

# Impact of incomplete pedigrees on inbreeding of Boran cattle in Kenya

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## Abstract

*The livestock sector contributes 12% of the Gross Domestic Product (GDP) in Kenya. The sector plays a critical role in attainment of food security, employment, poverty eradication and traditional obligations among others. Beef production sub sector is dominated by the local breeds of cattle with a smaller percentage of exotic breeds kept in specialized farms. Most of the ranches prefer the Boran breed of cattle due to their resistance to diseases and ability to withstand high temperatures. Boran cattle play an important role in Kenya especially in the arid and semi arid lands (ASAL). Though animal recording is done by the Kenya Boran Cattle Breeders' Society (KBCBS) through the Kenya stud book (KSB), misidentification of sires occur and or have not been recorded. The estimation of inbreeding assumes that all the stated relationships are accurate. Pedigree records are stored manually by the KSB resulting in a laborious process. Five thousand pedigree records from four stud herds were evaluated for inbreeding. The estimated inbreeding coefficient was low (0.0022) for records analyzed for a 40 year period in a closed nucleus breeding scheme. The high rate of sire misidentification (5-80%) among the four stud herds together with incomplete pedigree records may have caused the low inbreeding coefficient. The study shows the importance of proper records in determination of inbreeding which may be biased in the study herds. Inbreeding has been shown to reduce viability and performance of the livestock. This will impact negatively on the efforts to improve on food security and poverty eradication strategies.*

**Key words:** Inbreeding, Boran cattle, Pedigree records, Kenya

## Introduction

The livestock sector in Kenya contributes 10 - 12% to the gross domestic product (GDP) (Mwangi & Omore, 2004; Kabubo-Mariara, 2009), of which the Boran cattle breed plays an important role (Kios *et al.*, 2011). Improving the productivity of the livestock production systems is crucial for poverty alleviation (Rege & Gibson, 2003; Scarpa *et al.*, 2003; Rewe *et al.*, 2010) and the harsh conditions of the ASAL dictates the need for the use and improvement of the local cattle breeds such as the Boran. Boran cattle are kept on large commercial ranches and breeders often make use of multiple sire mating strategies. The unavailability of information from relatives in many Boran cattle populations in combination with the manual storage of records may lead to inbreeding.

The detrimental effects of inbreeding are well documented (Fioretti *et al.*, 2002; Adamec *et al.*, 2006; Mc Parland *et al.*, 2007). Inbreeding depression leads to the decline in performance particularly with regard to fitness and productivity traits thus reducing farm profitability (Mc Parland *et al.*, 2007). Several traits that can be negatively affected include increase in the age at first insemination (0.146 - 0.623 days) and first calving (0.209 - 0.763 days) for every 1% increase in inbreeding (Fioretti *et al.*, 2002). Dam and calf inbreeding leads to increased perinatal mortality in beef cattle with incidence ranging from 3.4 – 6.3 % in first parity animals (Adamec *et al.*, 2006; Mc Parland *et al.*, 2008). There are increased effects of 0.417% and 0.252% for dystocia and stillbirths per 1% increase of inbreeding in first parity cows giving birth to male calves (Adamec *et al.*, 2006).

It has also been shown in several studies that growth is also affected by inbreeding where a decrease in growth traits of between 0.04 - 2.07 kg in live weight of beef cattle at different ages for every 1% increase in inbreeding was observed (Burrow, 1998; Fioretti *et al.*, 2002). Inbred animals have decreased carcass weight, less carcass fat and are smaller with poorly developed muscle. The decrease in carcass weight is between 0.87 - 1.90 kg per 1% increase of inbreeding (Mc Parland *et al.*, 2008). Research has shown that beef breeds kept in extensive systems, under harsh climatic conditions and feed constraints show more pronounced impact of inbreeding depression (Carolino & Gama, 2008).

Inbreeding may lead to poor survival of the Boran cattle due to decline in adaptive traits. Losses in traits of economic importance in Boran cattle due to inbreeding are of great concern to the Kenyan Boran cattle breeders. Low fertility and slow growth could lead to increased age at first calving and prolonged generation interval. This will result into low off take which leads to poor returns to the Boran cattle breeders.

The inbreeding level of the Boran cattle stud herds in Kenya has not previously been determined. Coupled with the high sire misidentification rate of 5-80% (Kios *et al.*, 2011) and the multisire mating systems practiced by the Boran cattle breeders, inbreeding coefficient may be high. The inaccurate pedigree information found in most Boran stud herds also leads to high levels of inbreeding. This has been shown to be a common problem in the livestock industry with a substantial negative impact on estimates of inbreeding coefficients and depression (Banos *et al.*, 2001; Pollak, 2005; Dodds *et al.*, 2007).

The objective of the study was to determine the levels of inbreeding in the Boran stud herds using pedigree information kept at the Kenya stud book and evaluation of factors that may influence the accuracy of detecting inbreeding in these herds.

## **Materials and Methods**

### **Study Herds**

There are 29 ranches affiliated to Kenya Boran Cattle Breeders' Society (KBCBS). KBCBS was established in 1951 with the aim of promoting and standardizing the Boran breed (KBCBS, 2010). Only 15 of the ranches register their stud herds with Kenya stud book (KSB). KSB has 34,382 breeding records of registered Boran cattle covering the period 1951 to 2007. There are three categories of pedigree records kept by KSB: foundation, purebred and pedigree records. Foundation cattle records have minimal information (if any) on both parents and may have no information on the grand parents. These are mainly records of individuals resulting from unrecorded mating and the sire may be missing from the records. Also individuals with registered parents but do not meet the stringent breed standards are registered as foundation animals or culled.

The pedigree and pure bred cattle records have complete details of parentage but differ with regard to the depth of the pedigree information over generations with pedigree cattle records being more elaborate. Pedigree cattle have ancestral records for three or more generations. The culled males are castrated for fattening and all culled animals (bulls and heifers) are not registered or recorded with KSB. Over 50% of bulls are culled annually during inspection and most of the animals registered in KSB are females.

### **Data Collection**

Five thousand pedigree records of registered Boran cattle from four Boran stud herds, members of the KBCBS and KSB were used in this study for estimation of inbreeding coefficients. The records were for cattle born between 1972 and 2007. The records included; registration number, date of birth and sex of the animal, sire, dam, grand sire, grand dam and great grand sire and dam. The pedigree records were accessed with the permission of KSB, KBCBS and Kenya Livestock Breeders Organization (KLBO) and stored in excel sheets for analysis.

### **Statistical analyses**

The five thousand pedigree records were checked for completeness, errors and duplication with dBase plus software (dataBased Intelligence, 2004). Five hundred and forty four records were excluded from the final analysis due to duplication, incorrect date of birth or sex. These included parents born later than their offspring and records where sires were entered as dams or dams as sires.

The records were then analyzed to determine the inbreeding coefficient and the rate of inbreeding per generation. The inbreeding coefficient (F) was calculated using Proc Inbreed procedure of SAS software (2007) and verified with Animal Breeders Toolkit software (ABTK) (Golden *et al.*, 1995). The rate of inbreeding per generation was estimated by use of the Proc Inbreed procedure of SAS (2007)

## Results

The results of inbreeding coefficients analyses are presented in tables 1 and 2, showing the level of inbreeding, co-ancestry, distribution of inbreeding and the number of animals at each level of inbreeding. The study showed inbreeding coefficient of 0.0022 (0.22%) with most of the animals (96.4 – 96.8%) having zero inbreeding coefficients and only between 3.2 and 3.6% were inbred. The inbreeding coefficients of male animals in generations 1 to 3 and females in generation 1 and 2 were zero.

**Table 1: Inbreeding coefficients of the four study herds**

	Male x Male	Male x Female	Female x Female	All Animals
Inbreeding	0.0019(0.19%)	0	0.0022(0.22%)	0.0022(0.22%)
Co-ancestry	0.0027(0.27%)	0.002(0.2%)	0.0016(0.16%)	0.0018(0.18%)

Between 10 and 12 animals had inbreeding coefficients of more than 15% and only 3.2 to 3.6% of the animals in the study herds were inbred.

**Table 2: Distribution of inbreeding coefficients in the four study herds**

Inbreeding coefficients %	0	<5	5 to 10	10 to 15	>15
Number of Animals (SAS)	4283	76	44	24	12
%	96.4	1.8	1	0.5	0.3
Number of Animals (ABTK)	4697	75	44	25	10
%	96.8	1.6	0.9	0.5	0.2

SAS: Statistical Analysis Software, ABTK: Animal Breeders Toolkit Software

The results of inbreeding over generations for the four study herds are presented in table 3 showing inbreeding coefficients per generation for each sex and over sex. Animals in generations one and two were not inbred and inbreeding of females was detected from generation three with a slight increase in trend over the generations. Inbreeding in males was only detected at the fifth generation (Table 3).

**Table 3: Inbreeding coefficients of the four study herds over five generations**

<b>Generation</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
Male x Male	0	0	0	0	0.0011
Male x Female	0	0	0	0	0
Female x Female	0	0	0.0004	0.0003	0.001
Over sex	0	0	0.0003	0.0002	0.001

## **Discussion**

Most of the animals in generation 1 to 3 had none or little information on their parents and ancestors and this may have contributed to the low inbreeding coefficient. 50% of the records analyzed were in the category of foundation, a common feature in Boran cattle pedigree information. A total of 18,548 out of 34,382 (54%) Boran pedigree records at KSB are foundation records (KLBO, 2010). Foundation cattle records have minimal information on both parents and may have no information on the grand parents.

The overall inbreeding coefficient (0.22%) was much lower compared to findings of 0.25 to 3.13% by Gutierrez *et al.*, (2003) and 0.54 to 2.19% by Mc Parland *et al.*, (2007). The results in consideration of the high rate of sire misidentification (5-80%) (Kios *et al.*, 2011) and incomplete pedigree information may be grossly underestimated and may not reflect the actual inbreeding of these herds. This was below the expected in a closed nucleus breeding scheme that has been in existence for over five generations. This was anticipated due to lack of complete pedigree information of animals in generations 1 to 3. Pedigree information of Boran stud herds are processed and stored manually, a difficult task to retrieve and reconstruct complete pedigree information. The results of inbreeding based on SAS (2007) and ABTK (Golden *et al.*, 1995) were similar.

It has been shown that the inbreeding coefficient of an individual is sensitive to the accuracy and completeness of the available pedigree information (Mc Parland *et al.*, 2007). Missing information of the maternal grand dam of an individual in an otherwise complete pedigree would eliminate 39.6% of information available to detect inbreeding (Cassell *et al.*, 2003). The inclusion of unknown parental groups increases the number of animals with low inbreeding as they are assumed to be unrelated (Wiggans *et al.*, 1995). Missing pedigree information of the parent will lead to the inbreeding coefficient to be estimated at zero, though the missing ancestors may not be less related than the general population. It is critical to maintain accurate, complete pedigree information of several generations for ease of estimation and control of inbreeding.

Boran stud breeders usually practice a closed nucleus breeding scheme providing their own female replacements and breeding bulls with minimal introduction of animals from commercial herds (Rewe *et al.*, 2010). This practice will increase the rate of inbreeding if proper pedigree record keeping and planned mating is not done. Inbreeding affects estimates of genetic evaluations and may lead to increased overestimation of reliability under the animal model (Wiggans *et al.*, 1995).

Under estimated inbreeding in Boran cattle may lead to few embryos harvested per donor and may affect embryo export program of the Boran cattle breeders. It has also been demonstrated that genetic homogeneity compromises the quality of embryos in super ovulated cows. There is a decrease in the number of transferable embryos in cows with more than 9% inbreeding coefficient (Alvarez, *et al.*, 2005).

Boran cattle play an important role in the enhancement of the livelihoods of most livestock keepers in Kenya and increasingly in other parts of the world. Due to the growing importance of the breed and the threat of inbreeding, there is an urgent need to increase the accuracy of the pedigree information. Accurate pedigrees will have a positive effect on the response to selection and assist in control inbreeding.

### **Conclusion**

Though the inbreeding coefficient of the Boran study herds is low, incomplete pedigree information and high rate of sire misidentification may have masked the true rate of inbreeding and the results should be viewed with caution. Further work, using other methods including molecular techniques will ascertain the level of inbreeding in Boran cattle. The genetic improvement of this breed is paramount for continuous sustainability of the superior qualities it's associated with.

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### **References**

- Adamec, V, Cassell, B G, Smith, E P & Pearson, R E 2006. Effects of inbreeding in the dam on dystocia and stillbirths in U.S Holsteins. *Journal of Dairy Science* 89:307–314.
- Alvarez, R.H., Barbosa da Silva, M.V.G., Carvalho, J.B.P & Binelli, M., 2005. Effects of inbreeding on ovarian responses and embryo production from superovulated Mantiquiera breed of cows. *Theriogenology* 64: 1669-1676.
- Banos, G, Wiggans, G R & Powell, R L 2001. Impact of paternity errors in cow identification on genetic evaluations and international comparisons. *Journal of Dairy Science* 84: 2523 – 2529.
- Burrow, H.M 1998. The effects of inbreeding on productive and adaptive traits and temperament of tropical beef cattle. *Livestock Production Science* 55: 227 – 243.
- Carolino, N & Gama, L T 2008a. Inbreeding depression on beef cattle traits: Estimates, linearity of effects and heterogeneity among sire-families. *Genetic Selection and Evolution* 40: 511–527.

- Cassell, B G, Adamec, V & Pearson, R E 2003. Effect of Incomplete Pedigrees on Estimates of Inbreeding and Inbreeding Depression for Days to First Service and Summit Milk Yield in Holsteins and Jerseys. *Journal of Dairy Science* 86: 2967 – 2976.
- Dodds, K G, McEwan, J C & Davis, G H 2007. Integration of molecular and quantitative information in sheep and goat industry breeding programmes. *Small Ruminant Research* 70: 32-41.
- Fioretti, M, Rosati, A, Pieramati, C & Van Vleck, L D 2002. Effect of including inbreeding coefficients for animal and dam on estimates of genetic parameters and prediction of breeding values for reproductive and growth traits of Piedmontese cattle. *Livestock Production Science* 74: 137–145.
- Golden, B L, Snelling, W M & Mallinckrodt, C H 1995. *Animal Breeder’s Tool Kit 2.0. User’s Guide and Reference Manual*. Department of Animal Sciences, Colorado State University, Fort Collins.
- Gutiérrez, J P, Altarriba, J, Díaz, C, Quintanilla, R, Canon, J & Piedrafita, J 2003. Pedigree analysis of eight Spanish beef cattle breeds. *Genetic Science and Evolution* 35: 43 – 63.
- Kabubo-Mariara, J 2009. Global warming and livestock husbandry in Kenya: Impacts and adaptations. *Ecological Economics* 68: 1915 – 1924.
- KBCBS 2010. Boran cattle breeders’ society of Kenya, <http://www.borankenya.org/home.htm>
- Kios, D K, Van Marle-Köster, E & Visser, C 2011. Application of DNA markers in parentage verification of Boran cattle in Kenya. *Tropical Animal health and Production* DOI 10.1007/s11250-011-9921-2
- KLBO 2010. Kenya livestock breeders’ organization. <http://www.agro-info.net/?view>
- Mc Parland, S, Kearney, J F, MacHugh, D E & Berry, D P 2008. Inbreeding effects on post weaning production traits, conformation and calving performance in Irish beef cattle. *Journal of Animal Science* 86: 3338-3347.
- Mc Parland, S, Kearney, J F, Rath, M & Berry, D P 2007. Inbreeding trends and pedigree analysis of Irish dairy and beef cattle population. *Journal of Animal Science* 85: 322-331.
- Mwangi, D M & Omore, A 2004. The livestock revolution. A view on implication for Africa. In *Responding to the livestock revolution*, British Society of Animal Science 33: 51 – 66.
- Pollak, E J 2005. Application and impact of new genetic technologies on beef cattle breeding: a “real world” perspective. *Australian Journal of Experimental Agriculture* 45, 739-748.
- Rege, J E O, & Gibson, J P 2003. Animal genetic resources and economic development. Issues in relation to economic valuation. *Ecological Economics* 45: 319 – 330.
- Rewe, T O, Herold, P, Piepho, H-P, Kahi, A K & Valle Zárate, A 2010. Genetic and economic evaluation of a basic breeding programme for Kenya Boran cattle. *Tropical Animal Health Production* 42:327–340.
- Scarpa, R, Ruto, E S K, Kristjanson, P, Radeny, M, Drucker, A G & Rege, J E O 2003. An empirical comparison of stated and revealed preference value estimates. In *Valuing indigenous cattle breeds in Kenya*. *Ecological Economics* 45: 409 – 426.

Wiggans, G.R., VanRaden, P.M. and Zurbier, J., 1995. Calculation and Use of Inbreeding Coefficients for Genetic Evaluation of United States Dairy Cattle. *Journal of Dairy Science* 78, 1584-1590.