# Non- Genetic Factors influence birth weight of Friesian and Friesian x Fipa Cattle calves in one Highland farm of Tanzania


**Abstract**

Calving records were extracted from record books at TALIRI Uyole farm from 2013- 2022, to study and determine the influence of breed, sex, season of birth and year of birth on weight at birth of pure Friesian and its crosses (F1 Friesian x Fipa and 75% Friesian x Fipa) calves which are grazed under natural pasture. The least squares mean of BWT in Friesian, F1 and 75% calves were 25.51±0.98 kg, 26.45 ± 1.23 and 25.26 ± 0.94 respectively. It was observed that sex of calf and year of birth had a significant ($P<0.05$) influence on birth weight, with males being heavier than the female by 1.86 kg of the mean birth weight. Breed of calf and season of birth were not associated ($P>0.05$) with variation in mean birth weight of Friesian breed and its crosses at birth but variations on BWT at birth were noted where F1 had higher BWT compared to other breed/cross and calves born on wet season had a slightly higher BWT than calves born on the dry season. Under natural pasture grazing feeds are of poor quality as no any agronomic management practices and are mainly available in wet season thus cattle animal nutrients demand for body maintenance, reproduction and production activities are impaired.



**Keywords:** *birth weight, calf, fipa cattle, Sanga cattle*




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## 2. Introduction

Demand for good dairy cattle to increase milk production under smallholder farmers is a major constraint in many countries in Africa and particularly in Tanzania. In knowing this, in 2011 to 2015 researchers at Tanzania Livestock Research Institute (TALIRI) Uyole came up with a project funded by Tanzania commission for science and technology (COSTEC) to enhance availability of good dairy cattle by crossing pure breed Friesian and Fipa cattle local cattle … and obtained F1 Friesian x Fipa and 75% Friesian x Fipa cross bred cattle which were disseminated to small holder farmers to boost up their productivities (reproduction and production). The reasons of using these two breeds for cross breeding programme under this project was due to their unique or desired good characteristics which smallholder farmers prefer against other Tanzanian local cattle in the countries (Mwambene et all 2012) and Friesian are preferred because are higher milk yielders among the dairy cattle available in the country. Fipa cattle is a stabilized crossbred of 'Sanga and Zebu' (Rege and Tawah, 1999, Mwambene et al., 2012). Sanga cattle is name of indigenous cattle of some local areas in Africa. They are identified as a subspecies with the scientific name *Bos taurus africanus* (*Sanga cattle - Wikipedia).*

The Fipa breed has a good mothering ability, low birth challenges, high body weight at birth and high fertility, tolerant to harsh conditions/ feed shortages and adaptability to parasites, pests and diseases. In addition, it can tolerate drought as its body condition can remain good throughout the year. The breed is also used by farmers in routine operations and draught (Mwambene et al., 2012). The management of the Fipa cattle is of good productivity without substantial external input in the form of drugs (use of drugs, treatments), in the form of feed (e.g. use of feeding concentrate, feed supplements), without use of weather protection equipment/housing and without substantial external input of water and are well adapted to varied harsh conditions, hence making them a low-risk resource to the small holder farmers (Köhler-Rollefson, 2005). In contrast, Friesian (Boss Taurus) breeds that are exotic breed predominantly found in temperate countries have very higher productivities with substantial external inputs, but poor adaptation to tropical and intolerant of hash conditions, diseases and pests (Roschinsky et al., 2015). Therefore, crossbreeding of Fipa (*B.taurus africanus*) with Friesian *(B. taurus*) breeds was used under this crossbreeding, to combine the high-production potential of exotic breed with the

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adaptation traits (to abiotic and biotic stresses) – e.g., drought tolerance, cold tolerance, resistance or tolerance to diseases or parasites of the indigenous breeds.

Currently no any study has been conducted to understand reproduction and production traits of these cross bred dairy cattle so that to establish scientific information for future breeding program on stabilizing these cross breeds in the country. Therefore, the study aims to seek the genetic and non-genetic factors associated with variation on birth weight (BWT) and existing variations of BWT between Friesian, F1 and 75%

Weight at birth is the first characteristics of animal can be easily recorded and vital trait to be measured in the life of an individual and do not change much at the first few days of life. Early studies from 1950's to date, have established importance BWT with its positive genetic correlation with other vital traits in animal, for beef cattle, investigators have shown the importance of birth weight in predicting weaning weight, weight at 1 year, rate of gain weight gain to weaning, rate of gain during fattening, or rate of gain from birth to slaughter (Willard 1948, Munkaosi, 1955, Oni et al., 1988, Segura-Correa et al., 2017, Assan et al., 2002, Coffee et al., 2022)

Weight at birth is critical information to know as it has a bearing on calf survival and growth rates and can be utilized in adjusting weights taken at different times during the animal's growth. Many scientific reports, reported that within a number of species an association has been found between birth weight and viability, an experiment on pig have reviled that pre-weaning mortality and disease susceptibility are higher in low birth weight in pig (Wolf, Žáková, & Groeneveld, 2008). Some studies on cattle indicate that high BWT was associated with increased perinatal calf mortality and dystocia in dairy cattle (Johanson and Berger, 2003). Hence there is a need to establish information of some genetically and non-genetically factors influencing weight at birth of Friesian, F1 and 75% and variation on weight at birth of these breed under grazing management system. This information is useful for further selection and breeding programme of Friesian and Fipa cattle in Tanzania. Hence the objective of the study is to establish information on variation on BWT and factors influencing BWT at birth on Friesian, 50% Friesian x Fipa and 75% Friesian x Fipa breeds

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## 3. Materials and Methods

### 3.1. Study location

Data were recorded from cattle Record books at the Tanzania Livestock Research Institute (TALIRI), Uyole farm. TALIRI Uyole is located at Uyole, about 10 km from Mbeya City center with an altitude of about 1850 meters above sea level. It lies between latitudes 08.92044' – 08.92011' S and Longitudes 33.54053' – 33.53063' E. The Centre renders its services in the Southern Highlands Zone comprising of six regions (Iringa, Mbeya, Ruvuma, Rukwa, Katavi and Njombe). The Zone is situated between Latitudes 7◦ and 9◦ S and Longitudes 30◦ and 38◦ E with an elevation of 475 and 3000 meters above sea level, average annual temperature range between 6.8°C -22.4°C and annual rainfall range between 600 to 2600 mm per annum.

### 3.2.Animal Herds management and breeding

There are two cattle herds kept at TALIRI Uyole, Friesian dairy cattle and Crosses of Fipa and Friesian (Friesian x Fipa), the groups are grazed separately to avoid unplanned mating of the two herds, the main breeding method is natural mating, practiced as farm breeding strategy, using a Friesian bull which is the main source of genetic materials. These bulls are bought from other public farms and brought after every two to three years to minimize the effect of in breeding since the two herds size are small it is important to change the bull to increase heterosis (Hybrid vigor) within the herd. During the COSTEC project, there were female FIPA cattle for cross breeding strategies with Friesian bull as the source of genetic materials to obtain F1 and 75% Fipa x Friesian cross bred currently, there is only two main breed Friesian, F1 and 75% Fipax (Friesian cross) bred kept. All animals are kept on paddocks during the day and nights with no weather protection facility, weather protection facility is provided for born calves up to a weaning stage which is normal 3 to 4 months depending on health or condition of a calf.

### 3.3. Feed and feeding

Animals are grazed on natural pasture and very limited supply of input in the form of feed (e.g. use of feeding concentrate, feed supplements or additive), during the wet season natural pasture are plenty while in dry season low availability of natural pasture and animal are also gazed on crop residues which are off poor quality.

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### 3.4.Data source/ Data Collection

Data used in this study were obtained from the Tanzania Livestock Research institute farm, southern highland zone collected during the project implementation duration. The data comprised weights at birth of Friesian, F1 and 75%, A total of 160 birth weight were recorded at birth of cattle calved between 2013 – 2022. In addition, calves' number were recorded, breed of calves, sex. Season /month calves born and a year of birth.

### 3.5.Statistical analysis / Data analysis

BWT data obtained were analyzed using General Linear Model (GLM) procedure of the SAS Differences amongst means of a trait for different factors were analyzed by PDIFF/SAS. The following statistical model was employed for analysis:

$$Yijkl = \mu + Bi + Sej + Sk + Yl + eijkl$$

Where Yijkl = is dependent variable, μ = is overall mean, Bi = fixed effect of the breed, Se = fixed effects of sex, Sk= fixed effect of season of birth, Yl = fixed effect of Year a calf born, eijkl = random error term

## 4. Results and discussion

### 4.1.Influence of breed on birth weight

The least squares mean of weight at birth in Friesian, F1 (Friesian x Fipa) and 75% Friesian x Fipa crossbred calves were 25.51±0.98 kg, 26.45 ± 1.23 and 25.26 ± 0.94 respectively. FI crosses had a slightly higher weight than Friesian breed and 75% Friesian x Fipa crosses, normally pure breed has higher birth weight this difference can be due to the factor that pure breed is less adopted to harsh condition, disease and are pest intolerance, and need higher substantial amount of feeds hence under grazing condition in the tropical conditions they under perform in term of reproduction and production performance (Mwambene et al., 2012). From table one it is obvious that as the exotic blood increase to 75% the weight at birth decreases as well. On other hand these BWT were higher as compared to other cross breeds BWT reported elsewhere as a report of (23.9kg) Sanga × Friesian cattle in Ghana, (Apori and Hagan 2014). Kibwana et al. (2015) reported a weight at birth of 23.8 kg in non-supplemented group of animals and 24.8 kg in supplemented group in DRC, In Ethiopia Haile et al. (2011) reported 26

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kg in Friesian × Boran. More over these mean weights at birth were slightly lower as compared to other crossbreds reported (28.03 kg) (Mandal and Sachdeva 1999) (28.4 kg) (Muhammed et al. 2015), Segura-Correa et al. 2017 reported33.3 kg birth weight in Brown Swiss × Guzerat in Mexico. in New Zealand which is temperate condition and cattle are highly supplemented exotic breeds noted to have higher birth weight as reported the BWT of (38.4kg female Friesian and 41.8kg male Friesian) (Hickson et al., 2015).

**Table 1.** Effect of breed, sex, season, and year of birth on body weight at birth

| Factor | | Birth weight (lsm) |
|---|---|---|
| **Breed** | CrossF1 | 26.45 ± 1,23 |
| | CrossF2 | 25.26 ± 0.94 |
| | Friesian | 25.51 ± 0.98 |
| **Sex** | Female | 24.81 ± 0.52[b] |
| | Male | 26.67 ± 0.48[a] |
| **Season** | Wet | 25.80 ± 0.37 |
| | Dry | 25.48 ± 0.61 |
| **Year** | 2013 | 22.77 ± 1.46[b] |
| | 2014 | 20.14 ± 1.85[b] |
| | 2020 | 29.08 ± 0.77[a] |
| | 2021 | 28.31 ± 0.78[a] |
| | 2022 | 28.39 ± 0.83[a] |

Note, a,b Values within each subclass with different superscripts differ significantly (*P≤0.05*), N=160.

### 4.2.Sex of calf and year of birth

Sex of calf and year of birth had a significant (P<0.005) effect on body weight at birth, with males being heavier than the female by 1.86 kg of the mean body weight at birth. Similar results were reported by Kayastha et al. (2008), Olson et al. (2009) on crossbred cattle and Singh et al. (2011). There many factors influencing such as the size of maternal environment of a dam, parity or this superiority in BWT might be due to higher androgen hormone intensity of male fetus serum (Manzi et al. 2012).

### 4.3. Seasons influence on birth weight

Season had no significant effects but mean weight at birth of calves born in wet season were slightly higher compared to birth weight of calves born in dry period, limited availability of

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quality of forages for the grazing cattle during the dry season may influence negatively cattle nutritional status, hence affecting the availability of nutrients for foetal development. Kuralkar et al. (2005) also observed significant influence of season of calving on birth weight. It was observed that calves born during 2020-2022 were heavier than those born during 2013-2014. This variation in birth weight due to year could be attributed to availability of quality feeds on grazing areas and variation on management conditions over the years (Bilgic and Alic, 2004) reported Similar results for the effect of years on birth weight, under this study no any agronomic practice applied to improve natural pasture in grazing area thus pasture is of poor quality, and in the dry season there are scarcity of pasture in the grazing land. In a year with long dry period, feeds quality and availability are impaired as well.

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## 5. Conclusion and recommendation

The results of this study indicate that year of birth and sex of calf were associated with variation in mean birth weight in all Friesian, Friesian and Fipa crosses had a higher BWT compare to Friesian and 75%. This indicates the inheritance of the desired descriptors and values of Friesian and Fipa by F1(e.g. tolerance to harsh condition and requirements of low inputs). Hence there is a need to continues (searching for fund to support the programme) implementing this cross-breeding programme and collection of reproduction and production data which will be used for selection of individual animals within these breed groups for cross-breeding programme and genetic stabilization in the future.

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## References


Apori, S.O. and Hagan, J.K., 2014. The effect of non-genetic factors on the reproductive performance of Sanga and Friesian x Sanga crossbred dairy cattle breeds kept under hot and humid environment. Tropical Animal Health and Production, 46, 1045–1050.

Assan, N., Makuza, S., Mhlanga, F., & Mabuku, O. (2002). Genetic Evaluation and Selection Response of Birth Weight and Weaning Weight in Indigenous Sabi Sheep. Asian-Australasian Journal of Animal Sciences, 15(12), 1690–1694

Bilgic N and D Alic, 2004. Genetic and phenotypic parameter estimates of birth weight in Holstein Friesian calves. J Agric Sci (Turkey), 10: 72-75


**Comment [s121]:** 2002. references should be written as per the standards of journals

**Comment [s122]:** Alic. D

Bilgic N and D Alic, 2004. Genetic and phenotypic parameter estimates of birth weight in Holstein Friesian calves. J Agric Sci (Turkey), 10: 72-75.

Coffie, I., Kagya-Agyemang, J.K., Amposah, M. And Afriyie, A.B., 2022, Factors Influencing Reproductive and Calf Growth Performance Of Sanga Cows In The Ashanti Region, Ghana Ghanaian Journal Of Animal Science, Vol. 13 No.2, 2022

Haile, A., Joshi., B.K., Ayalew, W., Tegegne, A., Singh, A., 2011. Genetic evaluation of Ethiopian Boran cattle and their crosses with Holstein Friesian for growth performance in central Ethiopia. J Anim Breed Genet. 2011;128(2):133–40.

Hicksona RE, Zhangb IL and Naughton LR (2015) Brief Communication: Birth weight of calves born to dairy cows in New Zealand Proceedings of the New Zealand Society of Animal Production Vol 75: 257-259

Johanson, J. M., and P. J. Berger. 2003. Birth weight as a predictor of calving ease and perinatal mortality in Holstein cattle. J. Dairy Sci. 86:3745–3755

José C. Segura-Correa, Juan G. Magaña-Monforte, Jesús R. Aké-López, Victor M. Segura-Correa, José A. Hinojosa-Cuellar and Mario M. Osorio-Arce, 2017, Reed And Environmental Effects On Birth Weight, Weaning Weight And Calving Interval Of Zebu Cattle In Southeastern Mexico, Tropical and Subtropical Agroecosystems, 20 (2017): 297 – 305

Kayastha R B, Zaman G and Goswami R N. 2008. Studies on the birth weight of indigenous cattle of Assam. Indian Journal of Animal Research 42: 3.

Kibwana, D.K; Makunyavira, A.M.; Hornomic, J.L. 2015. Effect of improved feeding and housing, Friesian blood level and parity on milk production of Ankole x Friesian cows. Pakistan Veterinary Journal (2015), 35(1), 76–80.

Köhler-Rollefson, I. 2005. Indigenous Breeds, Local Communities. Documenting Animal Breeds and Breeding from a Community Perspective. Sadri, Rajasthan, India. ISBN No. 81-901624-1-1.

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**Comment [s127]:** Hicksona R.E, Zhangb I.L, Naughton L.R, 2015.

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**Comment [s133]:** 35(1), 76–80.

Kuralkar S, Ali S, Takarkhede R and Sahatpure S. 2005. Genetic analysis on birth weight in crossbred calves. Journal of Bombay Veterinary College 13(1–2): 78–80.

Mandal A and Sachdeva G K. 1999. Genetic analysis of birthweight of calves in cattle. Indian Journal of Animal Sciences 69(11): 979–80.

Manzi M, Junga J O, Ebong C and Mosi R O. 2012. Factors affecting pre and post-weaning growth of six cattle breed groups at Songa Research station in Rwanda. Livestock Research for Rural Development 24 (4): 68–70.

Muhammed E M, Mathew S, Xavier F and Naseema K T. 2015. Heritability of birth weight among crossbred cattle in Kerala under farm conditions. Journal of Indian Veterinary Association 13(1): 35–38.

Munkaosi, F. The Effect of Birth Weight on Some Economic Characteristics. Animal Breeding Abstr., 23: 1058. 1955

Mwambene PL, Katule AM, Chenyambuga SW, Mwakilembe PAA. Fipa cattle in the southwestern highlands of Tanzania: socio-economic roles, traditional management practices and production constraints. *Animal Genetic Resources/Ressources génétiques animales/Recursos genéticos animales*. 2012;51:1-14. doi:10.1017/S2078633612000112

Mwambene PL, Katule AM, Chenyambuga SW, Plante Y, Mwakilembe PAA. Fipa cattle in the southwestern highlands of Tanzania: molecular characterization. *Animal Genetic Resources/Ressources génétiques animales/Recursos genéticos animales*. 2012;51:31-43. doi:10.1017/S2078633612000392

Olson K M, Cassell B G, McAllister A J and Washburn S P. 2009. Dystocia, stillbirth, gestation length, and birth weight in Holstein, Jersey, and reciprocal crosses from a planned experiment. Journal of Dairy Science 92: 6167–71.

Oni O. O., Buvanandra V. and Dim N.I, 1988, Factors affecting birt weight and performance to weaning of Bunaji calves J. Agric Sc. Comb 11: 407 -410

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**Comment [s141]:** Olson K.M

Rege, J.E.O. & Tawah, C.L. 1999. The state of African cattle genetic resources II. Geographical distribution, characteristics and uses of present-day breeds and strains. Anim. Genet. Resour. Info., 26: 1–25. (available at ftp://ftp.fao.org/docrep/fao/012/x3565t/x3565t00.pdf).

Roschinsky, R., Kluszczynska, M., Sölkner, J., Puskur, R., & Wurzinger, M. (2015). Smallholder experiences with dairy cattle crossbreeding in the tropics: From introduction to impact. Animal, 9(1), 150–157. doi:https://doi.org/10.1017/S1751731114002079)

Sanga cattle - Wikipedia, site visited on 18th August,2024.

Segura-Correa, José C.; Magaña-Monforte, Juan G.; Aké-López, Jesús R.; Victor M.; Hinojosa-Cuellar, José A.; Osorio-Arce, Mario M. 2017 Breed and Environmental effects on birth weight, weaning weight and Calving Interval of zebu cattle in South Eastern Mexico. Tropical and Subtropical Agroecosystems, vol. 20, núm. 2, pp. 297–305

Willard, H. S. Effect of Holstein Birth Weight on Calf Gain and Final Weight. Wyoming Agr. Expt. Sta., Bull., 286: 14. 1948.

Wolf, J., Žáková, E., & Groeneveld, E. (2008). Within-litter variation of birth weight in hyperprolific Czech Large White sows and its relation to litter size traits, stillborn piglets and losses until weaning. Livestock Science, 115(2-3), 195- 205. doi: https://doi.org/10.1016/j.livsci.2007.07.009

**Comment [s142]:** 2015.

**Comment [s143]:** 2017.

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