A Comparative Study of Productive and Reproductive Performance between Mpwapwa Breed Cattle and Their Crosses

***M.M. Mabruck and I.P. Kashoma**

College of Veterinary and Medical Sciences, Sokoine University of Agriculture, P.O. Box 3020, Morogoro, Tanzania.

***Email: mercymabruck71@gmail.com**

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M.M. Mabruck and I.P. Kashoma

College of Veterinary and Medical Sciences, Sokoine University of Agriculture, P.O. Box 3020, Morogoro, Tanzania.

Email: mercymabruck71@gmail.com:

SUMMARY

Mpwapwa cattle, a Tanzanian composite dual-purpose breed which was established in 1960s is suitable for medium to low input production systems, but is faced with limited country-wide distribution. The aim of this study was to assess the productive and reproductive performances of Mpwapwa cattle breed and its crosses reared at Tanzania Livestock Research Institute (TALIRI). Retrospective data on age at first calving (AFC), calving interval (CI), pregnancy percentage (PP), lactation length (LL), average milk yield per day (AMYD) and total lactation milk yield (TLMY) obtained from 295 cows with the total of 885 lactations during five consecutive years (2015-2019) were analyzed. Overall mean of AFC, CI, PP, LL, AMYD and TLMY were 38.5±5.9 months, 19.92±5.64 months, 29.1%±14.4%, 237.72±71.20 days, 2.65±1.12 liters and 667.18±397.11 liters, respectively. The results of AFC, CI, LL and TLMY showed significance difference ($p < 0.05$) between Mpwapwa breed cattle and its crosses except for PP which did not show significance difference ($p > 0.05$). The results shows that reproductive and productive performance of Mpwapwa breed cattle and its crossbred cows was lower compared to the breeding goal of this breed. Therefore, it is recommended to investigate factors required to improve reproductive and productive performances to meet the intended objectives of establishing Mpwapwa Breed.

Key words: Mpwapwa cattle breed, age at first calving, calving interval, lactation length, total lactation milk yield

INTRODUCTION

Tanzanian shorthorn zebu is the predominant breed of cattle kept by the majority of smallholder farmers in pastoral and agro pastoral cattle production systems (Asimwe *et al*., 2016). These cattle are well adapted to tropical environments, they possess a high degree of heat tolerance, they are fairly resistant to ticks and tick-borne diseases and to many other diseases, and have low nutritional requirements (Cunningham and Syrstad, 1987). However, their productivity in terms of milk and meat is generally low, with predictable lactation milk yield ranging from 300 to 1,100 kg (Asimwe *et al*., 2015). In order to improve the low productivity of local cattle and thus reducing the gap between supply and demand, crossbreeding between tropical indigenous breeds with temperate dairy breeds to exploit heterosis, has been used in several tropical countries including Tanzania (Cunningham and Syrstad, 1987). Holstein-Friesian, Jersey, Ayrshire, and their corresponding crosses are preferred by most of sub Saharan countries for crossing with *Bos indicus* in order to increase the productivity (Chawala *et al*., 2020).

Mpwapwa cattle breed, established in Tanzania in 1960s, is a composite dual-purpose breed intended for production in medium to low input production systems, with the genetic constitution of 32% Red Sindhi, 30% Sahiwal, 19% Tanganyika Shorthorn Zebu (TSZ), 11% Boran, and 8% Ayrshire (Kiwuwa and Kyomo, 1971). The breeding goal was for cows to produce 2,300 kg of milk yield per 305-day lactation and for steers to reach a carcass weight of 230 kg in less than four years in low-input cattle production systems (Syrstad, 1990; Wilson, 2018). However, the set targets have not been realized, though the breed has been widely acknowledged by the community due to its disease resistance, and the ability of the bulls to be used for draught power (Komwihangilo *et al*., 2009). Ten years (1968) after declaration of Mpwapwa breed status, some Mpwapwa females were mated to Friesian, Ayrshire and Jersey bulls to produce a crossline and the

crossline females backcrossed to Mpwapwa bulls producing animals of various genetic background carrying from 3 - 88% Red Sindhi inheritance, 0 - 69% Sahiwal, 0 – 63% TSZ, 0 – 59% Boran and 0 – 34% *Bos taurus* (Mchau, 1988; Syrstad, 1990; Mkonyi, 1982).

Despite the breeding programs used to increase population of Mpwapwa breed cattle the total population has never grown above 1000 and most of these have been kept on the station of origin and some government stations with few individuals escaping into individual farmer households (Wilson, 2021). The low population of Mpwapwa cattle (<1,000) had led the Food Agriculture Organization of the United Nations (FAO) to characterize Mpwapwa cattle breed as being at risk of extinction (Rege, 1999; Scherf, 2000). Furthermore, there is scarce detailed or comprehensive baseline information of productive and reproductive performance of Mpwapwa cattle and their crosses at the nucleus breeding center, TALIRI Mpwapwa. Therefore, the aim of this study was to assess the productive and reproductive performances of Mpwapwa cattle breed and its crossbreed reared at Tanzania Livestock Research Institute (TALIRI). This information could serve as the basis for the exploitation of genetic potential to further advocate utilization of this breed.

METHODOLOGY

Description of the Study Area

Data for the current study originated from cattle reared at the Tanzania Livestock Research Institute (TALIRI) Mpwapwa, Tanzania. TALIRI farm is located at 1,100 m above sea level in the semi-arid zone of central Tanzania. The climatic seasons are divided into the wet (December to June) and dry season (July to November) with average annual rainfall of 660 mm, of which more than 90% falls between December and April. The area has a mean daily temperature of 26 °C, with the minimum temperature of 13.8 °C in August and a maximum of 30.2 °C in November.

Study design

The current study ran from December 2021 to April 2022 involved retrospective study design at TALIRI center. Data of individuals' animal performances of productive and reproductive for five consecutive years (2015 to 2019) were retrieved from farm records and used in this study. This study was granted ethical clearance certificate No. TLRI/RCC.21/008 by The United Republic of Tanzania Ministry of Livestock and Fisheries, Tanzania Livestock Research Institute.

Study animals and their management

A total of 295 cows with 885 lactation records were included in this study. The dataset consisted of Pure Mpwapwa breed (92), Mpwapwa-Boran cross of 50% (106), Mpwapwa 75%-Boran 25% cross (13), Mpwapwa-Sahiwal-Boran cross (72) and Danish red-Mpwapwa of 50% (12) cross. All animals were grazed on natural pastures consisting mainly of *Brachiaria brizantha, Cynodon dactylon, Panicum maximum, Cenchrus ciliaris Heteropogon contortus, Hyparrhenia* spp and *Chloris gayana.* Livestock health management included control of parasites and diseases through dipping (once per week), deworming, and regular vaccination against endemic diseases were practiced. The production seasons were divided into dry and wet season running from July to November and December to June respectively with natural service as a breeding practice. Lactating cows were milked twice per day and were given certain amount of farm made concentrates mainly composed of maize bran, minerals and sunflower or cotton seed cake in the course of milking. The restricted suckling method was applied until weaning age at of 90 days (3 months).

Data collection

Productive and Reproductive data of 295 cows for five consecutive years (2015 to 2019) were extracted and compiled from records kept on each individual animal record and field books. The records included identification number, date of birth, calving dates, and insemination season and pregnancy percentages. Records of milk yield produced during the whole lactation period were also transcribed from individual cow records. From the collected information, the following variables of interest were derived; age at first calving (AFC), calving interval (CI), pregnancy percentage (PP), lactation length (LL), average milk yield per day (AMYD), and total lactation milk yield (TLMY). The traits

studied were defined and described by Miah *et al*. (2018) and Hagan *et al*. (2022) as whereby age at first calving is the age a cow had its first calf expressed in months, calving interval is the time interval between two successive calvings expressed in months, lactation length is the length of time of milking after calving expressed in days, average milk yield per day is the average milk yield per cow per day recorded during the lactation period expressed in kilograms, total lactation milk yield is the total amount of milk produced expressed in kilograms per cow per lactation length, and pregnancy percentage is the percentage of cow that are pregnant at three months of pregnancy per number of cows inseminated.

Data management and analysis

The collected raw data were entered into an Excel sheet, cleaned, coded, imported and analyzed using a Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistical analysis was conducted to compute frequency and percentages for the qualitative data, mean and standard deviation for the quantitative data Furthermore, ANOVA table was used to examine differences between levels of significance between the variables. Differences were considered to be significant at the level $p<0.05$.

RESULTS

Out of 885 calves born during the five years under this study, 52.1% (n = 461) were males while 47.9% (n = 424) were female calves. Of the calve born, 31.19%, %, 35.93%, 24.41%, 4.41 % and 4.06% were Mpwapwa breed (MPW), Mpwapwa50%-Boran50% (MB), Sahiwal-Mpwapwa-Boran (SMB), Mpwapwa75%-Boran25 (MP3/4B1/4) and Danish Red 50%-Mpwapwa50% (DRMPW) respectively. Majority of calves 73.22% were born in dry season whereas the remaining 26.78% were born in wet season. The mean TLMY and AMYD, in liters, obtained in this study was 667.18± 397.11 and 2.65±1.12 (Table 1). Significant difference ($p < 0.05$) in TLMY was found between Danish Red-Mpwapwa with other group where Danish Red-Mpwapwa had higher TLMY compare to other groups and no significance difference was observed among other groups.

The overall lactation length in days was found to be 237.72±71.20 (Table 1). There was no significance ($p >0.05$) difference in lactation length among pure Mpwapwa breed, Mpwapwa-boran cross, Sahiwal-Mpwapwa-boran and Mpwapwa3/4-boran1/4. But significance difference ($p < 0.05$) was found between Danish red-Mpwapwa and other groups except for Mpwapwa3/4-boran1/4, whereas Danish red-Mpwapwa cross had longer lactation length compare to other groups. Effect of seasonal birth of a cow was found to be significance ($p < 0.05$) in Mpwapwa-boran cross and pure Mpwapwa breed whereas cow born in dry seasons had higher lactation length compare to those born in wet season. Impact of age of the cow was significance ($p < 0.05$) in Danish-red-Mpwapwa where cows of lower age at first calving had higher lactation length compare to those which had their first calving late. The overall Lactation length increased with parity up to fourth parity which then remained relatively constant up to the eighth parity and then drop.

Though there was non-significance difference in lactation length between lactations in wet and dry seasons, there was a slightly increase in lactation length in those that commenced in dry season (Mpwapwa, Sahiwal-Mpwapwa-Boran, Mpwapwa3/4-Boran1/4) compared to wet season. However, the overall mean total milk yield since was slightly higher for cows lactated during wet season compared to dry season (Mpwapwa) (Table 2).

Season of calving was also found correlated with its lactation length as it is slightly high in cows calved in dry compared to wet season (Mpwapwa, Mpwapwa-Boran, Mpwapwa3/4-Boran1/4). Unlike commencement lactation season, dry seasonal birth of the cow is associated with non-significance increase in total lactation milk yield (Mpwapwa, Mpwapwa-Boran) (Table 1). The overall mean age at first calving was38.5±5.9 month with a range of 30 months to 72 months (Table 1). The age of first calving was significantly different ($p < 0.05$) between pure Mpwapwa breed and Mpwapwa-Boran cross. The average calving interval of cows in this study was 19.92±5.64 months with the range of 12 to 24 months and 24 months as CI mode and median although there was slightly high CI for parity 1&2 compare to cows with ≥2 parities, this difference was not significant. The significance difference (*p*

$p < 0.05$) in calving interval was found among pure Mpwapwa breed with Mpwapwa-Boran, Mpwapwa-Sahiwal-Boran, and Danish red-Mpwapwa. The calving interval observed was in the following order of increasing; Danish red-Mpwapwa, Sahiwal-Mpwapwa-Boran, Mpwapwa-Boran, Mpwapwa3/4-Boran1/4 and top for pure Mpwapwa breed.

The overall pregnancy percentage which was diagnosed through per rectal palpation 3 months later after mating season was 29.1%±14.4% with non-significance high pregnancy percentage in dry season compare to wet season (Table 3). The pregnancy percentage was significance difference ($p < 0.05$) between 2015 and 2019 and between 2018 and 2019 where in 2019 the pregnancy percentage was the lowest compared to other years and no significance ($p > 0.05$) difference was observed per breeds.

Table 1. Means and standard deviation of AFC, CI, TLMY, AMYD and LL of pure Mpwapwa breed and its cross kept at TALIRI

BREED AND CROSSBRED	AFC (Months)	CI (Months)	TLMY (Kilograms)	AMYD (Liters)	LL (Days)
MPW	39.72±60[a]	21.72±4.68[a]	670.92±356.85[b]	2.70±0.97	241.54±69.61[b]
MB	37.56±5.76[b]	18.96±6[b]	615.20-372.46[b]	2.51±1.09	230.97±71.19[b]
SMB	38.88±6.12[ab]	18.72±6[b]	657.79±438.42[b]	2.56±1.25	234.28±74.23[b]
MP3/4B	36.48±5.76[b]	20.04±6.24[ab]	677.82±380.15[b]	2.65±1.06	241.46±70.50[ab]
DRMPW	36.48±3.12[b]	15.48±5.88[b]	1142.29±360.25[a]	3.93±.92	284.5±48.01[a]

Values in the same column with different letters in the superscript were significantly different ($p<0.05$), while number with at least one same leters did not differ significantly. *****AFC, age at first calving; CI, calving interval; TLMY, total lactation milk yield; AMYP; average milk yield per day; LL, lactation length; MPW, Mpwapwa breed; MB, Mpwapwa-Boran; SMB, Sahiwal-Mpwapwa-Boran; MP3/4B, Mpwapwa3/4-Boran1/4; DRMPW, Danish red-Mpwapwa.

Table 2. The overall mean total lactation milk yield and lactation length of Mpwapwa breed and its crossbreed

Character	Parameter	Season	
		Dry (july-nov)	Wet (dec-june)
Seasonal birth of a cow	TLMY (kg)	692.12	613.83
	LL(days)	244.19	223.86
Milk production commencement	TLMY (kg)	662.41	680.19
	LL (days)	240.7	229.54

Table 3. The means of pregnancy percentage of Mpwapwa breed and its crossbreeds

	Dry (%)	Wet (%)
MPW	29.32%± 10.11%	23.84%±9.72%
MB	38.10% ±19.89%	33.20%±12.04%
SMB	30.48%±18.10%	32.86%±17.63%
M3/B4	27.24%±19.38%	30.28%±6.39%
DRMPW	22.02%±11.10%	20.28%±17.86%

*MPW = Mpwapwa Breed; MB = Mpwapwa-Boran; SMB = Sahiwal-Mpwapwa-Boran; M3/B4 = Mpwapwa3/4-Boran1/4; DRMPW = Danish red-Mpwapwa, SD=Standard deviation

DISCUSSION

Total lactation milk yield (TLMY) is the measure of total volume of milk produced in kg in the whole lactation length of a cow and is among major measure of lactation performance in dairy industry. Genetics, nutrition, management, lactation age, climate (M'hamdi *et al.,* 2012), parity (Manzi *et al.,* 2020) and state of pregnancy (Mwatawala, 2006) are the factors affecting TLMY. Mean TLMY observed in this study was 667kg which is less compare to the previous mean TLMY reported at TALIRI in year 1966 which was 1879kg for the 1st-3rd lactation of Mpwapwa breed (Katyega, 1987), 1072kg from 1st to 9th lactation of Mpwapwa breed in 1980's (Mchau, 1988) as well as 1480kg average TLMY of Mpwapwa breed for the period of 1967 to2013 (Chawala *et al.,* 2017).

However, the present results are similar to that reported at TALIRI during 1995 (Chawala *et al.,* 2017). The disparity in total milk yield of Mpwapwa breed may be as a consequence of genetic, environment and interaction of both genetic and environmental factors. Infusion of further European blood (new genetics) and Sahiwal breed (Wilson, 2021) are genetic factor affecting the milk production performance of Mpwapwa breed at different years. Others could be environmental factors such as level of management; climatic condition, season of production; parity and age of the cow play a major role in overall total milk production performance. Furthermore, diverse restrictions on LL for records included in the study (Srystad, 1990) such as an increase in number of LL are associated with an increase in TLMY (Ngongoni *et al.,* 2006; Chenyambuga and Mseleko, 2009). The mean TLMY of the current study is also lower than; 2000-2500kg of most tropical crossbreed (Michael *et al*., 2021), 1654kg and 1729kg of Ayrshire and Friesian crossbreed at Kilolo district (Mgeni, 2010),4495kg and 3228 kg of cross breeds in smallholders and medium farms in Morogoro municipality (Ngou and Kashoma, 2015), and out of the range of 1,000 to 2,477 kg reported for improved zebu in the tropics (Cunningham and Syrstad, 1987) Nevertheless, our findings are within the range of300 to1100 kg of milk obtained from indigenous breeds in the tropics (Rege *et al.,* 2001; Tadesse and Dessie, 2003).

Lactation length (LL) refers to the period in days in milk production from calving to the time of drying off. Lactation length is affected by both genetic and non-genetic factors. The mean LL obtained from the current study was 237.72 days which is less compare with; 288 days of Mpwapwa breed reported by Katyega, (1987), 271.4 days of Mpwapwa breed obtained by Chawala *et al.* (2017). However, our LL finding is similar to 228 days of Mpwapwa breed (Das *et al.,* 1999), but higher than 209 days of Mpwapwa breed (Mchau, 1988) both on previous studies at TALIRI and less than 300 days of Mpwapwa breed on farm studies (Rushalaza and Kasonta, 1993). The possible reason for variation in LL might be due to management factors including nutrition, genetic background, climate of the year, season of calving, lactation number and age of cow. The mean LL obtained from the study had shorter LL than crossbreed cattle in most parts of Tanzania including; 258 – 288 days (Chenyambuga and Mseleko, 2009) and 333.3 ± 26.7 days Ngou and Kashoma, (2015). This is mainly due to the effect of genetic factor as *Bos taurus* has significant large LL compare to *Bos indicus* and thus crossbreeding results into increase in LL of crossbreed cows (Bee *et al.,* 2006; Galukande *et al.,* 2013; Osei-Amponsah *et al.,* 2020). The short LL of the current study result into long dry period which is unproductive since an increase in number of LL is associated with an increase in TLMY (Ngongoni *et al*., 2006; Chenyambuga and Mseleko, 2009).

Age at first calving (AFC) has impacts to both productive and reproductive life of the female directly through lifetime calf crop and milk production and indirectly through its influence on cost invested in for up-bringing (Gebrekidan *et al*., 2012). It is affected by nutrition, year and month of birth (climate) (Kelay, 2002), breed (genetic) and management. The AFC of the present study was 38.5 months which is high compare with; 32 months of Mpwapwa breed reported by Chawala *et al*. (2017) but low compare with 40.2 months of Mpwapwa breed (Katyega, 1987) and 49.4 months of Mpwapwa breed by Mkonyi (1982) from TALIRI and is also high than the range of 31.3-36.6 months of tropical crossbred heifers (Asimwe and Kifaro, 2007; Yifat *et al.,* 2009).

This difference is attributed most from non-genetic factors including poor nutrition and management as AFC trait has low heritability. Breed differences account for only about 1 to 8% of total variation in AFC (Mchau, 1991). AFC determines the beginning of the cow's productive life and influences her life time productivity (Ojango and Pollott, 2001) and hence high AFC of the current study is associated with poor productivity in both productive and reproductive traits.

Calving interval has two basic components: calving-to-conception interval (days open), which is the most important component determining the length of the calving interval, and gestation length, which is almost constant. (Mukasa-Mugerwa *et al*., 1991). The general calving interval of this study was 19.9months with the range of 12-24 months. The CI obtained in this study is high compare with; 14.5 months of Mpwapwa breed (Katyega, 1987), 17.6 month of Mpwapwa breed (Chawala *et al*., 2017) 15.9 months of Mpwapwa breed (Das *et al*., 1986) and 16 months of Mpwapwa breed (Syrstad, 1990) from on station. Long CI is associated with poor reproductive health such as; the ability of the cow to resume regular ovarian cyclicity after calving and display an overt heat signs, poor conception rate and the effect of bull ability used. The current study results for CI is also high compare to 402 to 480.4 days recounted by previous studies of cross breed in Tanzania (Asimwe and Kifaro, 2007; Chenyambuga and Mseleko, 2009). The current study showed that CI is twice that of LL which inferring that there is a long period when cows were neither lactating nor pregnant and, thus not productive and hence increase the cost of production.

Pregnancy percentage refers to the success rate for getting pregnancy from all attempts that leads to pregnancy. The overall pregnancy percentage obtained from the current study is very low which is29.1%±14.4%, which is low compare to 49% of Mpwapwa breed (Kabuni *et al*., 2022),52-87% of Mpwapwa breed reported by Kabuni and Laven, (2021). This difference may be due to assumption of bull fertility together with soundness and ignoring examination of bull prior use, ratio of bull to cows, failing to cull animal which do not meet required standard on farm due to low number of animals, and poor management practice on breeding herd.

The current study showed that the productivity and reproductivity of Mpwapwa breed kept at TALIRI, Mpwapwa nuclear center is currently low compared to the previous records when the breed was established. Thus, we recommend for proper and systematic scheduling of genetic improvement program, management practice and breeding scheme for further improvement of animals in terms of production and reproduction traits of the Mpwapwa cattle breed to meet the targeted purposes.

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CONFLICT OF INTEREST DECLARATION

The authors of this paper declare that there is no conflict of interest. They confirm that the order of listing authors has been agreed by them and the manuscript has been read and approved by all authors.

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