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EFFECTS OF BREED, VARIOUS ENVIRONMENTAL AND MATERNAL FACTORS ON GROWTH TRAITS IN CATTLE

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ABSTRACT

The objectives of the present study were to investigate the effects of breed, sex, parity, year of birth and season of birth on birth weight, weaning weight and yearling weight recorded on 713 calves born between 1996 and 2008. The data included offspring from five local cattle breeds (Dhanni, Lohani, Dajal, Red Sindhi, Cholistani) and crossbreds (Holstein or Jersey crosses) maintained at Barani Livestock Production Research Institute (BLPRI, Attock, Punjab, Pakistan).The data were analyzed using a mixed linear model with PROC MIXED. Overall means ± SD of birth, weaning and yearling weights, pre- and post-weaning growth rates were18.67 ± 2.60 kg, 72.88 ± 18.98kg, 116.05 ± 30.63 kg, 301.18 ± 104.03 g and 239.86 ± 117.32 g, respectively. All growth traits (birth weight, weaning weight and pre- and post-weaning growth rates) varied with breed, sex, parity of dam and season and year of birth. The calves of Lohani cattle (a short stature breed) had the lightest birth weights (16.4 kg) as compared to other breeds and crossbreds (> 18 kg). The heaviest weaning weights (91.25 kg) were found in calves from the Dajal breed, followed by weaning weights for Dhanni (78.54 kg), Cholistani (70.68 kg), Red Sindhi (70.46 kg) and Lohani (64.0 kg). The heaviest yearling weights were found in Dajal calves (148.48 kg) while the lowest yearling weights were found in Lohani calves (99.81 kg). Overall, birth, weaning and yearling weights were greater in male as compared to female calves ($P < 0.05$). The calves born to first parity cows had lighter birth and yearling weights as compared to calves from later parity cows. However, similar trends were observed for weaning weight of calves born to first and later parity cows. Spring born calves had heavier weaning weights (77.39 kg) than summer born calves (70.34 kg).Summer born calves had lighter yearling weight (110.04 kg) than calves born in other seasons (119-121 kg). The observed between breed variation for growth indicates an untapped potential for beef production and results have useful implications for breed improvement and management decisions for cattle breeds being raised under arid conditions.

Key words: birth weight, weaning weight, yearling weight**,** cattle breeds, Potohar region.

INTRODUCTION

The world's population is expected to reach 9 billion people by the year 2050. This prediction has lead to the call for food production to double by the year 2050. Consequently increasing production levels and efficiencies are a growing concern worldwide. Furthermore, meat is likely to have an increased share of the global market due to changes in the dietary preferences and income levels of people in developing countries (FAO, 2002). Opportunities exist for beef producers around the world to grab the chance of fulfilling ever increasing demand for meat with reasonable profit.

Beef contributes approximately 52% of the total meat produced in Pakistan (GOP, 2016). At present, there is no genetic improvement program for beef producing animals in Pakistan. Efforts to improve beef production potential of local cattle are required(Khan*et al.,* 2008) to achieve both quantitative and qualitative improvement of beef production at reduced cost. Although there is no specific breed of beef cattle in Pakistan, however, some local draught breeds can be potentially raised for beef production. The Dhanni, Dajal, and Lohani are basically draught type breeds whereas Red Sindhi and Cholistani breeds of cattle are considered suitable for milk production purpose(Afzal and Naqvi, 2003). A previous study on indigenous cattle breeds maintained at Barani Livestock Production Research Institute (BLPRI), Attock described some traits like milk production and calving interval including dry period (Aslam *et al.,* 2002). However, there is no information available on the beef production potential of the above mentioned breeds of cattle. Therefore, present study was designed to document beef production potential of the local cattle breeds under arid region of Punjab, Pakistan. This will facilitate the process of setting goals for breed specific conservation and improvement programs in future.

MATERIALS AND METHODS

Data on body weight traits of five local cattle breeds maintained at Barani Livestock Production Research Institute, Kherimurat, DistrictAttock were

collected for the period 1996-2008. Average annual rainfall in the area ranges from 600 to 900 mm and mean temperature ranges from 24 to 26 °C although temperature goes above 40 °C during the month of June (PMD, 2016). The cattle breeds included in the study were Dhanni, Dajal, Lohani,Cholistani, Red Sindhi and Crossbreds (mostly crosses of Red Sindhi and Dhanni with Friesian and Jersey). The brief introduction and images of these breeds are given in supplementary data file.The routine management practices for different breeds were basically the same. Animals were housed in conventional open sheds with adequate covered space to be used as shade and shelter for harsh periods of summer and winter. The breeding bulls and dry and lactating cows were kept in separate sheds. Cows usually graze on forages grown on the farmland. Grazing is also available on mountainous rangeland of the research station. Animals typically graze from morning to evening. Concentrate is usually fed to lactating animals and hay or silage was also used for feeding during the feed scarcity periods. The bulls used for natural breeding or artificial insemination was mostly farm produced. Artificial insemination was practiced to produce Holstein/Jersey crossbreds. Down calvers were usually kept in the maternity barns approximately two months before calving. Calves were allowed to suckle their dams after calving. Most cows were sent to pastures for grazing without their calves within a week after calving, depending on weather conditions. Calves were kept in separate pens except at milking time when they were allowed to suckle milk from their dams, until weaning around six month of age. Vaccination and deworming schedules were similar for all cattle breeds maintained at the research station. Cows were usually culled for old age, failure to produce milk or udder infections. Replacements were usually selected from calves born in the herd. All animals born at farm were assigned a unique identification at birth in the form of tattoo in the ear and same number was placed as freeze/hot brand on the thighs of animal as the animal matures. All animals were weighed on monthly basis and their body weight was recorded in a live weight register.

Birth weights for male and female calves were obtained from birth registers maintained at the farm. Weaning weight (weight at six month of age) and yearling weight (weight at one year of age) records of calves were obtained from live weight registers. Pre- and post- weaning growth rates were derived by subtracting final weights from initial weights and subsequent division by the number of days between two weights. The preliminary data analysis were performed using SAS (9.2) program. The statistical model to analyze growth traits included fixed effects of breed, parity of dam, season of birth and year of birth. The PROC MIXED procedure of (SAS Institute, 2008) was used to analyse the data using following linear model:

$$Y_{ijklmn} = \mu + B_i + S_j + P_k + Sb_l + Yb_m + E_{ijklmn}$$

where Y_{ijklmn} is a measurement of growth/body weight trait of the n^{th} animal born in m^{th} birth year and l^{th} birth season in k^{th} parity of dam class of j^{th} sex and i^{th} breed; μ is overall population mean; B_i is the fixed effect of i^{th} breed (6 levels); S_j is the fixed effect of j^{th} sex (2 levels); P_k is the fixed effect of k^{th} parity of dam class (2 levels) ; Sb_l refers to the fixed effect of l^{th} season of birth (4 levels); Yb_m refers to the fixed effect of m^{th} year of birth (13 levels) and E_{ijklmn} is the random residual associated with each record. Residual effect for each trait was assumed to be distributed as N (0, $I\sigma_e^2$) and N(0, $I\sigma_{hys}^2$), respectively. Five breed classes were defined as: 1 for Dhanni cattle, 2 for Lohani cattle, 3 for Red Sindhi cattle, 4 for Cholistani cattle, 5 for Dajal cattle and 6 for crossbred cattle. There were two sex classes (male and female), two parity of dam classes (calves born to first and later parity dams), four seasons of birth classes (Spring, March to April; Summer, May to August; Autumn, September to October; Winter, November to February) and thirteen year of birth classes (1996 to 2008).

RESULTS AND DISCUSSION

Means and standard deviations for five growth traits are given in Table 1. Overall means ± SD of birth, weaning and yearling weights, pre- and post weaning growth rates were 18.67 ± 2.60 kg, 72.88 ± 18.98 kg, 116.05 ± 30.63 kg, 301.18 ± 104.03 g and 239.86 ± 117.32 g, respectively. Generally, high values of standard deviations and minimum and maximum values for all growth traits (except birth weight) show that substantial variability exists among local cattle for growth traits and this variability can be exploited to improve growth potential of local cattle as beef animal in Pakistan. As all studied breeds of cattle were raised under more or less similar environmental conditions, it could be presumed that all between breed variability in growth traits is basically due to genetic differences.

Birth weight: Average birth weight for all breeds was 18.67 kg (Table 1). Breed factor was significantly related to the variation in birth weight of calves. Crossbred, Cholistani and Dajal cattle had higher birth weights (>19 kg) followed by Red Sindhi and Dhanni (between 18 and 19 kg), whereas Lohani had lowest birth weights (<17kg)(Table 2). Birth weights of other *Bos indicus* cattle are comparable to the results from present study. For instance purebred Brahman cattle calves had an average birthweight of 29.6kg as reported by Comerford *et al.,* (1988).Although birth weight of calves depends upon several factors including sex, dam size, temperature and maternal nutrition, however different size of breeds may have contributed to the differences in calf birth weights. Research has shown that the birth weight of the

calf would be approximately 7% of the dam's body weight(Westhuizen and Bergh, 2014). In a study on dairy cows, Linden *et al.,*(2009) demonstrated a linear relationship between cow height at parturition (distance from the floor to the upper end of the withers) and calf birth weightsuggesting that bigger cows are likely to produce heavier calves.

Males had heavier birth weights than female calves(Table 3). Male calves weigh approximately 5 to 8% more at birth than female calves. It might be attributed, at least partially, to the effect of the testosterone. Higher level of endogenous testosterone is associated with increased growth and carcass cutability in beef cattle (Gortsema *et al.,* 1974). Development of the male reproductive tract administered by testosterone secretion from the Leydig cells, begins as early as day 42 of gestation (Ball and Peters, 2004). This may partially explain higher birth weight of male calves compared to female calves as reported in the present study.

Calves born to first parity cows were generally lighter than later parity cows(Table 4), which is comparable to earlier findings in beef cattle (Krupa *et al.,*2005; Afroz *et al.,* 2011; Toušova *et al.,* 2014) and buffaloes (Saravaiya *et al.,* 1992; Naqvi and Shami, 1999).Parity is presumed to produce its pragmatic effect through changes in the maternal environmental conditions(Foote *et al.,* 1960).

Birth weights of calves were similar among all four seasons (Table 5) suggesting that season of birth was unrelated to birth weight of calves. Shahzad *et al.,*(2010) also noted a non-significant effect of season on birth weight of Cholistani calves in Pakistan. Birth weight of calves significantly varied with year of birth (Table 6), although no clear trend was observed for the effect of the birth year. In a previous study on Cholistani calves it has been observed that year, sex and dam parity affected the birth weights of calves (Shahzad *et al.,* 2010).

Weaning weight: Dajal breed of cattle was heavier (P<0.05) in weaning weight (91.25kg) followed by Dhanni (78.54 kg).Dajal and Dhanni cattle breeds are considered medium draught breeds of Punjab, Pakistan (Table 2). However, their status is endemic in terms of utility and conservation (Khan *et al.,* 2008). Three dairy type cattle (Red Sindhi, Cholistani and Crossbred) had similar weaning weights (approximately 70 kg). Lohani cattle had lowest weaning weight (64 kg) among all breeds studied. Lohani is a short stature cattle breed, which is primarily used for light draught and is found in Khyber-Pakhtunkhawa and Punjab provinces of Pakistan (Khan *et al.,* 2008). The breed conservation status of Lohani cattle is also endemic as reported by (Khan *et al.,* 2008).

Overall, male calves had higher (P<0.05) weaning weights than female calves (Table 3) indicating slightly more advantage of raising a male calve than a female calf. It is worth mentioning that although the male calves grew faster, the heifer calves also showed good growth. Furthermore, as noted by (Šeba, 2013) the fattening of heifers could be another choice for farmers, as in previous study heifer calves showed a better beef quality, especially tenderness (Hanzelková *et al.,* 2011). However only a few farmers are interested in fattening of this category and slaughter heifers are generally considered to be more of a waste. Weaning weight of calves born to first and later parity cows was similar suggesting that parity of dam is less important in determining weaning weight of their calves (Table 4).

Weaning weight of spring born calves was higher (P<0.05) followed by winter, autumn and summer (Table 5). The weaning weight of calves showed inconsistent pattern for year of birth factor although the effect of birth year on weaning weight was significant(P < 0.05). In a study on calves from seven beef breeds in Hungary, Szabo *et al.,*(2006) noted significant effects of age of dam, birth year, birth season and sex of calf on weaning weight.

Yearling weight: In line with the pattern of weaning weight data, Dajal breed of cattle showed highest yearling weight (148.5 kg) followed by Dhanni (121.4 kg), Crossbred, Cholistani, Red Sindhi (between 111 to 113.2 kg) and Lohani (99. 8 kg)as shown in Table 2. The between breeds results of weaning as well as yearling weight suggest that local draught cattle breeds (especially Dajal, and Dhanni) had greater potential for higher body weights as compared to Crossbreds and local dairy cattle breeds (Red Sindhi and Choistani). Additionally, Lohani cattle, being short statured breed showed good potential for growth. The maintenance and other management requirements of such a short stature breed could be lesser than larger breeds suggesting a new prospective for beef farmers to make the most of it.

Overall, male calves were heavier (P<0.05) than female calves at one year of age(Table 3). Calves born to first parity cows were lighter (P<0.05) than those born to later parity cows (Table 4). Moreover, calves born in Summer were lighter (P < 0.05) than calves born in other seasons (Spring, Autumn, Winter)as shown in Table 5. This could be attributed to lesser availability of feed resources in scarcity period of Summer that is generally longer in the region as compared to other lean periods i.e. Autumn. The yearling weight of calves varied with year of birth (P < 0.05) but showed irregular pattern across the years of birth(Table 6).

The findings of current study argue the possibility of improving local draught cattle breeds as potential beef cattle in Pakistan where, so far, no specific beef cattle breed exists. A genetic selection program for greater growth rate and improved beef quality may be initiated in these local draught breeds (Dajal, Dhanni and Lohani) to fulfill the ever increasing demand for beef in

the country and possibility of becoming an export point in the world. That will also conserve the precious genetic resources that country has. Dhanni and Dajal are already considered preferred sacrificial animals at the occasion of Eidul Azha (an yearly Muslim festival) where Muslims sacrifice (slaughter in the name of Allah) thousands of animals all over the world each year. Therefore, there is a promising market for beef in and out of the country for local beef breeders.

Pre- and Post-weaning Growth Rate: Growth traits were significantly affected by the breed of the calves (Table 2). Dajal had higher (P<0.05)pre-weaning growth rate (PRGR) followed by Dhanni, Red Sindhi, Cholistani, Crossbred and Lohani. For post-weaning growth rate (POGR), the order from higher to lower was Dajal, Crossbred, Dhanni, Red Sindhi, Cholistani and Lohani. Although Dajal had lowest number (i.e. N=21) among all breeds in the present study, nonetheless, it seems to have greater potential for growth under arid conditions. The second higher was Dhanni breed in pre-and post-weaning growth rates. On the other hand, Lohani were the lowest in all body weight and growth traits than rest of the cattle breeds. Crossbred cattle, which are mainly bred and raised for milk production, had higher POGR (P < 0.05) than Lohani; similar POGR to Dhanni, Red Sindhi and Cholistani but lower POGR than Dajal breed. Male calves had higher (P<0.05) PRGR and POGR than female calves (Table 3). Calves born to first and later parity dams had similar PRGR and POGR (Table 4). This indicates that preference may be given to Dajal breed over crossbred in fattening yards. Calves born in Spring had highest PRGR followed by Winter, Autumn and Summer. For POGR, calves born in Winter had higher growth rate followed by Autumn, Spring and Summer (Table 5). Both PRGR and POGR were significantly affected by year of birth although no particular trend was observed (Table 6).

Table 1. Basic Statistics of the growth traits in Pakistani cattle breeds.

Trait	No. of Records (N)	Mean ± SD	Min.	Max.
Birth Weight (kg)	713	18.67 ± 2.60	12	34
Weaning Weight (kg)	713	72.88 ± 18.98	50	172
Yearling Weight (kg)	713	116.05 ± 30.63	70	252
Pre-Weaning Growth Rate (g/day)	713	301.18 ± 104.03	138.89	844.44
Post-Weaning Growth Rate (g/day)	713	239.86 ± 117.32	94.44	944.44

Table 2. Effects of breed on growth traits of calves in Pakistani cattle breeds.

Tr[a]it	Estimates of Least Square Means (± S.E.)						
	Dhanni (N=178)	Lohani (N=142)	Red Sindhi (N=130)	Cholistani (N=44)	Dajal (N=21)	Crossbred (N=198)	Overall P-value
Birth Weight (kg)	18.1625[a] ±0.1831	16.4451[b] ± 0.2112	18.2063[ac] ± 0.2096	19.9878[d] ± 0.3672	19.2660[acde] ± 0.4948	19.9918[d]f ± 0.1758	<.0001*
Weaning Weight (kg)	78.5410[a] ±1.3815	64.0017[b] ± 1.5941	70.4637[bc] ±1.5817	70.6805[abcd] ± 2.7707	91.2525[ae] ± 3.7338	69.4463[bcd]f ± 1.3265	<.0001*
Yearling Weight (kg)	121.44[a] ±2.2079	99.8066[b] ± 2.5476	112.90[ac] ± 2.5277	111.64[abcd] ± 4.4280	148.48[e] ± 5.9671	113.21[acd]f ± 2.1198	<.0001*
Pre-Weaning Growth Rate (g/day)	335.44[a] ±7.5396	264.20[b] ± 8.6997	290.32[bc] ± 8.6318	281.63[bcd] ±15.1212	399.93[ae] ± 20.3770	274.75[bcd]f ± 7.2391	<.0001*
Post-Weaning Growth Rate (g/day)	238.33[a] ±9.1333	198.92[ab] ±10.5386	235.76[abc] ±10.4563	227.54[abcd] ±18.3174	317.94[acde] ± 24.6841	243.13[acde]f ± 8.7692	<.0001*

[1] Least Square Means with different superscript letters within a row differ (P < 0.05)
[2] Probability values with * symbol show difference (P < 0.05)

Table 3. Effects of sex on growth traits of calves in Pakistani cattle.

Trait	Least Square Means (± S.E.)		
	Male (N=376)	Female (N=337)	Overall P-value
Birth Weight (kg)	19.0275[a] ± 0.1619	18.3257[b] ± 0.1713	<.0001*
Weaning Weight (kg)	75.9862[a] ± 1.2218	72.1424[b] ± 1.2927	0.0023*
Yearling Weight (kg)	123.17[a] ± 1.9526	112.66[b] ± 2.0660	<.0001*
Pre-Weaning Growth Rate (g/day)	316.44[a] ± 6.6679	298.98[b] ± 7.0550	0.0113*
Post-Weaning Growth Rate (g/day)	262.12[a] ± 8.0773	225.09[b] ± 8.5463	<.0001*

[1] Least Square Means with different superscript letters within a row differ (P < 0.05)

[2] Probability values with * symbol show difference ($P < 0.05$)

Table 4. Effects of parity of dam on growth traits of calves in Pakistani cattle.

Trait	Least Square Means (± S.E.)		
	Parity 1 (N=119)	Parity ≥ 2 (N=594)	Overall P-value
Birth Weight (kg)	[1]18.3482[a] ± 0.2317	19.0050[b] ± 0.1186	0.0042*
Weaning Weight (kg)	72.5554 ± 1.7484	75.5732 ± 0.8948	0.0805
Yearling Weight (kg)	114.54[a] ± 2.7942	121.29[b] ± 1.4300	0.0146*
Pre-Weaning Growth Rate (g/day)	301.15 ± 9.5418	314.27 ± 4.8832	0.1637
Post-Weaning Growth Rate (g/day)	233.24± 11.5586	253.96 ± 5.9153	0.0695

[1] Least Square Means with different superscript letters within a row differ (P < 0.05)
[2] Probability values with * symbol show difference (P < 0.05)

Table 5. Effects of season of birth on growth traits of calves in Pakistani cattle.

Trait	Least Square Means (± S.E.)				
	Autumn (N=99)	Spring (N=231)	Summer (N=157)	Winter (N=226)	Overall P-value
Birth Weight (kg)	19.0668 ± 0.2512	18.4552 ± 0.1873	18.4849 ± 0.2126	18.6995 ±0.1913	0.1233
Weaning Weight (kg)	73.7683a ± 1.8954	77.3961ab ±1.4134	70.3426ac ± 1.6042	74.7502abcd ± 1.4436	0.0008*
Yearling Weight (kg)	119.94a ± 3.0291	120.72ab ± 2.2588	110.04c ± 2.5637	120.95abd ± 2.3070	0.0002*
Pre-Weaning Growth Rate (g/day)	303.90a ± 10.3439	327.45ab ± 7.7137	288.10ac ± 8.7548	311.39abcd ±7.8782	0.0005*
Post-Weaning Growth Rate (g/day)	256.48a ±12.5303	240.71ab ± 9.3442	220.53abc ± 10.6053	256.69abd ±9.5434	0.0108*

[1] Least Square Means with different superscript letters within a row differ (P < 0.05)
[2] Probability values with * symbol show difference (P < 0.05)

Table 6. Effects of year of birth on growth traits of calves in Pakistani cattle.

Trait	Least Square Means (± S.E.)													
	1996 (N=41)	1997 (N=72)	1998 (N=52)	1999 (N=46)	2000 (N=49)	2001 (N=50)	2002 (N=53)	2003 (N=50)	2004 (N=68)	2005 (N=74)	2006 (N=59)	2007 (N=40)	2008 (N=59)	Overall P-Value
Birth Weight (kg)	19.2126 ±0.3775	18.3443 ±0.3047	18.5649 ±0.3398	18.8073 ±0.3394	18.2961 ±0.3355	19.0134 ±0.3261	17.8103 ±0.3225	17.9364 ±0.3294	18.9094 ±0.2901	18.6308 ±0.2786	19.8931 ±0.3074	18.6646 ±0.3637	18.7125 ±0.3145	0.0001*
Weaning Weight (kg)	67.3544 ±2.8489	61.0231 ±2.2992	71.7651 ±2.5645	77.4366 ±2.5609	91.5400 ±2.5316	72.0882 ±2.4610	76.6008 ±2.4340	76.9563 ±2.4857	81.6891 ±2.1889	74.0038 ±2.1027	66.8982 ±2.3195	70.8098 ±2.7447	74.6702 ±2.3730	<.0001*
Yearling Weight (kg)	100.94 ±4.5529	97.4846 ±3.6745	121.61 ±4.0984	120.75 ±4.0926	142.40 ±4.0458	117.24 ±3.9329	122.35 ±3.8898	127.03 ±3.9724	128.96 ±3.4982	108.83 ±3.3604	119.32 ±3.7068	110.89 ±4.3864	115.08 ±3.7924	<.0001*
Pre-Weaning Growth Rate (g/day)	267.45 ±15.5477	237.10 ±12.5479	295.56 ±13.9957	325.72 ±13.9759	406.91 ±13.8159	294.86 ±13.4306	326.61 ±13.2832	327.89 ±13.5654	348.78 ±11.9460	307.63 ±11.4754	261.14 ±12.6583	289.70 ±14.9792	310.88 ±12.9507	<.0001*
Post-Weaning Growth Rate (g/day)	186.58 ±18.8340	202.56±1 5.2002	276.91 ±16.9540	240.63 ±16.9301	282.56 ±16.7362	250.82 ±16.2695	254.17 ±16.0909	278.19 ±16.4328	262.59 ±14.4711	193.47 ±13.9010	291.24 ±15.3340	222.64 ±18.1453	224.49 ±15.6881	<.0001*

[2] Probability values with * symbol show difference (P < 0.05)

Conclusions: The present study provides first reports on the growth potential of various indigenous cattle breeds under arid conditions. We have demonstrated that breed, season, sex and parity of dam influenced beef production traits. The documented factors may be considered for genetic evaluation and management decisions to improve beef production under arid conditions. Moreover, indigenous breeds appear to have substantial growth potential to be developed as beef cattle breeds for better utilization of indigenous farm animal genetic resources (FAnGR).

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