traits that are exemplified with milk production are governed by polygenes. Nowadays, a key interest of cattle herders was raising the milk production in non-descriptive/indigenous cattle through traditional breeding methods. However, these breeding methods has less accomplishment in the growth rate of milk produce because of its medium heritability. Therefore, animal producers targeted to bring the changes in the genotype to get favourable phenotypes. Mainly variation in milk production performance traits can be ascribed to several fixed factors. An animal production ability primarily depends on its genetic makeup and several factors which are of environmental origin that are not disseminated from parents to progeny known as fixed factors (Nyamushamba *et al*., 2013) [3]. These factors that are affecting milk production included effect of period of calving, season of calving, parity and age at first calving. When the milk production trait has low heritable value, the additive genetic effect on that particular character became feeble and non-genetic factors have the substantial effect on that trait. As a result, animal's real genetic ability was hidden by environmental factors. So, environmental variance holds all variation of non-genetic origin, is a source of in accuracy that reduces correctness in genetic studies. Selection within the best environment allowed better gene expression and ameliorate response to selection was observed by Missanjo *et al*. (2011) [4].

The upliftment of milk production can be achieved through selection of genetically high-ranking animals at premature age. In addition to that, dense use of young, genetically supercilious males and females in selection, decreased the generation length. Production of animals were also evaluated by details on climatic factors influencing milk characteristics.

In this connection, formulating the breeding and management practices in conforming with season, period and age of animals which render better output with less input cost. The goal of this research work was to identify the effect of non-genetic factors, estimating heritability and repeatability on milk yield characterstics in Punganur with statistical techniques.

2. Materials and Methods

2.1 Data structure

Milk yield records accounted 87 Punganur cattle inseminated by 20 breeding males in the time course of 23 years (1994-2016) were composed from records of ancestry, daily milk yield registers. Common lactation records were considered for present investigation and animals having abnormal lactation records excluded from present study. Abnormal lactation records evidenced by pathological conditions including abortion, still births and lactation duration are less than 100 days etc. Data for the analysis was considered after removing the eccentric data on the outside of two-standard deviation on both the tail of the normal distribution. The following traits have been analyzed *viz*., total lactation milk yield, lactation length, peak yield, milk yield per day of lactation length and milk yield per day of calving interval. Data have been classified according to calving period, calving season and parities to estimate and assess the effects of several fixed factors on milk production characterstics. Animals having all completed lactation records have been grouped into six lactations to find out the effects of calvings on the milk characterstics. Depending on climatic conditions existing in the region, each calender year has been further partitioned into four seasons (Dangi *et al*., 2013) [5] i.e. winter (December-February), Summer (March-May), Rainy (June-August) and autumn (September-November) etc., to estimate effects of different seasons of calving on milk production traits. It is absolutely evident that there could be few differences in production traits of animals from year-over-year as data of Punganur cattle was spread over 23 years in current study. There might be erratic effects of different non-genetic factors which could be possible because of environmental agents like green, dry roughages and concentrate feeds and fodders, management and environment. Hence, corrected data has been classified as four periods (Period-I consisted of 1994-1998, Period-2 consisted of 1999-2003, Period-3 consisted of 2004-2008 and Period-4 comprised of 2009-2016) with the aim to reduce within period variance and augment between period variance.

2.2 Statistical analysis

Punganur cattle data pertaining to milk production traits were being in non-orthogonal nature and data was analysed by general linear model with univariate analysis using SPSS software. A modified Duncan's multiple range test was applied to find out the difference in two pairs of factors, given by Kramer (1957) [6].

The statistical model of milk production traits (TLMY, LL, PMY, MY/LL and MY/CI):

$$Y_{ijk} = \mu + Y_i + S_j + P_k + e_{ijk}$$

Where,

Y_{ijk} = TLMY, LL, PMY, MY/LL and MY/CI of ijk cow with i^{th} year, j^{th} season and k^{th} parity

μ = Overall mean

Y_i = the fixed effect of i^{th} period of calving (i=1994 to 2016)

S_j = the fixed effect of j^{th} season of calving (winter, summer, rainy and autumn)

P_k = the fixed effect of k^{th} parity (k= 1, 2, 3, 4, 5 and 6)

E_{ijk} = Random error associated with each observation.

3. Results and Discussion

The descriptive statistics such as means and coefficient of variation of milk production traits of Punganur were summarized in Table 1.

Table 1: Descriptive statistics for production traits of Punganur cows

Trait	Parity	N	Mean±SE	CV %
Production traits				
Lactation length (days)	First	158	258.32 ± 1.175	5.71
	Overall	927	238.59 ± 0.517	6.59
Total lactation milk yield(kg)	First	158	447.28± 0.884	2.48
	Overall	927	466.86 ± 2.067	13.48
Peak yield (kg)	First	157	2.59± 0.12	6.2
	Overall	926	2.72± 0.184	20.64
Milk yield per day of lactation length (kg)	First	158	1.728 ± 0.009	6.59
	Overall	923	1.96± 0.015	23.06
Milk yield per day of calving interval (kg)	First	157	1.024± 0.004	5.27
	Overall	549	1.032 ± 0.0033	7.61

SE-Standard error, CV-Coefficient of variation, n-Number of observations

Table 2: Least square means (±standard errors) for first lactation milk yield traits in Punganur

Effects	Lactation length	Total lactation milk yield	Peak yield	Milk yield per day of lactation length	Milk yield per day of calving interval
Overall mean (μ)	257.94± 1.45 (n= 158)	447.201± 1.111 (n=158)	2.59± 0.12 (n=157)	1.726± 1.699 (n=159)	1.033± 0.006 (n=157)
Period of calving	*	NS	NS	NS	*
P1(1994-1998)	259.91± 4.59^a (n=10)	447.192 ±3.442 (n=10)	2.645± 0.058 (n=10)	1.726± 0.041 (n=10)	1.068 ±0.017^a (n=10)
P2(1999-2003)	262.20 ±1.86^a (n=53)	451.321± 1.523 (n=53)	2.608± 0.024 (n=52)	1.710± 0.17 (n=53)	1.028 ±0.008^b (n=52)
P3(2004-2008)	249.89± 2.5^b (n=30	446.193± 1.999 (n=30)	2.652± 0.032 (n=30)	1.719± 0.024 (n=30)	1.019 ±0.10^b (n=30)
P4(2009-2016)	259.77 ±1.75^a (n=65)	444.100 ±1.397 (n=65)	2.567± 0.022 (n=65)	1.747± 0.016 (n=65)	1.018± 0.007^b (n=65)
Season of calving	*	NS	NS	NS	NS
Winter (Dec-Feb)	253.65± 3.50^b (n=50)	449.639± 1.76 (n=50)	2.705± 0.044 (n= 50)	1.731± 0.032 (n=50)	1.034± 0.009 (n=47)
Summer (Mar-May)	252.94± 2.89^b (n =30)	446.891 ± 2.085 (n= 30)	2.584± 0.037 (n=29)	1.728± 0.026 (n=30)	1.040± 0.01 (n=47)
Rainy (Jun-Aug)	260.04± 2.54^a (n=41)	445.431 ±1.851 (n=41)	2.594± 0.032 (n=41)	1.717± 0.023 (n=41)	1.025 ±0.09 (n=41)
Autumn (Sep-Nov)	265.14 ±2.611^a (n=37)	446.844±1.918 (n=37)	2.589± 0.033 (n=37)	1.726 ±0.025 (n=37)	1.035 ±0.010 (n=37)

**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

Table 3: Least square means (±standard errors) for overall lactation milk yield traits in Punganur

Effects	Lactation length	Total lactation milk yield	Peak yield	Milk yield per day of lactation length	Milk yield per day of calving interval
Overall mean (μ)	238.59± 0.517 (n=927)	470.539± 0.721 (n=927)	2.736± 0.10 (n=926)	1.986± 0.008 (n=923)	1.058 ± 0.004 (n=549)
Period of calving	NS	**	**	NS	**
P1(1994-1998)	239.475 ±0.465 (n=71)	466.198 ±2.109^{c} (n=71)	2.688± 0.029^{b} (n=71)	1.971±0.023 (n=71)	1.058± 0.009^{a} (n=48)
P2(1999-2003)	240.089± 0.621 (n=320)	469.982 ± 1.018^{b}(n=320)	2.788 ±0.013^{a} (n=319)	1.981 ±0.01 (n=319)	1.050± 0.005^{b} (n=190)
P3(2004-2008)	238. 254 ±0.874 (n=162)	471.973± 1.398^{a} (n=162)	2.745± 0.018^{a} (n=162)	1.993 ±0.015 (n=161)	1.066 ±0.007^{ab} (n=96)
P4(2009-2016)	239.674 ±0.580 (n=374)	474.005± 0.947^{a} (n=374)	2.725± 0.012^{a} (n=374)	1.998 ±0.01 (n=372)	1.057± 0.006^{ab} (n=215)
Season of calving	*	NS	NS	*	NS
Winter (Dec-Feb)	237.159± 1.071^{b} (n=293)	470.864± 1.154 (n=293)	2.708± 0.022 (n=293)	1.967± 0.018^{b} (n=291)	1.057 ±0.006 (n=170)
Summer (Mar-May)	252.94± 2.89^{b} (n =178)	471.758± 1.382 (n= 178)	2.757± 0.019 (n=177)	1.987± 0.015^{b} (n=177)	1.06 ±0.006 (n=110)
Rainy (Jun-Aug)	260.04± 2.54^{a} (n=241)	469.621± 1.213 (n= 241)	2.735± 0.017 (n=241)	1.986± 0.013^{b} (n=241)	1.046± 0.006 (n=143)
Autumn (Sep-Nov)	265.14 ±2.611^{a} (n=215)	469.915± 1.300 (n= 215)	2.746 ±0.019 (n=215)	2.004± 0.015^{a} (n=214)	1.068± 0.006 (n=126)
Parity	**	**	**	**	**
First	257.948 ±1.145^{a} (n=158)	446.099 ±1.469^{c} (n=158)	2.618 ±0.024^{d} (n=157)	1.726± 0.019^{d} (n=154)	1.026± 0.005^{c} (n=157)
Second	240.577± 1.145^{b} (n=158)	465.188 ±1.469^{b} (n=158)	3.16 ±0.024^{b} (n=158)	2.22 ±0.019^{b} (n=158)	0.960± 0.005^{d} (n=150)
Third	237.137± 1.153^{c} (n=153)	547.477± 1.490^{a} (n=153)	3.527± 0.024^{a} (n=153)	2.706 ±0.019^{a} (n=153)	1.092± 0.006^{ab} (n=128)
Fourth	240.167± 1.229^{bc} (n=131)	549.535± 1.599^{a} (n=131)	2.774± 0.025^{c} (n=131)	2.097 ± 0.020^{c} (n=131)	1.068± 0.007^{b}(n=80)
Fifth	239.937 ±1.225^{bc} (n=131)	425.864± 1.595^{d} (n=131)	2.184 ±0.025^{e} (n=131)	1.701± 0.020^{d} (n=131)	1.104 ±0.015^{a} (n=17)
Sixth and above	220.472± 0.901^{a} (n=196)	389.073± 1.317^{e} (n=196)	2.156 ±0.019^{e} (n=196)	1.465 ± 0.015^{e} (n=196)	1.096± 0.015^{ab} (n=17)

**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

Table 4: Estimates of (Co) variance components and genetic parameters for first and overall lactation traits in Punganur

Trait	σ_e^2	σ_p^2	σ_a^2	h^2±SE	r ±SE
First lactation production traits					
Lactation length	193.85	213.748	19.895	0.093± 0.236	-
Total lactation milk yield	215.849	216.992	1.14302	0.005± 0.34	-
Peak yield	0.0201802	0.025681	0.0055017	0.214±0.204	-
Milk yield per day of lactation length	0.001	0.012256	0.013256	0.075± 0.236	-
Milk yield per day of calving interval	0.0014259	0.0030425	0.001616	0.469 ±0.273	-
All lactations production traits					
Lactation length	88.2963	216.544	125.299	0.579± 0.445	0.014± 0.390
Total Lactation milk yield	0.21948	1.5663	0.05826	0.037 ±0.017	0.823 ±0.027
Peak yield	0.4524	0.4725	0.01	0.021± 0.045	0.021± 0.046
Milk yield per day of lactation length	0.02703	0.18895	0.08082	0.428 ±0.043	0.429± 0.041
Milk yield per day of calving interval	0.03342	0.0534	0.01	0.187 ±0.281	0.187± 0.242

σ_e^2 = error variance, σ_p^2 = phenotypic variance, σ_a^2 = additive variance, h^2 =heritability, r = repeatability, SE=standard error.

3.1 Milk Production performance traits

3.1.1 Total lactation milk yield

The least square mean for total lactation milk yield over a period of 23 years was 470.539± 0.721 kg for 927 records of Punganur cattle reared at Livestock Research Station, Palamaner, Chittoor district, Andhra Pradesh (Table 3). These values are similar to those reported by Rajendran (1995) [7] in Kangayam, Rao *et al.* (2000) [8] in Punganur, Bindya and Sosamma (2010) [9] in Vechur, Ganapathi *et al.* (2013) [10] in Bargur and Parameswari *et al.* (2020) [11] in Alambadi. However, these means were more than the values disclosed by Murugeppa *et al.* (2020) [12] in Malanad Gidda and lower estimates than those declared by Vinoo *et al.* (2005) [13] in Deoni. The least squares mean for total lactation milk yield was maximum throughout the period 1999 to 2003 and lowest during period 2009 to 2016. The deviation was significant (p<0.01). The disparity in total lactation milk yield recorded in various periods were very less which indicates there is no difference in management in addition to the environmental effects.

Parity showed significant (p≤0.01) differences for that cahracter. Vinoo *et al.* (2005) [13] had identical observation in Ongole cattle. However, Shingare *et al.* (2015) [15] in Deoni, Dash *et al.* (2023) [16] in Sahiwal divulged non-significant effect of parity on total lactation milk yield. This shows that lactating cows at initial age are not completely developed, their mammary glands are not completely operative and confer less lactation yield. However, fully matured females which are in the middle and late lactation give more milk yield.

Season of calving showed non-significant (p≤0.05) variation for the said trait. Vinoo *et al.* (2005), Shingare *et al.* (2015) and Dash *et al.* (2023) [13, 15, 16] also made similar observations in their studies. This could be due to seasonal influence on total lactation milk yield and it was almost negligible.

3.2 Lactation length

The aggregate least squares average for lactation length was 238.59± 0.517 days for 927 lactation records of Punganur cows (Table 3). Lactation lengths that were observed in Punganur cows that calved during different periods almost similar. The females undergone parturition in autumn season had the lengthy period of lactation (265.14±2.611 days) followed by rainy season (260.04±2.54). Least square ANOVA marked highly significant effect of parity (p≤0.01) on over all lactation length observed in the present study (Table 3). Contrary to this, Vinoo *et al.* (2005) [13] found non-significant effect of parity in Ongole. The lactation length of punganur is not exceeding 10 months. Therefore, shorter lactation length did not prolong the calving interval and not

affected the number of progeny that would be acquired throughout the lifespan of cow. Thus, trail should be made for producing Punganur progeny every year with a lactation period less than 10 months.

3.3 Peak yield

The least square means of peak milk yield afflicted by period and season of calving at first lactation, period, season of calving and parity at over all lactations were summarized in Tables 2 and 3 respectively. Over all LSM of peak milk yield in Punganur cow was 2.736±0.10 kg for 926 records. However, Rao *et al.* (2000) [8] in Pungnur observed 3.5 kg, Murugeppa *et al.* (2020) [12] in Malnad Gidda reported 3.69 kg in their studies. The observed differences of PMY due to season of calving hvenot been significant, which indicated that the variation in that trait remain unchanged irrespective of any season of calving. These results were in congruence with Salunkhe (2007) [17] in Deoni. The ANOVA suggested, impact due to period of calving and parity ($p \leq 0.01$) was significant (Table 3). However, there was very less reports in other small cattle like Malnad Gidda, Nattukuttai.

3.4 Milk yield per day of lactation length

The least square means of milk yield per day of lactation length influenced by period and season of calving at first lactation, period, season of calving and parity at overall lactations were presented in Tables 2 and 3 in that order. Overall LSM of milk yield per day of lactation length of Punganur cow was 1.986±0.008 kg for 923 records. Results indicated that period of calving and season of calving have not been significant, whereas parity ($p \leq 0.01$) was significant. However, there is no reported literature in small cattle like Vechur, Maland gidda and Nattukuttai on this trait.

3.5 Milk yield per day of calving interval

The least square means of milk yield per day of calving interval affected by period and season of calving at first lactation, period, season of calving and parity at overall lactations were displayed in Tables 2 and 3 respectively. Overall LSM of milk yield per day of calving interval of Punganur cow was 1.058 ± 0.004 kg for 549 records. Results indicated that period of caving was non-significant, whereas season of calving ($p \leq 0.05$) and parity ($p \leq 0.01$) were significant. However, there is no reported literature in small cattle like Vechur, Malnad Gidda and Nattukuttai on this trait. It is an estimate to compare cows with unusual calving interval lengths with respect to milk yield which in turn useful to differentiate the reproductive efficiency between cows.

4. Estimates of Heritability

Variance and heritability for milk production traits are depicted in Table 4. Heritability estimates of total lactation milk yield, lactation length, peak yield, milk yield per day of calving interval and milk yield per day of lactation length at first lactation in Punganur cows were 0.005, 0.093, 0.214, 0.469 and 0.075 respectively. The corresponding values for all lactation traits in Punganur cows were 0.037, 0.579, 0.021, 0.187 and 0.428 respectively. These heritabilities were lower when compared to the values reported by Vinoo *et al.* (2005) [13] in Ongole cattle, Bindya and Sosamma (2010) [9] in Vechur. The estimates for this Punganur were very low except for lactation length for overall lactations and milk yield per day of calving interval for first lactation which can be improved by providing the better environment in turns of nutrition, health care and shelter.

5. Repeatability

The repeatability estimates in Punganur cattle for total lactation milk yield, lactation length, peak yield, milk yield per day of calving interval and milk yield per day of lactation length at overall lactations have been 0.823, 0.014, 0.021, 0.187 and 0.429 respectively. Repeatability values with respect to this trait of other dwarf cattle such as Vechur and Malanad Gidda are not available to compare repeatability values of Punganur cattle.

6. Conclusion

From this study, it could be stated that the milk production performance traits of Punganur cattle were influenced by fixed factors. Period of calving had significantly effected on milk production characteristics except lactation length and milk yield per day of lactation length. Season of calving significantly influenced the lactation length and milk yield per day of lactation length. Parity had significant effect on all milk production characterstics. Knowledge on the effect of these fixed factors (calving period, calving season and parity) might assist in making farming operation resolutions for refinement of the cattle groups. The activities of nutrition, mating and sanitation directions should be done for advancement of milk production performance characteristics. The heritability and repeatability values arrived from this study will be useful in the selective breeding program with reference to Punganur cattle.

Milk from small cattle like Punganur is often a valuable source of nutrition and income for local communities. Milk consists of essential nutrients, including proteins, fats, vitamins and minerals. Studying milk production traits helps to upgrade the quality and quantity of milk produced by small cattle, thereby enhancing the nutritional security of population that rely on this milk for sustenance and farmers can improve the yield and quality of milk, which can lead to increased income generation through the sale of surplus milk and dairy products. This information can be used for selective breeding programs to enhance the overall milk production capabilities of Punganur cattle populations. Punganur cattle are often raised in diverse agro-ecosystems, including marginal lands and suitable for semi-intensive system of dairy farming and farmers can practice sustainable agriculture by utilizing available resources effectively and minimizing environmental impact.

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