COMPARATIVE ASSESSMENT OF PRODUCTIVE AND REPRODUCTIVE PERFORMANCES OF MPWAPWA BREED CATTLE AND ITS CROSSES

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQIREMENTS FOR MASTER DEGREE IN ANIMAL REPRODUCTION AND BIOTECHNOLOGY OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO.

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EXTENDED ABSTRACT

Mpwapwa breed, an Indo-African composite dual-purpose cattle, is suitable for production in medium to low input production systems, established in Tanzania in 1960s with the breeding goal of 2,300 kg milk yield per 305-day lactation length and for steers to reach a carcass weight of 230 kg in less than four years. This breed is currently faced with slow country-wide distribution which may be associated with many factors including scarcity comprehensive baseline information on productive and reproductive performances of animals, diseases, management practices and government policy. Therefore, the aim of this study was to assess the productive and reproductive performances of Mpwapwa cattle breed and its crosses reared at the nuclear breeding center, Tanzania Livestock Research Institute (TALIRI), Mpwapwa and under low in-put smallholder farmers around Mpwapwa district. A retrospective study of five consecutive years (2015 - 2019) involving 295 cows reared at TALIRI and a cross sectional study involved 986 cows kept by 100 householders in seven administrative wards of Mpwapwa district were used in this study. In retrospective study, individual animal records including date of birth, calving dates, insemination records, pregnancy rates (PR), lactation length (LL), average milk yield per day (AMYD), and total lactation milk yield (TLMY) were captured. For smallholders, the questionnaire captured socio-demographic characteristics of farmers, animals' lactation length, average milk yield per day, number of services per conception (NSC), age at first heat, age at first calving, calving interval and major animal reproductive problems. Results from the animals kept at TALIRI revealed an overall mean of AFC, CI, PR, LL, AMYD and TLMY of 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 for AFC, CI, LL and TLMY showed significance difference ($p < 0.05$) between Mpwapwa breed cattle and its crosses. However, PR results did not show significance difference ($p > 0.05$) between Mpwapwa breed and its crosses. For smallholders, majority of respondent (>94%) were married males, having primary education (66%), had over 15 years of experience of keeping livestock (76%) and keeping more than 20 Mpwapwa cattle breed (76%) for different motives such as economic enterprise, supplementary enterprise, home milk consumption and hobby. Recorded average productive and reproductive performance of animals in low-input production system were; 332 ± 16.7 days of lactation length, 3.08±1.11 liters of average milk yield per day, 17.5±6.6 months of calving interval, 32.3±8.21 months of age at puberty, 44.04±6.49 months of age at first calving,

1.23±0.14 of average number of services per conception. Major animal problems reported were calf mortality of (17.0%), retained fetal membrane (24.0%), anestrous (20.0%), abortion (17.0%), endometritis (12.0%), repeat breeding syndrome (9.0%), dystocia (8.0%), pyometra (5.0%), uterine (3.0%) and vaginal prolapse (2.0%). It is concluded that reproductive and productive performance of Mpwapwa breed cattle and its crosses reared at the nuclear breeding center as well as under smallholders were lower as compared to the target goal set in 1960s when the breed was established. Therefore, there is a prudent need for improvement of management practices both at TALIRI as well as at smallholders so as to optimize the reproductive and productive performances of the Mpwapwa cattle; an Indo-Euro-African synthesis.

DECLARATION

I, **Mercy Maxwell Mabruck,** do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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DEDICATION

To my adorable parents

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LIST OF ABBREVIATIONS

AFC	Age at First Calving
AMYD	Average Milk Yield per Day
AP	Age at Puberty
CI	Calving Interval
DRMPW	Danish Red- Mpwapwa
FAO	Food Agriculture Organization of the United Nations
LL	Lactation Length
MB	Mpwapwa-Boran
MP3/4B1/4	Mpwapwa ¾-Boran ¼
MPW	Mpwapwa breed
PR	Pregnancy Rate
SMB	Sahiwal-Mpwapwa-Boran
SPSS	Statistical Package for Social Sciences
TALIRI	Tanzania Livestock Research Institute
TLMY	Total Lactation Milk Yield
TSH	Tanganyika Shorthorn Zebu

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background

Tanzania has the fastest growing populations in the world with about 50 percent agriculture households depending upon livestock enterprises as major means of income generation (Msalya *et al*., 2017). Tanzania has approximately 33.94 million being second to Ethiopia in Africa for cattle population, accounting for 11% of the African cattle population and 1.4 percent of global cattle population cattle population (FAO, 2014; URT, 2022). Livestock related activities in Tanzania contribute towards attaining development goals of national Growth and Reduction of Poverty by 7.4% of Tanzania's agriculture gross domestic product (GDP) with about 2% of the GDP coming from dairy sector (URT, 2021). Nevertheless, livestock sector produces about 3.4 billion liters of milk consumed in the country of which 70% originating from the traditional sector (i.e. from indigenous cows), whereas the remaining 30% coming from the commercial farms (NBS, 2021). Similarly, 53% of meat consumed in Tanzania originates from indigenous cattle (Tanzania Shorthorn Zebu, Boran, Ankole and Mpwapwa breeds), while the remaining 47% of meat comes from poultry, pig, sheep and goats (MLFD, 2022)

Mpwapwa breed is a composite dual-purpose breed in Tanzania suitable for both milk and meat production in medium to low input production systems. Mpwapwa breed was established in 1960s (Kiwuwa and Kyomo, 1970) with the genetic constitution of Mpwapwa cattle consists of 32% Red Sindhi, 30% Sahiwal, 19% Tanganyika Shorthorn Zebu (TSZ), 11% Boran, and 8% Ayrshire (Kiwuwa and Kyomo, 1970). 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 of 230 kg in less than four years in low-input dairy production systems (Bwire *et al.,* 2005). Mpwapwa breed has been widely accepted by the community owing to its higher milk and meat yield than TSZ, disease resistance, and the ability of the bulls to be used for draught power (Komwihangilo *et al*., 2009). Despite of many efforts used to increase population of Mpwapwa breed cattle, the total population has never grown went above 1000 and most of these have been kept on the station of origin and some government stations with few individuals escaping into smallholder farmers (Wilson, 2021). Several challenges have faced the multiplication and country-wise distribution of the breed, and these include high mortality rate due to East Coast Fever (ECF) in 1990s, high turnover of animal breeding experts, and policy changes

(Wilson, 2009). The low Mpwapwa cattle population (<1,000 females) had led the Food Agriculture Organization of the United Nations (FAO, Rome) to categorize Mpwapwa cattle breed as being at risk of extinction (Rege, 1999; Scherf, 2000). However, multiplication efforts from 1999 onwards have increased the population of the breed owing to farmers' increased demand for the improved cows and bulls. These multiplications have lead crossing of Mpwapwa cows to bulls of different breeds such as Friesian, Ayrshire and Jersey producing crossline and the crossline females backcrossed to Mpwapwa bulls. These crossing and backcrossing produce animals of various genetic background carrying from 3 to 88 per cent Red Sindhi inheritance, 0 to 69 per cent Sahiwal, 0 - 63 per cent TSZ, 0 - 59 per cent Boran and 0 - 34 per cent *Bos taurus* (Mchau, 1988; Syrstad, 1990; Mkonyi, 1982).

1.2 Productive performances

1.2.1 Total lactation milk yield (TLMY)

Total lactation milk yield is among major measure of productive performance in dairy industry. It is the measure of entire amount of milk produced in kg in the whole lactation length of a cow. According to (Hudson *et al*., 2018), the peak milk yield usually occur 40-80 days post-calving in mature cows and then declines, whereas first lactating heifers tend to have typically much flatter lactation curves. Cows normally have a lactation curve that loses 8% to 10% per month after the peak and in rare cases some may lose 4% or less in which in this case make a longer calving interval acceptable (Esslemont, 2003).

Different factors are reported to affect the total lactation milk yield in cattle including feeds (quality and quantity), season, breed, age of animal, milking interval and frequency, and diseases (Naceur *et al.,* 2012). Primiparous cows tend to have the lowest milk production than multiparous cows (Migose *et al.,* 2006; Maximilian *et al.,* 2020; Mwatawala, 2006). Milk yield is also maintained longer at the maximum and falls more slowly when the cow is empty than when she is pregnant as a result of increase nutrients requirement for the fetal development and changes of hormonal profile (Abdalah and McDaniel, 2000; Mwatawala, 2006). The effect of season in milk production is seen in regions with unimodal rainfall distribution (Msanga and Bee, 2003) but not in bimodal rainfall distribution (Mwatawala, 2006). Lactation performance is also indirectly affected by year of calving due to larger variability of climatic conditions mainly rainfall which affect secondarily thorough feed availability (Udo, 1993). Good health and

freedom from diseases especially milk fever and ketosis optimize milk production also are associated with drop in milk yield (Mgeni, 2010). Increase in frequency of milking results into the increase of milk yield (Mwatawala, 2006), however unequal interval in milking results in less milk yield than those milked at equal interval (Stelwagen *et al.,* 2007). Poor nutrition result into low milk production (Mtui, 2004). Cattle breed is also reported to significantly affect lactation performance (Guo-li *et al.,* 2006) where *Bos Taurus* cattle tend to have higher milk yield as compared to *Bos indicus* (Systard, 1995). Incomplete milking for several consecutive days may also results into reduction in milk yield (Stelwagen, 2001).

Although indigenous TSHZ are tolerant to heat stress, disease, parasite resistance and hardy, their productivity are generally low with total lactation milk yield range 300 - 400 liter per lactation, (MLFD, 2015). Milk production has been re-counted to range from 2 to 3 liters per day in Zebu cows and 6 to 20 liters per day for developed crossbreed dairy cows (Epaphras *et al.,* 2004; Lyimo *et al.,* 2004; Kurwijila *et al.,* 2012). For Mpwapwa breed, daily milk yield of from 6kg to 9 kg and 1,800kg to 2,800 kg per lactation have been reported (Das et al., 1989)

1.2.2 Lactation length (LL)

The lactation length is another important measure of production performance of dairy industry. Lactation length is the period of time in milk production from calving to drying off which is usually expressed in number of days. Lactation length of 305 days is normally accepted as a standard in most dairy entities which reflects management practices designed to have animals concurrently pregnant and re-initiating lactation yearly (Syrstad, 1990). Longer lactation length above 305 days (10 months) can be accepted if milk harvesting is continued, this extended lactation period has practical implications to farmers as it provides benefit for the extended calving interval (Tamire and Enqueselassie, 2007). Nonetheless, the effectiveness of shortened as well as extended lactation length depends on lactation persistency.

Factors affecting lactation length include genetic background, environmental condition (climate, year and season of calving), management practice (nutrition and diseases occurrence) and state of animal (lactation number and age). Lactation performance traits are indirectly affected by year of calving through different in management practices, disease frequencies and variability in climatic conditions which results into

fluctuations in feed resources (Mchau, 1991). Lactation length increase with increase proportion of exotic blood in dairy cattle in the tropics (Systard 1995). A study conducted in North Showa zone showed that local breeds had shorter lactation length (273.9 days) than crossbreeds (333.9 days) (Mulugeta and Belayneh, 2013). Similarly, lactation length of 270 to 297 days have been reported in Mpwapwa breed cows (Das et al., 1989; Chawala et al., 2017), 288 days in Ayrshire x Boran crosses under smallholder production system of Tanzania (Chenyambuga and Mseleko, 2009), and 7.1 ± 2.8 months in Tanzania shorthorn zebu cows (Mwambene *et al*., 2012).

1.2.3 Dry period

Dry period is the period of time when the cow is not producing milk. It usually takes six to eight weeks before next lactation (kok *et al.,* 2019). The purpose of dry period is to give the epithelial cells within the mammary gland a rest and time to regenerate before the next lactation for optimum lactation performance in the next lactation (Kuhn *et al.,* 2005). Milk production in cattle reared under tropical conditions generally cease sever months before next lactation due to lower milk yield and thus shorter lactation length compare to temperate dairy breeds which milk yield is suppressed by advanced stage of pregnancy and some don't dry as expected and hence forced to dry off (Systard, 1990).Therefore, crossing native cattle with European breeds has resulted in cross breeds of longer lactation lengths and shorter dry periods (Mchau, 1991).

Drying-off is the process of allowing the udder pressure to reach the point at which milk secretion is stopped and eventually the remained milk in the udder is absorbed by the blood (Balikowa, 1997). The methods used for drying off are either gradual drying off (which may take few days to several weeks) or abrupt (which takes one day). However, there is no standardized drying off procedure to optimize welfare, udder health and milk production of a cow on the following lactation since the procedure depends on herd and cow characteristics/performance (Vilar and Rajala, 2020).

Optimum dry period length depends on breed, parity and farm management. Heifers are recommended to be milked for about 260 to 270 days and allowed a dry period of 90 to 100 days as they are expected to continue growing throughout their first lactation (Payne, 1990). Studies showed that reduction or absence of dry period results into the decrease in milk production and improving fat and protein content of the succeeding lactation (Remond *et al.,* 1997; Andresen *et al.,* 2005). Extension of dry period for > 70

days results into reduction of milk yield together with its component (Kuhn *et al.,* 2007) and beyond 100 days led to shorten lactation length hence total milk yield (Sawa *et al.,* 2012).

1.3 Reproductive performance

Reproductive performance in cattle is normally assessed by analyzing female reproductive characters (Aynalem *et al.*, 2011). Chief traits that are usually considered in evaluating reproductive performance are age at puberty, age at first calving, calving interval, days open and number of services per conception (Yifat, 2009; Aynalem *et al*., 2011). Optimal reproductive efficiency is necessary for efficient milk production and has an important influence on herd profitability (Pryce *et al*., 2004). In most modern dairies, the general practice is to breed cows early with the aim of creating a calving interval of 12 to 13 months, which is considered optimum.

1.3.1 Age at first calving (AFC)

Age at first calving is the period between birth of an animal to her first calving. It determines the beginning of the cow's productive life and influences her life time productivity (Ojango and Pollott, 2001). AFC has impacts to both productive and reproductive life of the female directly through its effect on her lifetime calf crop and milk production and indirectly through its influence on the cost financed for up-bringing (Gebrekidan *et al*., 2012).

Age at first calving in cattle is affected by nutrition, year and month of birth (Kelay, 2002). Farm size has been indicated to affect AFC in dairy cattle through different management practice. According to (Lemma Abate and Kebede, 2011) small and large dairy farms in Addis Ababa had longer (34.2 months) and shorter (32.6 months) AFC, respectively. Cattle breed is reported to affect age at first calving where local breeds tend to have high AFC compare to cross breeds cows (Mulugeta and Belayeneh, 2013), and Mchau, (1991) reported that breed differences account for about 1 to 8% of total variation in AFC. Hayatnegakar (1991) revealed significant differences in age at first calving between crossbred cattle with varying levels of *Bos taurus* inheritance by comparing Jersey x zebu crosses and Friesian x Zebu crosses with 50 and 75% exotic inheritance, where jersey x zebu were younger at first compare to Friesian crosses, with 50% cross shorter age at first calving compare to 75% in both crosses of jersey and Friesian breed. Mwatawala, (2006) observed that cattle born in dry summer season tended to calve for

the first time later than those born in the wet summer season, which is caused by the differences in availability of forages between seasons which affect their growth performances, nevertheless not all studies agreed with these findings as Kifaro, (1995) reported non-significant effect of season on age at first calving. Geographical location also contribute to variation in AFC which is attributed to livestock feeds, frequency of diseases and parasites (Pyena, 1990). The standard AFC for cow in tropical condition is reported to be 24 to 36 months as is associated with the highest in; first lactation yield, life time production and proportion of total life spent in active milk production (Wathes *et al.,* 2008). For Tanzanian cattle, various AFC have been reported ranging from 1057 – 1230 days in Friesian cows kept at Kitulo LMU (Kashoma *et al*., 2015), 38.4±0.5 months in Ayrshire and Boran crossbred cattle kept in smallholder farms in Mufindi district (Chenyambuga and Mseleko, 2009), 30.9 ± 0.8 months in cattle managed under smallholder and medium farms around Morogoro municipality (Ngou and Kashoma, 2015), 31.3 - 36.6 months in dairy cattle under smallholder production system in Bukoba District (Asimwe and Kifaro 2007), 32 to 49.4 months in mpwapwa breed (Chitawala *et al*., (2017); Katyega, 1987; Mkonyi (1982) and 50 ± 1.3 months in Tanzania shorthorn zebu/Fipa cattle (Mwambene *et al*., 2012).

1.3.2 Calving interval (CI)

The period between two successive calvings is called calving interval (Mulugeta and Belayeneh, 2013). CI is the best indicator of cattle reproductive efficiency (Karume, 2013). It is the period between successive parturitions and is a function of postpartum anestrus period (from calving to first estrus), service period (first postpartum estrus to conception) and gestation length (Tewodros, 2008). According to Mukasa-Mugerwa *et al*, (1991), CI has two basic components: 1) calving-to-conception interval (days open), which is the most important component determining the length of the calving interval, and 2) gestation length, which is more or less constant, varying slightly due to breed, calf sex, litter size, dam age, year and month of calving, and little can be done to significantly manipulate the gestation length. The calving to conception interval itself is influenced by cow and management/environment-related factors, such as method and efficiency of heat detection, type and efficiency of breeding service and the ability of the cow to resume regular ovarian cyclicity after calving, display an overt heat signs, and conceive with the given service. In general, CI is influenced by nutrition, season, milk yield, parity (Meikle *et al*., 2004).

Calving interval is an important factor in measuring the breeding efficiency and directly correlates with the economics of milk production. Estimates of calving interval in zebu cattle range from 12.2 to 26.6 months (Mukassa-Mugrewa, 1989; Gebrekidan *et al*., 2012). CI is a fertility trait that can be used in selection programs to minimize the negative effects that selection for production have on fertility (Mostert *et al.,* 2010). Effect of parity was reported by (Giday, 2001), however, others (Agyemang and Nkhonjera, 1990; Haile-Mariam and Mekonnen, 1996) reported non-significant effect of parity on CI. The longer calving interval in younger cows might be due to higher nutrient requirement for growth in addition to milk production and maintenance thus delays the onset of postpartum heat. Various values of CI have been reported in Tanzanian cattle including 401.9 ± 15.4 days in Ayrshire and Boran crossbred cattle kept in smallholder farms in Mufindi district (Chenyambuga and Mseleko, 2009), 477 (335±860) days in dairy cattle kept in smallholder herds in a rural highland area of northern Tanzania (Kanuya *et al*., 2000), 15 to 18 in Mpwapwa cattle breed and its crosses kept at different production systems (Komwihangilo *et al*., 2009; Rushalaza and Kasonta, 1993; Chawala *et al*., 2017), 17.6 ± 5.1 months in Tarime Zebu Cattle (Chenyambuga *et al*., 2008) and 15.5 ± 0.6 months in indigenous Tanzania shorthorn zebu (Fipa cattle) in three districts of southwestern highlands of Tanzania (Mwambene *et al*., 2012). The "days open" period should not go beyond 80 to 85 days if a calving interval of 12 months is to be attained (Kanuya and Greve, 2000)

1.3.3 Days open (DO)

Days open is the period between calving and conception in cows (Tewodros, 2008) it also called calving-to-conception interval. Days open is influenced by the length of time for the uterus to completely involutes, resumption of normal ovarian cycle, occurrence of silent ovulation, accuracy of heat detection, management, semen quality and skill of inseminator or efficiency of bull (Yosef, 2006; Melaku *et al*., 2011), and diseases (Maizon *et al*., 2004). Days open affect lifetime production and generation intervals, and hence the annual genetic gain (Yosef, 2006). As is recommended that for 12 months calving interval target, the days open period should not exceed 80-85 days (Kanuya and Greve, 2000). However, differences in DO been observed and associated with many factors including genetic background, parity, body weight at calving, poor nutrition during post-partum period, milk yield or management factors such as ability of farmers to detect heat signs after calving (Mejia et al., 1998; Sanh *et al*., 1995; Ngou and Kashoma, 2015; Kashoma *et al*., 2015). Parities have influence on DO as it has been observed that cows

in parity one had the highest mean DO followed by those in second, third and the fourth parities (Asimwe and Kifaro, 2007; Tadesse *et al*., 2010; Kashoma *et al*., 2015). In early lactations, first calving heifers experience physiological changes permitting the first calvers to put on weight prior to next calving because at the beginning of lactation have high nutrition demands for growth, milk production and reproduction (Mwatawala, 2006).

1.3.4 Number of services per conception (NSC)

Number of services per conception refers to the number of services either natural or artificial that are performed to obtain successful conception (Mukassa-Mugrewa, 1989). NSC depends largely on the mating system being practiced, it is always lower under uncontrolled natural breeding and higher where hand mating or artificial insemination is used (Mukasa-Mugrewa, 1989). Factors affecting NSC mainly are the reproductive health status of the animal, breeding system used, the management practices in a farm and the semen quality (Tewodros, 2008). Elevated temperatures during summer months could well have attributed to the increased services per conception (Rajan *et al.,* l98l; Jassim, 1982). Moderate atmospheric temperatures and abundant green folder during spring are probably responsible for the improvement in services per conception. Number of services per conception displayed a highly significant annual variation due to annual changes in atmospheric conditions, quantity and quality of feeds available and differential management practices followed over the years (Jajo, 1984). Several findings on NSC have been reported in Tanzania including 2.7± 05 and 2.1 ± 0.7 in smallholders and medium farms, respectively in Morogoro municipality (Ngou and Kashoma, 2015), 1 to 3 in cattle crossbreeds kept in different production systems (Kanuya *et al*., 2000; Asimwe and Kifaro, 2007: Chenyambuga and Mseleko, 2009), 1.53 and 1.71 in naturally and artificially inseminated, respectively Boran cattle kept under ranch conditions in Tanzania (Mwatawala and Kifaro, 2009).

1.4 Reproductive health problems

1.4.1 Abnormalities in pregnancy development.

Gestation is the period of time that a female is pregnant. Mammalian embryonic development is a complex process, involving delicate synchronization of numerous events. To calf a normal offspring, these events should be sequential followed and regulated so as to archive normal pregnancy development and to produce a normal offspring, unless that there will be abnormalities of developing fetus and may even cause death of fetus and complications on dam. Causes of abnormalities that occur during

development in pregnancy can be grouped to those that are due to genetic, environmental and genetic environmental interaction. Such factors include; genetic disorders, genetic environment interaction, chemical toxicities, nutrients deficiencies, maternal infections, and physical conditions such as heat can alter fetal morphology or subsequent function (Noakes *et al.,* 2009).

The embryo is most susceptible to teratogenicity agents during periods of rapid differentiation. Many chemical agents have been subjected to investigation for detrimental effects on the embryo or fetus during pregnancy; including cosmetics, food additives, fungicides, herbicides, insecticides, pesticides, and other agricultural chemicals, as well as environmental contaminants, drugs, hormones, and vaccines. (Noakes *et al.,* 2009).

Disastrous insults of fetal growth later in gestation may present as abortions, fetal mummification, stillbirth, or neonatal mortality. Nonlethal aberrations may lead to lowered viability at birth, possibly accompanied by congenital abnormalities with grossly visible lesions that may suggest damage occurring during a particularly vulnerable period of fetal development and growth. It is now well understood that infection of a pregnant ruminant with a teratogenic arbovirus induces various lesions of the developing fetal nervous system once the fetus has commenced development of an immunological capacity at the end of the first trimester (Noakes *et al*., 2009). The lesions produced are dependent on the stage of development of the fetus, for example, in cattle in Australia, Akabane virus (AKAV) induces hydranencephaly at the end of the first trimester, followed by arthrogryposis in midgestation, whereas bovine viral diarrhea virus (BVDV) may induce cerebellar dysplasia from infection of the CNS in midgestation (Kirkland *et al.,* 1988). Nevertheless, if the agent only induces harm in the developing embryo when aligned with maternal nutritional deficiency or excess or some other maternal physiological disturbance, then identifying the aetiology of the loss or congenital disorder may become very complicated.

1.4.2 Abortion

All cases where the pregnancy terminates early and the fetus is expulsed are called abortion. There are a number of causes of abortion both infectious and miscellaneous. According to Hovingh (2009) infectious agents causing abortion includes; bacteria, viruses, protozoa and fungi, others are genetic abnormalities, toxic agents and heat

stress. Mastitis (Santos *et al.,* 2003) and twin pregnancies (Nielen *et al*., 1989) are also reported as causes of abortions. Among most infectious causing abortion includes; Brucellosis, Trichomoniais, Vibriosis/Campylobacteriosis, Mycosis, Salmonellosis, Lesteriosis and Leptospirosis. Infectious agent are the main causes of abortion in cattle as compared to non-infectious causes. Abortion is a serious threat to livestock, and it is also a public health issue as it is often induced by zoonotic microorganism (Benkirane *et al.,* 2015). It has been suggested that an abortion rate of 5% and more in a herd is considered an indication of abortion problem (Deas, 1981).

1.4.3 Calf mortality

Calf mortality is one of the major constraints to herd growth and genetic upgrading in the dairy sector. Studies of calf morbidity and mortality in Africa indicates high calf loss in both market-oriented and subsistence dairy production systems where studies of calf mortality on smallholder farms indicate pre-weaning and early post-weaning mortality rates in the range of 15% to 25% (Fentie *et al*., 2020). In Tanzania, calf mortality rates range from 9% to 45% have been reported (Changa *et al.,* 2010). Both infectious and noninfectious causes contributed to the mortality of the calf. Calf diseases that cause morbidity and mortality are the results of the complex interaction of the management practices, the environment, infectious agents, and the animal itself. Mortality of neonates was mainly attributed to conditions such as diarrhea and pneumonia associated with poor housing, hygiene, and nutrition (Lema *et al.,* 2001). Generally, more than 64% of calf mortality occurred within one month of age, and about 50% mortality occurred in the first week of life (Fentie *et al*., 2020). Calves may also be vulnerable to environmental stress at an early age. The high mortality of calves during the first month of age suggests that there should be given more attention to calf management in the first few weeks of life. Debnath *et al*., (1995) reported sex influence on calf mortality with high incidence of male calf mortality compared with female calf. Good calf rearing is important as it ensures availability of good future replacement stock.

1.4.4 Prolapse of the cervix and vagina

Cervical and vaginal prolapse (CVP) is a disorder of ruminants, normally in late gestation, rarely seen after parturition and hardly occurs unconnected with pregnancy or parturition. It can be recognized by the protrusion of varying parts of the vaginal wall and sometimes the cervix through the vulva, so that the vaginal mucosa is exposed (Noakes *et al*., 2009). The exact cause of the disorder has not been ascertained but several

factors are generally believed to play a part. Such factors include; inefficiency in anatomical anchorage of the genital tract in some breeds example Hereford cattle (Woodward and Queensberry, 1956), excessive fat deposition in the perivaginal connective tissue and ligamentous relaxation due to a state of endocrine imbalance in which estrogenic hormones predominate, mechanical factors, such as the increasing intraabdominal pressure of late pregnancy and gravity acting through the medium of a sloping byre floor when cattle are tethered, are considered to be significant (McLean and Claxton 1960), severe straining in response to vaginal trauma or infection after a serious dystocia and inheritance of CVP. Initially, the lesion involves a protrusion of the mucous membrane, more frequently the floor of that part of the vagina that lies just cranial to the urethral opening. In severe cases the whole of the anterior vagina and cervix may protrude eventually even the rectum may become everted. The protruding tissues, with their circulation impaired, are prone to injury and infection. Thrombosis, ulceration, and necrosis of the prolapsed organ, accompanied by toxemia and severe straining, lead to anorexia, rapid deterioration in bodily condition, and occasionally death and significant fertility reduction in cattle (Patterson *et al.,* 1981). Uterine prolapse is regarded as an emergency condition, and it should be managed before excessive oedema, mucosa trauma, contamination and fatal haemorrhage could lead to a poor prognosis (Miesner and Anderson, 2008). If prompt attention is given, simple measures often succeed. (Noakes *et al*., 2009).

1.4.5 Dystocia

A normal birth occurs when the expulsive forces are sufficient to propel a fetus of normal size and disposition through a birth canal of adequate size. Dystocia occurs when any of these are abnormal or insufficient. Thus, the causes of dystocia can be considered in terms of the: Expulsive forces, Adequacy of the birth canal, Size and disposition of the fetus. Defects of the expulsive forces and of the adequacy of the birth canal are commonly referred to as maternal dystocia, whereas those due to defects of the presentation of the fetus or to its disproportion (i.e., with respect to the size of its dam) are known as fetal dystocia (Noakes *et al.,* 2009). Abnormalities of any part of the reproductive tract (birth canal) structures can lead to dystocia. Such abnormalities include function disturbances of the genitalia (e.g., incomplete cervical dilation; torsion of the uterus), obstructions (e.g., neoplasia), or mechanical abnormalities (e.g., double cervix; remnants of the paramesonephric ducts). Rarely, the uterus can be displaced into a subpubic position or through a hernia in the abdominal wall. Abnormalities of the

surrounding tissues can, likewise, lead to dystocia. Such tissues include the pelvis (e.g., heritable pelvic malformation such as occurs in Belgian Blue cattle; fractures of the pelvic bones; sacroiliac dislocation), the bladder (e.g., prolapse into the vagina), or excess intrapelvic fat (Noakes et al., 2009). The most common cause of dystocia in cattle is feto-maternal disproportion, with faulty disposition of the fetus being the next most common in both beef and dairy cattle (Citek *et al.,* 2011). Feto-maternal disproportion is more common in heifers than in multigravida cows (Zaborski *et al.,* 2009). The risk of dystocia is consistently higher in primiparous than multiparous cows. Edwards, (1979), found that dystocia was more common in heifers than multiparous cows, such that there were 66.5%, 23.1%, and 14.3% assisted deliveries in first, second, and third calvings respectively. Many subsequent studies have confirmed this trend (Mee *et al.,* 2011). Some breeds are more at risk of dystocia than others: large, or 'double muscled' beef breeds, Holstein heifers is worryingly high, with figures of 17%, 21%, 22%, and 40% of all primiparous births requiring assistance (Mee *et al*. 2011). Various authors have shown that heifers, which are older at their first calving, have a reduced risk of dystocia (Hickson *et al.,* 2009) than those which are younger, although it may be that as age increased beyond an optimal point the risk of dystocia increases. According to (Mushonga *et al*., 2017) the statistical analysis of data showed high incidence of dystocia of 16.67% in artificial inseminated cows than those served by bulls which is 4.96% ($p<0.05$) this may be due to the use of semen from high weight bull for small weight breed cows of a study animals, also higher incidence of dystocia in cow carring male calves (11.54%) than those carrying female calves (6.80) which is simirally to other studies of (Johanson *et al.,* 2011; McDermott *et al.,*1992) due to the difference in male and female calf weights at parturition. There is no significant difference in dystocia between breeds however, dystocia was high in cross breed of cows when compare with local and exotic breed of dairy cows (Yohannes *et al.,* 2018).

In principle, this dystocia can be delivered by correction of the fetal disposition or delivery by traction, with fetotomy or Caesarean surgery. The consequences of dystocia are numerous, ranging from increased stillbirths and perinatal mortality to severe trauma to the offspring or its mother.

1.4.6 Retained fetal membrane

Retained fetal membrane also known as retained placenta, or retained cleansing occur when the calf's side of the placenta fail s to separate from the mother's side. Separation normally occurs after the calf is born and early separation is usually one of the causes of

stillbirth. Retention of fetal membrane usually is defined as a failure to expel fetal membranes within 24hr after parturition whereas normal expulsion occurs within 3-8hrs after parturition. Cows with retain fetal membranes are at increased risk of delayed uterine involution, increased days open, increased services per conception, increased CI, decrease pregnancy rate (Stevens and Dinsmore, 1997), developing metritis, ketosis, mastitis, and even abortion in a subsequent pregnancy which in turn lead to decreased fertility and potential losses in milk production (Laven and Peters, 1996).

There are a number of factors associated with retained fetal membrane including induced parturition, shortened gestation, abortion, twining, dystocia, fetotomy, cesarean section, nutritional deficiencies, infectious agent (Joosten *et al.,* 1987), immunosuppression (Laven and Peters, 1996), breed, body condition, parity (Hemayatul et al., 2012) and age (Azad, 2010). According to Azad(2010), reported incidence of retained fetal membrane of 37.5% and 25% in cross and local dairy cow breed respectively where the incidence of 33.3% and 37.5% based on age of cow in young and old cow respectively was also reported. First parity had highest incidence of retained fetal membrane followed by 2^{nd}, 3^{rd} to the last parity (Hemayatul *et al*., 2012).

The incidence of RFM in cows range from 1% to 30% (Islam *et al.,* 2012). Swai et al., (2005), reported the incidence of RFM in some smallholders' dairy herds in Tanzania to be 17.2% whereas according to Kashoma and Ngou, (2021) observed the overall prevalence of retained fetal membranes in medium dairy farms Tanzania to be 10.35%. Common methods used for treatment of RFM are manual removal, intrauterine application of antibiotics, uses of hormone, ozone therapy and collagenase treatment, however these therapeutic approaches are relative effective (Stevens and Dinsmore, 1997; Drillich *et al*., 2006; Drillich *et al*., 2007; Zobel and Tkalcic, 2013; Haffner, 1998).

1.4.7 Endometritis and Metritis

The most important causes of infertility in dairy cows are reported to be metritis and endometritis (Gautam *et al.,* 2009). This is the inflammation of the uterus that occurred after entry of bacteria during or immediately after carrying out artificial insemination (AI), coitus or parturition (Kassahun and Negasse, 2020). Persistance and severity of infection on uterus depends on the degree of contamination, strength of uterine defence mechanism and presence of substrates that supports growth of the microbes such as devitalized tissues (Arundhat *et al.,* 2015).

There is a wide variation between metritis and endometritis (Mounir *et al.,* 2017). Metritis is inflammation of the wall of the uterus which in most cases occurred during the first 10-14-days of delivery and sometimes it is referred as toxic puerperal metritis (Deori and Arundhati, 2015). It is characterized by an enlarged uterus containing a watery red-brown fluid to viscous off-white purulent uterine discharge, which often has a fetid odor or unpleasant smell. Endometritis is inflammation of the functional lining of the uterus, called the endometrium (Abdullah *et al.,* 2015). It also refers to inflammation of the mucus membrane of the uterus; it is characterized by purulent discharge from the vulva that appeared three weeks after parturition or later. According to Abdeli *et al*., (2016), clinical endometritis is defined as the presence of a purulent discharge detectable in the vagina 21-days or more postpartum or mucopurulent discharge detectable in the vagina after 26-days of postpartum and subclinical endometritis is characterized by inflammation of the endometrial and the presence of neutrophils in cytology or biopsy histology, in the absence of signs of clinical endometritis.

Risk factors for endometritis and metritis were categorized as extrinsic and intrinsic factors. Extrinsic factors concerned all environmental conditions characteristics shared by animals in same herd whereas intrinsic factors are specific variable characteristics of the individual cow (Mounir *et al.,* 2017). Extrinsic factors include; calving season and nutrition whereas intrinsic factor are; parity of the animal, dystocia, retained placenta, metabolic stress (Mounir *et al.,* 2017), negative energy balance (Markusfeld, 1987). Among the pathogenic bacteria that can affect the uterus and causes metritis and endometritis includes; *Escherichia coli,* Arcanobacterium pyogenes, *Fusobacterium necrophorum*, Bacteroides species, Staphylococcus species Pasteurella species, Haemophilussomnus, *Pseudomonas aeruginosa,* Clostridium species, and Streptococcus species. Among these, Arcanobacterium pyogenes, coliforms, and the Gram-negative anaerobes, Fusobacterium, and Bacteroides species are commonly encountered (Paisley *et al.,* 1986).

Metritis and endometritis results in impairment of reproductive performance though delayed uterine involution and damages to embryos. Additionally, uterine infection and inflammation are associated with some alteration in the pattern of follicle growth on ovaries and disruption of subsequent luteal phase durations (Arundhat *et al.,* 2015). Uterine diseases pathology extension of infection to the oviduct likely disrupts the delicate balance of the immune systems that are required for fertilization, bacterial

infections disrupt the endocrine signaling in the hypothalamic-pituitary- gonadal axis and the secretion of gonadotrophins (Arundhat *et al.,* 2015). The reported incidence of endometritis in cattle varies widely: 10% (Bouters and Vandeplassche, 1977), 37% (Markusfeld, 1984) and 20% (Whitmore and Anderson, 1986). Clinical metritis and endometritis can be treated by anti-inflammatory drugs flunixin meglumine, antibiotics (pens-trip and long-acting oxytetracycline), intrauterine infusion by using saline or iodine tincture solutions.

1.5 Problem statement and justification

Despite the measures taken to increase the population of Mpwapwa cattle breed, the population of this breed neither went above 1000 at one time nor did being widely distributed (Wilson, 2021). This scenario is attributed by scarce detailed or comprehensive baseline information of productive and reproductive performance of Mpwapwa cattle and their crosses at the nucleus breeding center at TALIRI Mpwapwa and almost non-existent of information on the performance of the Mpwapwa breed kept by smallholders under low-input system. Therefore, the aim of the current study was to assess the current productive and reproductive performances of Mpwapwa cattle breed and its cross breeds reared at Tanzania Livestock Research Institute (TALIRI) and by smallholders under low-input systems in order to serve as the basis for the exploitation of genetic potential to further advocate utilization and multiplication of this breed.

1.6 Objectives

1.6.1 General objective

To assess productive and reproductive performances as well as reproductive health problems of Mpwapwa breed cattle and its crossbreeds reared under smallholders and TALIRI in Mpwapwa district.

1.6.2 Specific objectives

- To assess the reproductive performance of Mpwapwa breed cattle and its crossbreeds managed at TALIRI and smallholder farmers at Mpwapwa district.
- To assess the productive performance of Mpwapwa breed and its crossbreeds kept at TALIRI and smallholder farmers at Mpwapwa district.
- To assess the major reproductive health problems of Mpwapwa breed and its crossbreed kept at TALIRI and under smallholder farmers at Mpwapwa district.

1.6.3 Methodology

The current study ran from September 2021 to April 2022 which involved two main parts; the survey and retrospective parts. For the first part, a cross section study employing questioner filling was used to get animals' information from smallholder farms around Mpwapwa district whereas the second part involved getting retrospective animal data kept at TALIRI as well as observation on the animal management at farm.

A structured questionnaire (which was pre-tested before administrated to farmers) was used to gather information about general animal husbandry, production and reproductive performances. The questionnaire focused on securing information on demographic characteristics of farmers (respondents), number of animals kept, keeping system and feeding as management system; lactation length (LL) and lactation milk yield (LMY) as productive performance; whereas number of services per conception (NSC), age at puberty (AP), age at first calving (AFC) and calving interval (CI) were measure of the reproductive performances. Other data collected included reproductive health problems such as calf mortality, anestrus, repeat breeding, uterine prolapse, dystocia, abortion, retained placenta and other post-parturient conditions, (Appendix 1). At TALIRI center, individual animal productive and reproductive data five consecutive years (2015 to 2019) were retrieved from farm records and used in this study. The records included identification number, date of birth, calving dates, insemination and milk yield produced during the whole lactation period. From the collected information, the following variables of interest were derived; age at first calving (AFC), calving interval (CI), pregnancy rate, 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). 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.

1.6.4 Organization of the dissertation

This dissertation was prepared based on publishable manuscripts format of the Sokoine University of Agriculture. Chapter one contains the introduction, literature review, problem statement and justification, objective of the study, methodology of the study together with the organization of the dissertation. Chapter two contains a paper that is

accepted in peer reviewed scientific journal; the paper addressed the comparison of productive and reproductive performance of Mpwapwa breed and its crosses reared at TALIRI, nucleus breeding center Mpwapwa. Chapter three contains a manuscript submitted in peer reviewed scientific journal, the manuscript addressed the productive and reproductive performance of Mpwapwa breed and its crosses reared by small holders at Mpwapwa district. The final chapter of this dissertation draws overall discussions, conclusions and recommendations.

CHAPTER TWO

2.0 COMPARISON OF PRODUCTIVE AND REPRODUCTIVE PERFORMANCE BETWEEN MPWAPWA CATTLE AND THEIR CROSSES KEPT AT NUCLEUS BREEDING CENTER, MPWAPWA.

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ABSTRACT

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 rate (PR), 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, PR, 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 was obtained. The results of AFC, CI, LL and TLMY showed significance

difference ($p < 0.05$) between Mpwapwa breed cattle and its crosses except for PR which did not show significance difference ($p > 0.05$) between Mpwapwa breed and its crosses. It is concluded that reproductive and productive performance of Mpwapwa breed cattle and its crossbred cows in years under the present study at TALIRI were lower as compared to the breeding goal of this breed. Therefore, it is required to improve management practices for better reproductive and productive performances of the Mpwapwa cattle: an Indo-Euro-African synthesis.

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

2.1 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 (Cunnigham 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* (Chawala *et al*., 2020).

Mpwapwa cattle breed, established in Tanzania in 1960s, is a composite dual-purpose breed suitable 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. This information could serve as the basis for the exploitation of genetic potential to further advocate utilization of this breed. 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).

2.2 METHODOLOGY

2.2.1 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.

2.2.2 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.

2.2.3 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 about 90 days (approximately 3 months).

2.2.4 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, insemination season and pregnancy rates. 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 rate, 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 follows:

1. Age at first calving is the age a cow had its first calf, expressed in months.
2. Calving interval is the time interval between two successive calvings, expressed in months.
3. Lactation length is the length of time of milking after calving expressed in days.
4. Average milk yield per day is the average milk yield per cow per day recorded during the lactation period expressed in kilograms.
5. Total lactation milk yield is the total amount of milk produced expressed in kilograms per cow per lactation length.
6. Pregnancy rate is the percentage of cow that are pregnant at three months of pregnancy per number of cows inseminated.

2.2.4 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 $p<0.05$. -

2.3 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 (Figure 1). Majority of calves 73.22% were born in dry season whereas the remaining 26.78% were born in wet season.

Figure 2.1: Percentage of male and female calves born at TALIRI under study duration in Mpwapwa breed and its crossbreds. MPW, Mpwapwa breed; MB, Mpwapwa-Boran; SMB, Sahiwal-Mpwapwa-Boran; MP3/4B, Mpwapwa3/4-Boran1/4; DRMPW, Danish red-Mpwapwa.

2.4 Production performance

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 (Table. 1).

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 remain relatively constant up to the eighth parity and then drop.

Though there was non-significance difference in lactation length between lactation commence in wet and dry seasons, there is slightly increase in lactation length in those that commenced in dry season (Mpwapwa, Sahiwal-Mpwapwa-Boran, Mpwapwa3/4-Boran1/4) unlike wet season but this doesn’t count to overall mean total milk yield since there is slightly increase in total milk yield for cow commence lactation in wet season compare dry season (Mpwapwa) (Figure 2A).

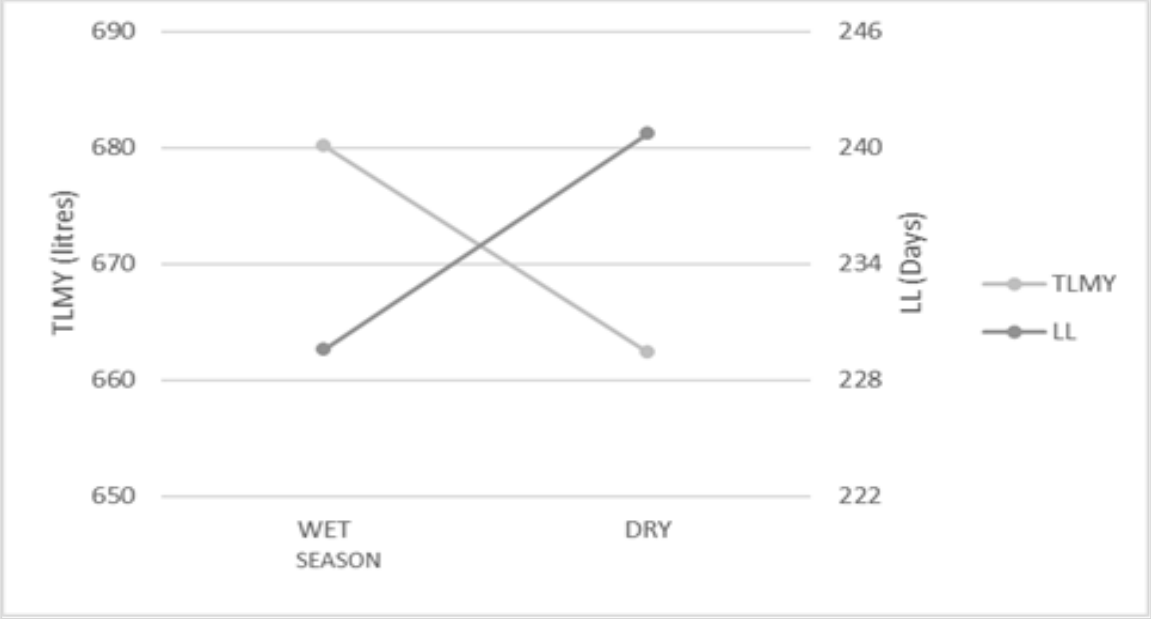


Figure 2.2: The overall mean total lactation milk yield (TLMY) and lactation length (LL) of Mpwapwa breed and its crossbreeds per production commencement season (dry and wet season running from July to November and December to June respectively).

Season of calving was also found correlated with its LL as it is slightly high in cows calved in dry as compare to those in 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) (Figure 2B).

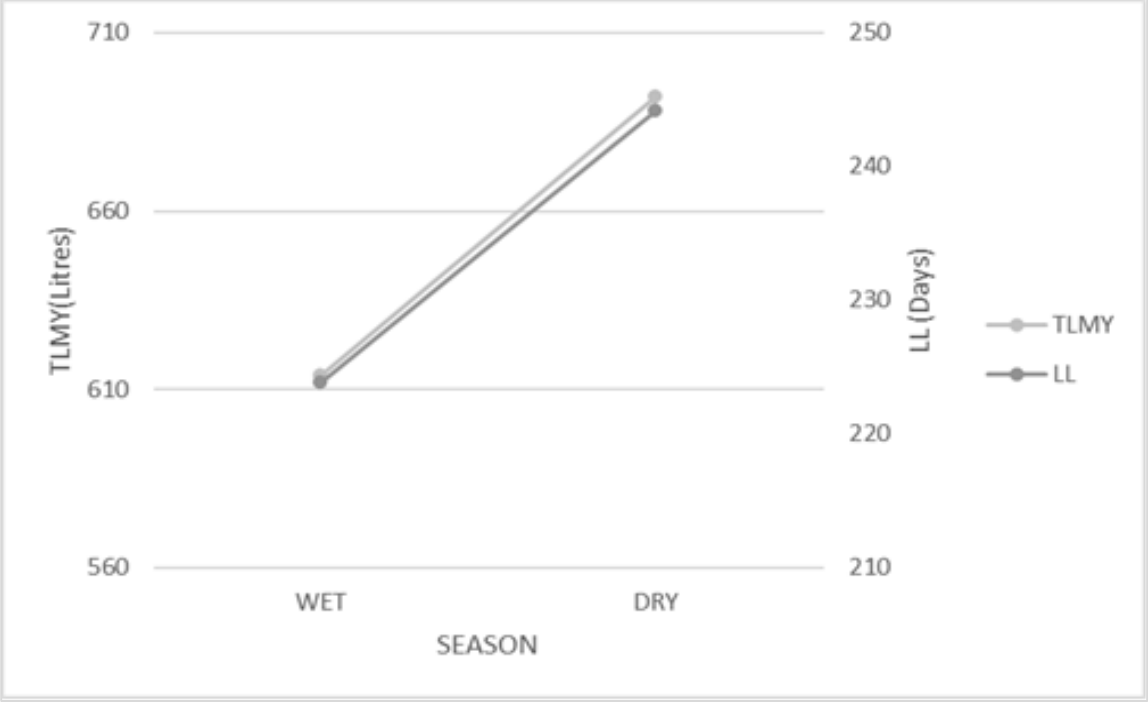


Figure 2.3: The overall mean total lactation milk yield (TLMY) and lactation length (LL) of Mpwapwa breed and its crossbreeds per seasonal birth of a cow (dry and wet season running from July to November and December to June respectively).

2.4 Reproductive performance

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 age at first calving was increasing from; Mpwapwa3/4-Boran1/4, Danish red-Mpwapwa, Mpwapwa-Boran, Sahiwal-Mpwapwa-Boran to Mpwapwa.

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 (Table 1). Although there was slightly high CI for parity 1&2 compare to cows with ≥2 parities, this difference was not significant. The significance difference ($p < 0.05$) 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.

2.5 Pregnancy rate

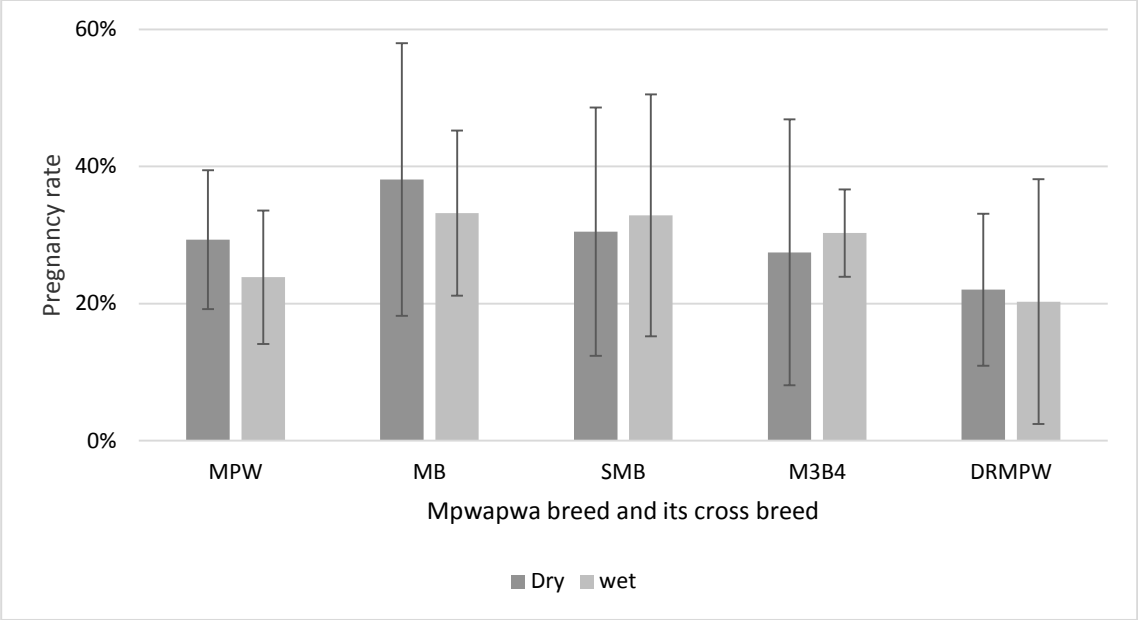
The overall pregnancy rate which was diagnosed through per rectal palpation 3 months later after mating season was 29.1%±14.4% with non-significance high pregnancy rate in dry season compare to wet season. The pregnancy rate was significance difference ($p < 0.05$) between 2015 and 2019 and between 2018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

Table 2.1: Means and standard deviation of AFC, CI, TLMY, AMYD?? and LL of pure Mpwapwa breed and its cross kept at TALIRI

BREED	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 letters 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.



The means (± SD) of pregnancy rate of mpwapwa breed and its crossbreed. MPW, Mpwapwa breed; MB, Mpwapwa-Boran; SMB, Sahiwal-Mpwapwa-Boran; MP3/4B, Mpwapwa3/4-Boran1/4; DRMPW, Danish red-Mpwapwa.

2.6 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 TALIRIin year 1966 which was 1879kg for the 1^{st}-3^{rd} lactation of Mpwapwa breed (Katyega, 1987), 1072kg from 1^{st} to 9^{th} 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 is 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 rate refers to the success rate for getting pregnancy from all attempts that leads to pregnancy. The overall pregnancy rate 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 programme, 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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2.8 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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CHAPTER THREE

3.0 ON-FARM ASSESSMENT OF REPRODUCTIVE AND PRODUCTIVE PERFORMANCES OF MPWAPWA CATTLE BREED AND ITS CROSSBRED IN LOW-INPUT SMALLHOLDERS

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ABSTRACT

A cross sectional study was conducted at Mpwapwa district with the objective of assessing the productive and reproductive performances of Mpwapwa breed cattle and its crossbred under low in-put smallholder farmers. Primary data was collected using semi-structured questionnaire and interview. The total number 100 householders keeping 986 Mpwapwa breed and its crosses at different parities (one up to six) were included in this study. For the analysis descriptive statistics such as frequency, percentage, mean, standard deviation and test statistics such as chi-square and t-test was used. For productive performance, average lactation length (LL) was 332 ± 16.7 days and average milk yield per day (AMYD) of 3.08±1.11 liters were recorded. Average calving interval (CI) of 17.5±6.6 months, average age at puberty of 32.3±8.21 months, mean age at first

calving (AFC) of 44.04±6.49 months and the average number of services per conception (NSC) of 1.23±0.14 were reproductive records. Major animal problems were calf mortality of (17.0%) retained fetal membrane (24.0%), anestrous (20.0%), abortion (17.0%), endometritis (12.0%), repeat breeder (9.0%), dystocia (8.0%), pyometra (5.0%), uterine (3.0%) and vaginal prolapse (2.0%). In general, the observed productive and reproductive performances of Mpwapwa breed and its crossbred is low compare to the target goal when it was established and even lower than Mpwapwa cattle breed and its crossbred reared nuclear point, Tanzania Livestock Research Institute (TALIRI). Therefore, there is a prudent need for improvement of management practices at farm level so as to optimize the reproductive and productive performances of the Mpwapwa cattle; an Indo-Euro-African synthesis.

Key words: Age at first calving, calving interval, lactation length, lactation yield, reproductive disorders

3.1 INTRODUCTION

Tanzania is predominantly rural, with about 65% of the population engaged in agriculture of which 33.0 % are engaged in crops and livestock, and 2.0 percent in livestock activities only (URT, 2021). The livestock industry in Tanzania is supported by many exceptional natural resources including diverse natural vegetation, extensive rangelands, and diversely resilient low production livestock breeds. Furthermore, livestock is valuable in sustainable agriculture by providing manure and labour for increased productivity and therefore enhancing the well-being and increased income of farmers (MLFD, 2010). Currently, Tanzania has about 33.9 million cattle, where 33.8 million cattle and 143,000 cattle are owed by smallholder farmers and large-scale farms, respectively (URT, 2021). Conferring to the analysis of livestock sector (LSA) baseline Tanzania accounts for about 1.4% of the global cattle population and 11% of African cattle population (FAO, 2014). Approximately 97% of Tanzania cattle population is composed mainly of innate Tanzanian short horn zebu (TSHZ) (*Bos indicus*), where the remaining 3% is composed of exotic and cross breeds (MLFD, 2015).

Although indigenous TSHZ are tolerant to heat stress, disease, parasite resistance and hardy, their productivity and reproductivity are generally low: 18-24 months calving interval, calf mortality rate 30 - 40%, milk yield 300 - 400 liters per lactation, and mature weight of 200 - 350kg with carcass weight 100 - 175 kg (MLFD, 2015). To increase productivity of indigenous cattle breeds, several strategic approaches have been planned and implemented by Tanzanian government including selection and crossbreeding of indigenous breeds to exotic dairy breeds, countrywide use of artificial insemination, and establishment of dairy heifer breeding units or Livestock Multiplication Units (LMU)

with major function of production and distribution of improved heifers and bulls (Chawala *et al.,* 2017). Despite of the great potential of cross breeding method, it faces with some challenges such as mis-match between genotype and production system with respect to environmental conditions (Gebreyohannes *et al.,* 2013).

Mpwapwa breed is an Indo-African composite dual-purpose breed established in 1958s to suit for milk and meat production in medium - to low-input production environments (Kiwuwa and Kyomo, 1971; Rushalaza and Kasonta, 1993). The target of this breed was for cow to produce 2300kg total lactation milk yield for 305days and for steers to produce a carcass of 230kg in less than 4 years in medium to low input production system (Systard, 1990). Though its genetic composition is currently not constant and clear (Syrstad, 1990), at the time of its declaration as a breed in 1958 it had a genetic composition of 32% Red Sindhi, 30% Sahiwal, 19% Tanganyika Shorthorn Zebu (TSZ), 11% Boran, and 8% Bos taurus, mainly Ayrshire (Kiwuwa and Kyomo, 1971). Owing to good production performance (milk and meat yield compared to TSHZ), disease resistance, and the ability of the bulls to be used for draught power, mpwapwa breed has been widely accepted by the community (Komwihangilo *et al.,* 2009). As from 1999 onwards, multiplication efforts to increase the population of the breed have been undertaken involving multiplication of the pure Mpwapwa breed and escalation of the animal by backcrossing the present pure Mpwapwa with Boran and Sahiwal (Bwire *et al.*, 2005).

Despite the efforts of increasing the number of Mpwapwa breed cattle to low-input smallholders, information on the production and reproduction performance of these animals reared by smallholders under low-input system is virtually non-existent. This is

in contrast to the animals kept at nuclear point with has high-input system, where extensive studies on phenotypic, genetic, and economic parameters have been reported. Therefore, the aim of this study was to benchmark the current productive and reproductive performance of mpwapwa breed and its crossbred reared in smallholders under low-input systems.

3.2 MATERIALS AND METHODS

3.2.1 Description of the Study Area

This study was carried out in seven administrative wards of Mpwapwa district, Dodoma region, Tanzania. Mpwapwa district is among seven districts of Dodoma region which is predominantly arid lying between 915 to 1,200 meters above sea with spontaneous mountain chains in the Southern and Western parts. Mpwapwa district is situated between Latitudes 6°00” and 7°30” South of the Equator and between Longitude 35°45” and 37°00” East of Greenwich. It borders Kilosa and Gaito Districts on the Eastern part, Kongwa District on the Northern part, Chamwino District on the Western area and Kilolo District on the South. The district has a dry savannah type of climate characterized average daily temperature ranging from 24 – 29^{o}C. The climate is further divided into rain and dry seasons, with rainy season starting from December to April having rainfall of between 600 – 1200 mm where the mountainous areas receiving the heavy rains of up to 1,200 mm per annum.

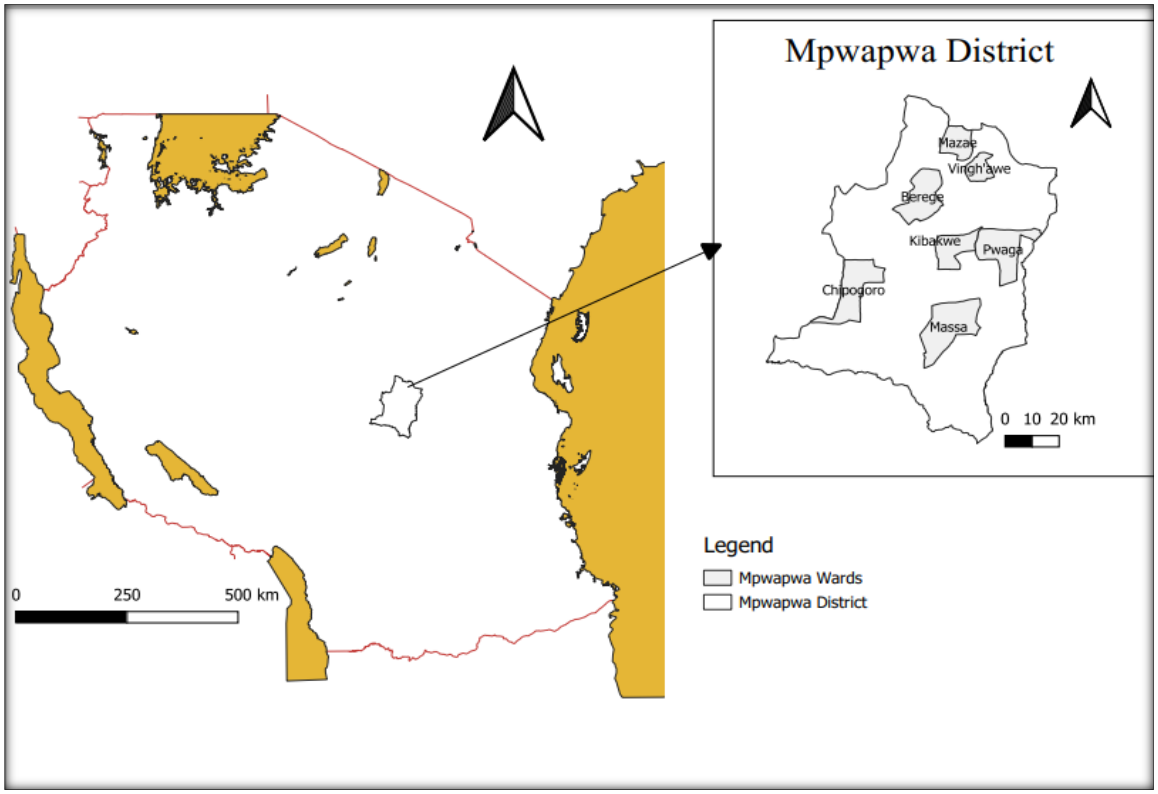

Figure 3.1: Map of the study area

3.2.2 Study design

A cross sectional study design was conducted from September, 2021 to April, 2022 to gather information concerning the productive and reproductive performance of Mpwapwa cattle breed and its crosses kept by smallholders in seven administrative wards of Mpwapwa district namely; Massa, Chipogolo, Belege, Mazae, Ving'hawe, Kibakwe and Pwaga (Figure 1).

3.2.3 Data collection

A total of 100 farmers keeping Mpwapwa cattle and its crosses were interviewed randomly with pre-tested structured questionnaire. The information captured by questionnaire included demographic data (personal information, gender, age, occupation

family size, educational level and general animal husbandry. Collected animal productive data were lactation length (LL) and average milk yield per day (AMYPD) whereby reproductive performance was assessed basing on number of services per conception (NSC), age at first heat, age at first calving (AFC) and calving interval (CI). Other collected data included reproductive health problems such as calf mortality, anestrus, repeat breeding, uterine prolapse, dystocia, abortion, retained placenta and other post-parturient conditions. A total of 986 cows of Mpwapwa breed and its crosses at different parities (one up to six) were used in this study. The traits studied were as previously defined and described by Miah et al (2018) and Hagan et al (2022):

7. Age at first calving is the age a cow had its first calf, expressed in months.
8. Age at first heat is the age at which the heifer had its first estrous expressed in months.
9. Calving interval is the time interval between two successive calvings, expressed in months.
10. Number of services per conception is the average number of services resulting in conception.
11. Lactation length is the time of period from when a cow starts to secrete milk after parturition to the time of drying off, expressed in days.
12. Average milk yield per day is the average milk yield per cow per day recorded during the lactation period, expressed in kilograms (liters).

3.2.4 Data management and analysis

The collected raw data were first entered into an Excel sheet, cleaned, coded, and then imported into Statistical Package for Social Sciences (SPSS) version 21 software for analysis. Descriptive statistics such as frequency, percentage, means and standard deviation were analyzed and presented in the form of table 1, figure 2 and 3. Furthermore, t-test and chi-square tests were used to examine differences between levels of significance between the variables. Differences were considered to be significant at the level $p<0.05$.

3.3 RESULTS

3.3.1 Demography of the respondents.

Majority of respondent (94%) were male with almost all (98%) respondents being married. The respondents' education level spanned from informal education, primary school, secondary school and college education with distribution percentages of 27%, 66%, 6% and 1%, respectively. Most farmers (76%) had long experience of keeping livestock for more than 15 years followed by (17%) with experience of 10 to 15 years. It was generally observed that 76% farmers have more than 20 Mpwapwa cattle breed and its crosses in their farms with about 50% of all farmers had >5 family members participating in livestock activities (Table 1). Almost all farmers (>95%) had different motives for engaging in cattle keeping activities including; economic enterprise, supplementary enterprise, home milk consumption and hobby where majority of them had more than one motive with the economic enterprise as a leading motive.

Table 3.1: Demographic characteristics of respondents

Parameters	Categories	Percentage (%)
Gender	Female	6%
	Male	94%
Marital status	Single	1%
	Married	98%
	Widow	1%
	Widower	0%
Level of education	Informal education	27%
	Primary education	66%
	Secondary education	6%
	College education	1%
Farming experience	1-4.5	6%
	5-9.5	5%
	10-15	17%
	>15	72%
Cattle population	1-5	6%
	6-10	9%
	10-20	9%
	>20	76%

farming experience in years and cattle population in numbers

About 93% of farmers perform extensive feeding system by allowing their animals to graze in communal areas with the remaining 7% perform grazing together with either stall feeding or tethering systems. Supplementary concentrate feeding was practiced by 37% of the respondents whereas 54.1% farmers give supplements only to lactating animals. Following the seasonal variations in availability of feed, only 9% of farmer either had established pasture, buying from vendor or use crop residual during dry

season, 67% farmers relay only on communal grazing natural pasture and the remaining 24% used both natural pasture and either established pasture, buy from vendors or crop residues. Feed conservation is practiced by only 63% of farmers where almost all of them conserve feed in form of standing hay at some paddocks. Farmers (83%) gets animal health services from government animal health officer who visit the farmers only when needed (86%).

3.3.2 Reproductive characteristics

The reported number of calves which Mpwapwa cattle breed and its crosses can produce per reproductive life span ranged from 4 - 6 as it was stated by majority (83%) of respondents. Regarding the calving season, 63% of farmers reported to have their animals calving during rainy season, 20% in dry season whereas 17% observed their animals calving in all season of the year. Majority of farmers 97% use natural breeding system with minority (3%) acknowledged to use artificial insemination at least once in their farming practices. More than half number of farmers (63%) practice selection of animals for breeding purposes. The criteria used for selection of breeding bulls include physical appearance, pedigree history and service efficiency. Regarding selection of breeding cows, most used phenotypic characteristics included pedigree history, physical appearance and growth rates. Thirty-seven percent of farmers exclusively admitted to own bulls where majority 63% did not have bulls only get their cows serviced from either neighbor's bulls or communal grazing bulls. Majority (70%) of farmers submit heifer for breeding only when exhibit signs of estrus. There was no specific voluntary period for cow from parturition to first mating as majority (81%) of farmers admitted to submit their

cows for breeding once the signs of estrous observed as majority of farmers keep both bulls and cow together while grazing.

The average age at puberty of Mpwapwa cattle breed and its crosses from the current study was 32.3±8.21 months (Figure 2) with most of heifers (88%) reaching puberty between 2 and 3 years of age. Furthermore, the study revealed that the average age at first calving (AFC) of Mpwapwa breed and its crosses kept under low-input was 44.04±6.49 months (Figure 2) with the majority of heifer (87%) calving for the first time between 3 and 4 years of age. The mean calving interval (CI) for animals obtained from the current study was 17.5±6.6 months (Figure 2) where 96% of cows having between one and two years of CI while the minority (4%) have four and above years of CI. The length in days from calving to first estrous ranged between 60 – 90 days. With the exception of cows with reproductive disorders which differ ($p < 0.05$) from cows with normal postpartum period, the number of days between calving and first estrous/mating were not different between parities. The mean number of services per conception was 1.23 ± 0.14 (range 1 – 3) with a coefficient of variation of 23.1%. Numbers of services per conception were lowest among primiparous than in multiparous and tended to increase ($p > 0.05$) with parity.

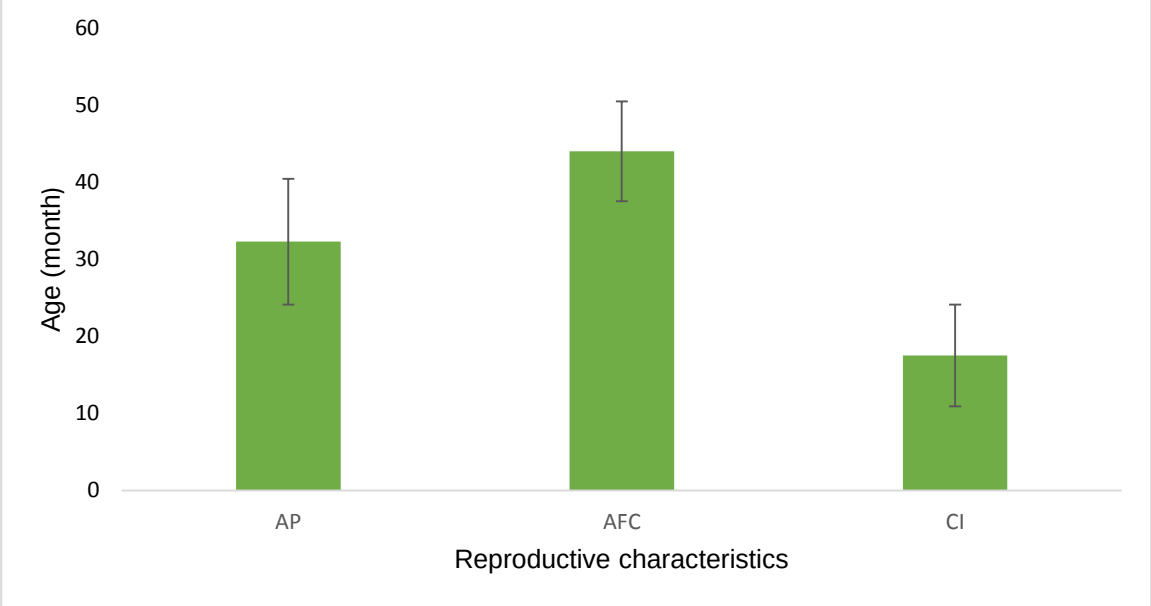

Figure 3.2: The mean and standard deviation of: AP (age at puberty), AFC (age at first calving) and CI (calving interval) of mpwapwa breed and its crossbred at Mpwapwa district.

3.3.3 Productive characteristics

High percentage of farmers (49%) responded to start milking their cow 1 month after calving, 26% after one week, 2% after 2 weeks others > 2 months, and will break milking only when the animal stops producing milk. The average LL of Mpwapwa breed and its crosses under farmers' condition were 6-12 months (332 ± 16.7 days) as reported by 74% of farmers and <6 months as observed by 26% of farmers. No difference ($p > 0.05$) in LL between cows calved during rainy and dry season was observed by farmers. The average milk yield per day (AMYD) of cows under this study was 3.08±1.11 liters with highest milk production observed during rainy season which was highlighted by most of farmers (96%). Furthermore, 87% of farmer observed the difference in milk yield between non-pregnant and in-calf cows where non-pregnant cows had high milk production compare to pregnant one of the same parities. Similarly, 61% of farmers observed variation in milk

production between animal calved during rainy and dry season, where those calved during rainy season had high milk production by 0.5-1.5 liters per day as observed by 50% of farmers.

3.3.4 Reproductive challenges

In the current study, 100% of respondents reported to had no observed any congenital abnormalities in their animals whereas 40% of farmers experienced non-reproductive challenge in cattle they keep. Calf mortality rate of <20% was observed by 51% farmers, 30-40% by 9% farmers and none calf mortality rate by 40% farmers. Diseases (calf scours and tick borne disease), hunger and toxicity were the most mentioned causes of calves' death. Among the major reproductive health problems, retained fetal membrane (24.0%), anestrous (20.0%), abortion (17.0%), endometritis (12.0%), repeat breeder (9.0%), dystocia (8.0%), pyometra (5.0%), uterine (3.0%) and vaginal prolapse (2.0%) were the most commonly encountered reproductive health problems in Mpwapwa breed and its cross cows during the study period. The most sited side effects associated with most of postpartum reproductive disorders included reduced milk production (26.0%), extended return to estrous (20.0%), and death of animals (3.0%). Only few farmers consulted veterinarian for treatment of endometritis (8.0%), repeat breeding syndrome (4.0%), retained fetal membrane (17.0%) and abortion (2.0%). Feeding of dogs was the major method of disposing aborted fetuses (15.0%) and retained fetal membranes (25.0%).

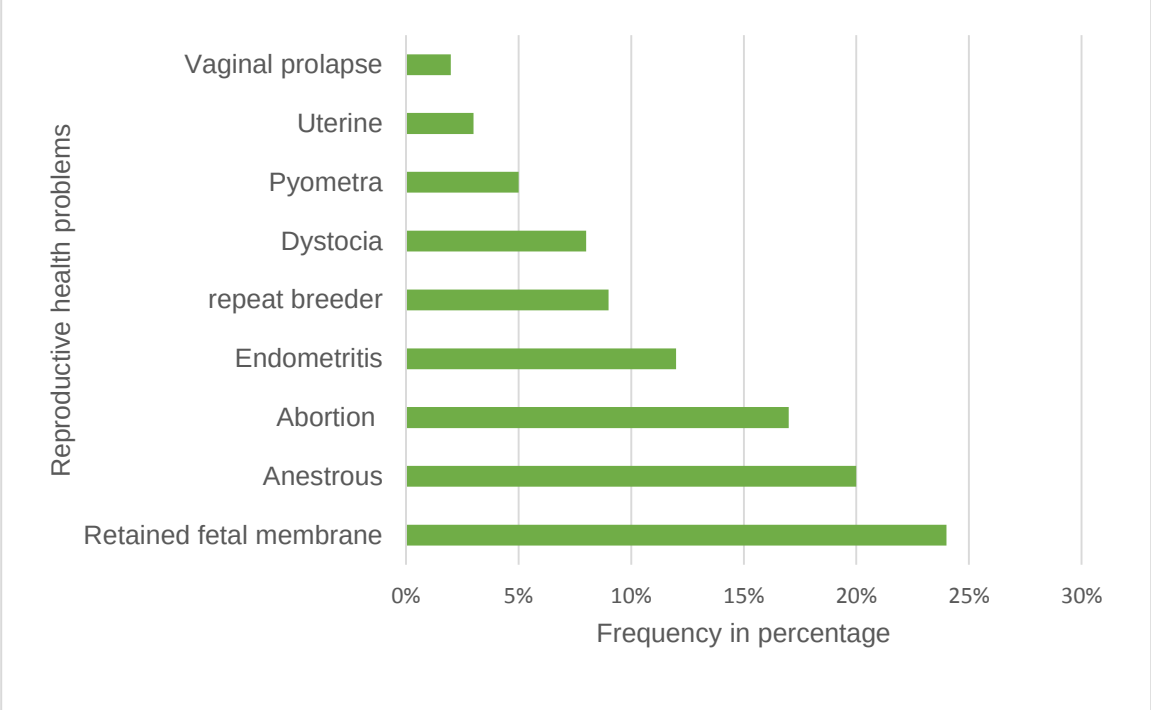

Figure 3.3: Reproductive health problems of mpwapwa cattle breed and its crossbred under farmers' condition.

3.4 DISCUSSION

The average age at puberty (32.3±8.16 months) from the current study is comparable with the range of 742-1120 days (26.5-40.12 months) and 24-36 months previously reported for Mpwapwa breed (Kanuya *et al.*, 1993) and Mpwapwa crosses (Komwihangilo *et al.*, 2009). The similarity in age at puberty of mpwapwa cattle and its crossbred from different studies is due to genetic comparability and the effect of body weight in the onset of puberty. The high age at puberty of Mpwapwa cattle and its crossbred can therefore be reduced through improvement of calf (animal) nutrition, since it is body weight rather than chronological age that affect the onset of puberty (Kanuya *et al.*, 1993).

The occurrence of peak calving between December and April implies that most conceptions took place between April and July of the previous year. This is the period of the year when temperatures in the study area are relatively cool, some natural grass for grazing are plenty from the preceding rainy season, and thus animals have good body condition AND are likely fertile. Previous studies in elsewhere (Knopf *et al.,* 2000; Madibela *et al.,* 2001; Kanuya *et al.,* 2006) reported similar trend of calving in different indigenous breeds of cattle. This seasonal pattern of conception and calving could be an adaptive physiological mechanism by the indigenous animals so that calving occurs at a time of plentiful nutrition including easy availability of drinking water. However, this seasonal calving pattern leads to uneven milk availability along the year.

The current average AFC of 44.04±6.48 months for mpwapwa breed and its crosses is high compare to 33 ±9.7 months of mpwapwa breed reared by small holder farmer around Berege ward, Mpwapwa district as it was reported by Rushalaza and Kasonta, (1993) and 32 months of Mpwapwa breed reared on station at Tanzania Livestock Research Institute, Mpwapwa, Tanzania (Chitawala *et al.,* 2017). However, our findings are almost similar to 40.2 and 45.6 months (1383 days) for mpwapwa breed cows as reared at TALIRI - Mpwapwa previously reported by Katyega, (1987) and Mkonyi, (1982), respectively. Notably, higher average age at first calving 4.3 ± 3.3 years have been reported in Tarime Zebu Cattle (Chenyambuga *et al.,* 2008) and 50 ± 1.3 months in Tanzania shorthorn zebu/Fipa cattle (Mwambene *et al.,* 2012). The variations of AFC reported for mpwapwa cattle breed and its crosses could be attributable to many factors such as nutrition level, genetic constitution and management factors leading to poor conception rate of heifers that tend to remain in the herd for a long time. The breeding

protocol for Mpwapwa cattle ever-since the breed was established stipulated that heifers that weigh less than 200 kg at the age of two to be culled and not used for breeding (Bwire *et al.,* 2005). However, this has not been practiced by smallholders as no such knowledge on the farmers as a result heifer that could not meet the stipulated criterion were likely to be retained for breeding.

The number of services per conception (NSC) mainly depends mating system used, it is lower under uncontrolled natural breeding and higher in hand-mating or artificial insemination practices. In this study, the overall mean NSC 1.23 ± 0.14 (range 1 – 3) which has a tendency to increase with parity (few services in primiparous and more in multiparous animals), was in agreement with others who reported a range of 1.34 – 2.2 NSC for Ethiopian indigenous cows (Abrha *et al.,* 2020), 1.53 and 1.71 in naturally and artificially inseminated Boran cattle kept under ranch conditions in Tanzania (Mwatawala and Kifaro, 2009). On the other hand, other researchers (Ngou and Kashoma, 2015; Kashoma *et al.,* 2015) have reported relatively higher (1.8 - 2.5) NSC than in the present study. The significant effect of parity on NSC observed in this study was in consistent number of studies (Demeke *et al.,* 2004; Mwatawala and Kifaro, 2009; Ngou and Kashoma, 2015; Kashoma *et al.,* 2015) where it has been observed that primiparous animals were more efficient than multiparous cow with respect to reproduction. The variations in NSC reported by different researchers may be associated with many factors including accuracy in estrous detection, proximity to bulls or AI services, breeding system used (natural versus artificial insemination), and nutritional status of cows at time of service.

The overall mean CI of 17.5±6.6 months observed in the current study is similar to 15-18 months and 16.4±3.23 months as previously reported by Komwihangilo et al. (2009) and Rushalaza and Kasonta, (1993), respectively in Mpwapwa cattle breed and its crosses kept in smallholders. Furthermore, the CI obtained in this study is similar to 17.6 months reported by Chawala et al. (2017) in Mpwapwa breed kept on station at TALIRI – Mpwapwa and 17.6 ± 5.1 months CI reported in Tarime Zebu Cattle (Chenyambuga *et al.,* 2008). However, our CI finding is high than that of 409 days (13.5 months) and 447 days (14.7 months) previously reported by Katyega, (1987) and Das et al (1986), respectively in Mpwapwa cattle breed. Remarkably, lower CI of 15.5 ± 0.6 months has been reported in indigenous Tanzania shorthorn zebu (Fipa cattle) in three districts of southwestern highlands of Tanzania (Mwambene *et al.,* 2012). The variation in calving interval may be associated with many factors such as inability of the farmer to detect heat, early embryonic mortality, failure by the farmers to obtain the breeding bull at the correct time and some level of infertility due to moderate under nutrition.

The mean daily yield at peak (3.08±1.11 liters) reported in this study is lower than the previous results reported by Komwihangilo et al (2009) of 4 to 6 litters and Rushalaza and Kasonta, (1993) of 5.5±1.1 litters from Mpwapwa breed and its crosses both kept under smallholder farming system. The cow's average milk yield per day findings reported here also is lower than 6.9±0.45 liters and 8.6±0.54 liters from purebred and crossbred Mpwapwa cattle, respectively (Mejia *et al.,* 1998) kept under high-input management system of TALIRI, Mpwapwa. However, the reported average milk production/cow/day 3.08 liters is higher than the 2 - 3 liters produced by Tanzania shorthorn zebu (Chenyambuga *et al.,* 2008; Mwambene *et al.,* 2012; Msanga *et al.,* 2012)

and 2.02±0.48 liters for Boran cattle breed (Bayssa *et al.,* 2021). The difference in milk yield may be as a consequence of genetic, nutrition, season of calving, parity, management, environment, and their interactions since have significant effect on milk yield (Kumar *et al.,* 2014).

The overall number of days in milk (average lactation length) of 332 ± 16.7 days reported in the present study is comparable with 300 ±17 days observed previously by Rushalaza and Kasonta, (1993) in Mpwapwa breed kept in low-input under smallholders. However, our findings are higher than that of 250 days reported by Komwihangilo et al. (2009), 288 days (Katyega 1987), 271 days (Chawala *et al.,* 2017), 228 days (Das *et al.,* 1999) and 209 days (Mchau, 1988) both in Mpwapwa cattle breed and its crosses. Furthermore, the LL observed in the present study was within the range of 326 - 400 days reported for crossbred cows in smallholder dairy farms in sub-Saharan Africa (Chenyambuga and Mseleko, 2009; Gebreyohannes *et al.,* 2013; Ngou and Kashoma, 2015). The probable reasons for variation in LL might be genetic composition, nutrition, environmental and management systems where animals kept.

Postpartum health disorders have a carryover effect on animal's performance as their associated with reduced milk yield, mastitis, reduce pregnancy rates, impair conceptus development, and increase embryo losses (Macmillan *et al.,* 2021). In this study, retained fetal membrane, anestrous abortions, endometritis, repeat breeder, dystocia, pyometra, uterine and vaginal prolapse were the major reproductive problems mentioned by the respondents. Our finding was comparable with the findings reported elsewhere (Swai *et al.,* 2005; Kashoma and Ngou, 2021; Dawit and Fesseha, 2020; Misebo *et al.,* 2018;

Wagari *et al.*, 2016; Molalegne *et al.*, 2011; Kifle and Moges, 2016). The high incidences and variation in occurrence of the reproductive disorders may be due to presence of predisposing factors such as breeding variation, nutritional status of animals, geographical location, and management factors.

Also, we investigated mortality rate in mpwapwa breed and its crosses during their first 6 months of life and identified the main causes of death and observe the calf mortality rate of about 17% per 100 animal risk in a year where infectious diseases, hunger and toxicity were the most mentioned causes of calves' death. Similar mortality rates to those observed in this study have been reported among zebu calves in Tanzania (Kanuya *et al.*, 2006; Swai *et al.*, 2009), Kenya (Thumbi *et al.*, 2013). In sub-Saharan Africa, pre-weaning calf mortality of 15 to 35% is typical on many dairy farms with infectious diseases being the major risk factor (Muraguri *et al.*, 2005; Tesfaye, 2019; Alemu *et al.*, 2022). From our finding and others, it is evident that although Mpwapwa cattle are relatively resistance to diseases as compared to exotic breeds, calf mortality is high and possibly is responsible for sluggish country-wide spreading of the breed.

3.5 CONCLUSION AND RECOMMENDATION

In general, current productive and reproductive performances of mpwapwa breed and its crosses is low compare to the target goal of this breed. Poor management practices (poor nutrition, poor animal health care, poor housing) is the leading factor for the current low performances of mpwapwa breed and its cross breed. The government and non-government organization should work together to ensure proper and regular extension and health services together with multiplication and distribution of pure Mpwapwa breed,

so as to optimize the performance of Mpwapwa breed cattle on farm in order to improve life standard of farmers.

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3.4 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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CHAPTER FOUR

4.0 DISCUSSION CONCLUSION AND RECOMMENDATION

4.1 Discussion

The aim of the current study was to assess the current productive and reproductive performances of Mpwapwa cattle breed and its cross breeds reared at Tanzania Livestock Research Institute (TALIRI) and by smallholders under low-input systems at Mpwapwa district. The findings of this study, answered a set of questions that require instantaneous actions regarding different factors and their interaction that underlying the current productive and reproductive performances of Mpwapwa breed and its cross breeds both at nuclear breeding center as well as in low-input production system. The obtained results of reproductive performance (AFC, CI and PR) as well as productive performance (LL, AMYD and TLMY), showed significance difference ($p < 0.05$) between Mpwapwa breed cattle and its crosses between animals reared at TALIRI and smallholders. The current findings are however agree and disagrees with other studies carried at TALIRI at different times by different researches (Mkonyi, 1982; Das *et al*., 1986; Katyega, 1987; Mchau, 1988; Chawala *et al.*, 2017). The disparity of the findings is a consequence of genetic, environment and managemental factors. Infusion of further European blood and Sahiwal breed (weak monitoring of the genetic progress (Chawala *et al.*, 2017)) are the leading genetic factor affecting the performance of Mpwapwa breed (Wilson, 2021). Diverse restrictions on LL for records included in the studies (Srystad, 1990) and other environmental factors such as level of management, climatic condition, season of production, parity and the age of cow together with their interaction with genetic factor also resulted into variation in performances of Mpwapwa breed and its cross breeds in

this study from others. According to Chawala et al, (2017), the characters of the Mpwapwa cattle breed have an overall decline in both phenotypic and genetic progress over the past four decades. Furthermore, the current performances of mpwapwa breed and its crossbred at farm condition is however low compared to the previous studies (Rushalaza and Kasonta, (1993); Komwihangilo et al 2009) owing to different factors (genetic, management, environmental and their interaction together with poor knowledge on animal husbandry) with lack of record keeping by the farmers as a limitation of the study.

4.2 Conclusion

This study disclosed that the overall productive and reproductive performance of Mpwapwa breed and its cross breed was low compared with the targeted goal of this breed with significance difference ($p< 0.05$) in both production and reproduction performances of Mpwapwa breed between TALIRI and smallholders. In general, inferior management practices (poor nutrition, poor animal health services, poor housing, poor breeding practices, poor selection practice in smallholders), backcrossing and unrestricted breeding at TALIRI could be associated with the current inferior performances.

4.3 Recommendation

1. Thus, proper and systematic scheduling of genetic improvement program, management practices and breeding scheme for further improvement of Mpwapwa cattle breed should be put in place for optimum production and reproduction performances so as to meet the targeted purposes.

2. The government and non-government organization should work together to ensure proper and regular extension and health services together with multiplication and distribution of pure Mpwapwa breed, so as to optimize the performance of Mpwapwa breed cattle on farm in order to improve life standard of farmers.

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