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Phenotypic Characterisation of Selected South African Beef Cattle Breeds: A Systematic Review

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ABSTRACT

The phenotypic characteristics of livestock are very fundamental in describing the uniqueness of animal genetic resources. Phenotypic characteristics of South African beef cattle breeds are poorly understood. The objective of this study was to systematically review phenotypic characterization of Nguni, Bonsmara, Afrikaner and Sussex cattle breeds. Databases such as Google Scholar, PubMed, ScienceDirect, and Web of Science were assessed systematically using the combination of the following key terms: "Sussex, Nguni, Afrikaner and Bonsmara and phenotypic characterization or morphological characterization". The keywords were combined in various combinations. The results were limited to English language papers only and no restrictions on the year of publication. Overall, a total of 23 eligible studies were found published between year 2004 and 2022 in South Africa, United Kingdom, New Zealand and Indonesia. The results showed that from the 23 eligible articles, 20 articles were predominantly from South Africa meanwhile one article was from United Kingdom, New Zealand and Indonesia respectively. Whilst, three articles, revealed that white colour was common in the coat of three selected South African cattle breed (Afrikaner, Nguni and Sussex). Furthermore, four articles from the results on horn presence indicated that both horn and poll strain were naturally present in four selected cattle breeds. While three articles on quantitative results showed that birth weight on three cattle breeds ranges from 33 and 37kg. While on the other hand male Nguni cattle animals reported a higher ear length as compared to female animals. This, systematic review concludes that the selected South African cattle breeds are phenotypically different from each other as much as there are some little similarities in some traits. This review brings evidence that South African cattle breeds are phenotypically diverse in terms of body size and structure. Therefore, this information of phenotypic traits in South African cattle breeds might be used when developing breeding program. Lastly, this systematic review suggests more future studies in other South African cattle breeds to identify phenotypic characterization.

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Key words
Coat colour, Horn presence, Birth weight, Body length, Weaning weight, Cattle breed, Sussex, Ngumi, Afrikaner Bonsmara

INTRODUCTION

Beef cattle farming plays a very vital role in many countries' economy through job creation and is of cultural importance in many communal areas (Tyasi *et al*., 2020). In South Africa, the red meat industry revealed a foremost role in beef cattle production, with more than 70% of beef cattle slaughtered in the formal sector originating from commercial feedlots (Grobler *et al*., 2018). The phenotypic characteristics of livestock are very important in describing the uniqueness of animal genetic resources (Tyasi *et al*., 2020). There are several studies examined the phenotypic characteristics of South African cattle breeds focusing on qualitative and quantitative traits. Qualitative traits such as coat colour in Nguni (Sanarana *et al*., 2016), Bonsmara (SA Studbook and Animal Improvement Scheme, 2004), Afrikaner (Bareki, 2019) and Sussex (Bila, 2019), and horn presence in Nguni (Sanarana *et al*., 2016), Bonsmara (SA Studbook and Animal Improvement Scheme, 2004), Afrikaner (Bareki, 2019) and Sussex (Bila, 2019). Quantitative traits such as birth weight, weaning weight and yearling weight in

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Nguni (SA Studbook and Animal Improvement Scheme, 2004), Bonsmara (SA Studbook and Animal Improvement Scheme, 2004), Afrikaner (Bareki, 2019) and Sussex (Bila *et al*., 2021), and hip height, sternum height, withers height, body length, rump length, rump width, hindquarters width, heart girth and ear length in Nguni (Tyasi *et al*., 2020; Hlokoe and Tyasi, 2022) and Sussex cattle breeds (Bila, 2019). Even though there are studies that have discussed the phenotypic characteristics of Nguni, Bonsmara, Afrikaner and Sussex breeds, there is no systematic review documented in South African context. Hence, the objective of this study was to systematically review the phenotypic characterisation of selected South African cattle breeds such as Nguni, Bonsmara, Afrikaner and Sussex breeds. Lastly, this systematic review will help researchers and beef cattle farmers to understand the phenotypic structure of their animals.

MATERIALS AND METHODS

Eligibility criteria

Identification of the population, exposure, and outcomes (PEO) components of the research question were performed for this systematic review as described by Bettany-Saltikov (2010). The beef cattle was defined as the population of the study, with the Sussex, Nguni, Afrikaner and Bonsmara as exposure and phenotypic characterization or morphological characterization as outcomes. Before deciding to conduct the study, a preliminary search of the PEO components on Science Direct was conducted.

Search strategy

All the investigators independently performed a publication search in the databases up to the 24th of March 2023, using the combination of the following key words: South African beef cattle breeds, Sussex, Nguni, Afrikaner, Bonsmara cattle breeds, phenotypic characterization, and morphological characterization. Keywords were combined in various combinations. Lastly the results were limited to English language papers only. This search was organised following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) as explained by Moher *et al*. (2009).

Inclusion criteria

All the retrieved articles were screened for eligible studies according to several standards and were considered eligible if they met the following criteria: South African beef cattle breed, phenotypic characterization or morphological characterization. Secondly, keywords such as South African beef cattle breeds being Sussex, Nguni, Afrikaner and Bonsmara were used for searching articles.

Exclusion criteria

The exclusion criteria of the current study contained: Eight duplicate records four records irrelevant to South African beef cattle breeds, Sussex, Nguni, Afrikaner and Bonsmara four articles papers with no animal breed mentioned in the publications and with authors failing to be contacted, and six studies which were in the form of an abstract without the full text of the article. Overall, the research papers were narrowed in the study to 23 research papers which were used and cited.

Data extraction

All the three investigators independently extracted the data of the current study, and a consensus was reached concerning all items. The information obtained from each article consisted of the first author, year of publication, cattle breed and country.

RESULTS

Searched results

A total of hundred and fifty articles were retrieved through a publication search. About eight of these articles were duplicates that were removed. As a result, a total of hundred and forty-two were considered appropriate for the selection of title and abstract. Another six were eliminated after a review of the title and abstract, and one hundred and fifteen were eliminated after a review of the full text with reasons stated in Figure 1. Finally, a total of twenty-three full-text articles qualified for inclusion in the study.

Characteristics of included studies

The twenty-three articles identified as meeting the criteria were evaluated and considered appropriate for inclusion as shown in Table I. The studies used in this systematic review were published between year 2004 (Annelie and SA Studbook and Animal Improvement Scheme) and 2022 (Nguni Cattle Breeders Society South Africa). However, most studies included ranged from 2011 to 2022, with about fifteen studies from 2011 to 2020 and four studies from 2021 to 2022. Lastly two studies were published in year 2011, two in year 2014 and one in year 2021.

Publication by country

Figure 2 show the number of publications used per country. The results showed that studies were from four different countries, South Africa being on top with twenty studied which accounted 87%. Meanwhile on the other hand United Kingdom, New Zealand and Indonesia had one study which was enough to account 4% in the studies used, respectively.

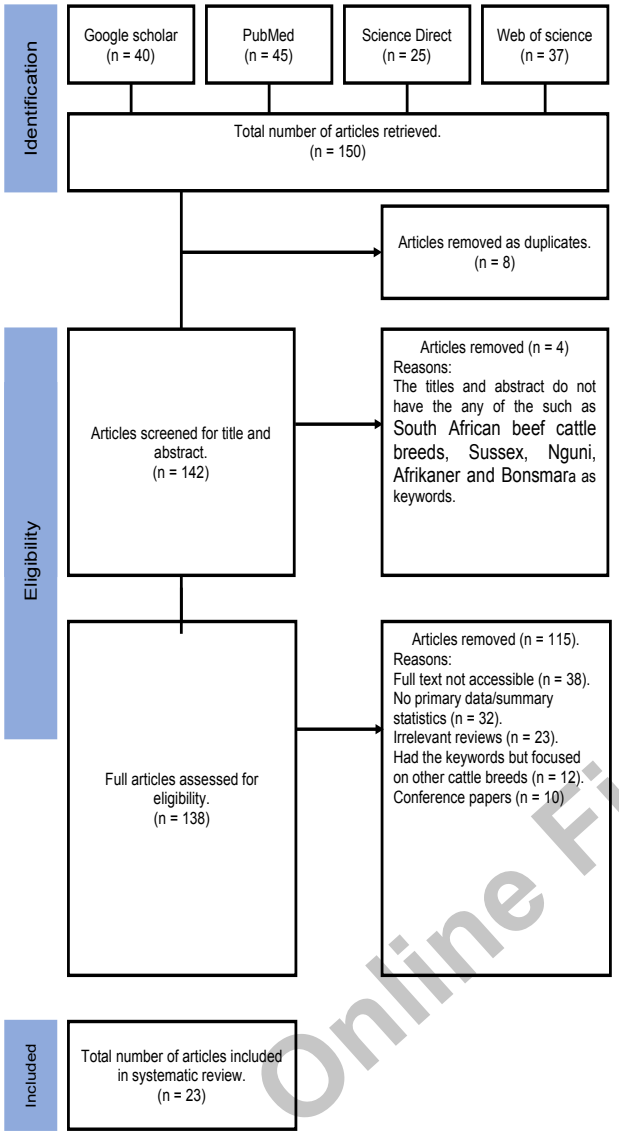

Fig. 1. Flowchart of identification and selection of studies for systematic review.

Origin of selected South African cattle breeds

Table II below present the origin of the selected South African cattle breeds used in this systematic review. The results showed that studies reported two cattle breeds originating in South Africa which accounted 50% of the selected cattle breeds used in the study while one cattle breed was reported to originate in North Africa which accounted 25% of the cattle breeds used. Lastly, results showed that only one cattle breed was reported to originate outside the African geographic area (England) which was enough to account 25% of the selected cattle breeds in the study.

Table I. Characterization of included studies.

Authors	Country	Breed
Annelie (2014)	South Africa	Sussex
Banga *et al.* (2016)	South Africa	Nguni
Bareki (2019)	South Africa	Afrikaner
Bergh *et al.* (2010)	South Africa	Nguni
Bila (2019)	South Africa	Sussex
Bila *et al.* (2021)	South Africa	Sussex
Boligon *et al.* (2012)	Indonesia	Afrikaner
BCBS (2022)	South Africa	Bonsmara
Grobler *et al.* (2018)	South Africa	Bonsmara
Horsburgh (2013)	New Zealand	Nguni
Hlokoe and Tyasi (2022)	South Africa	Nguni
Mapholi *et al.* (2011)	South Africa	Nguni and Bonsmara
Mapholi *et al.* (2014)	South Africa	Nguni and Bonsmara
Marufu (2011)	Southern Africa	Nguni and Bonsmara
Mwai (2015)	United Kingdom	Afrikaner and Nguni
Muller *et al.* (2006)	South Africa	Afrikaner and Nguni
NCBS (2022)	South Africa	Nguni
Piener *et al.* (2014)	South Africa	Afrikaner
Ramalatsona (2014)	South Africa	Afrikaner
SAS-AIS (2004)	South Africa	Sussex, Nguni, Afrikaner and Bonsmara
Sanarana *et al.* (2016)	South Africa	Nguni
Tyasi *et al.* (2020)	South Africa	Nguni
Van de Pypekamp (2013)	South Africa	Nguni

SAS-AIS, SA Studbook and Animal Improvement Scheme; BCBS, Bonsmara Cattle Breeders Society; NCBS, Nguni Cattle Breeders Society, South Africa.

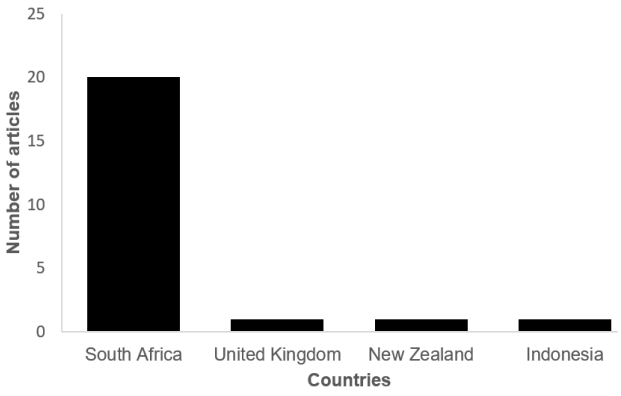

Fig. 2. Publications by country.

Table II. Origin of selected south African cattle breeds.

Authors	Breed	Country of origin
Bareki (2019)	Afrikaner	South Africa
SAS-AIS (2004)	Bonsmara	South Africa
Sanarana *et al*. (2016)	Nguni	North Africa
Bila (2019)	Sussex	England

SAS-AIS, SA Studbook and Animal Improvement Scheme.

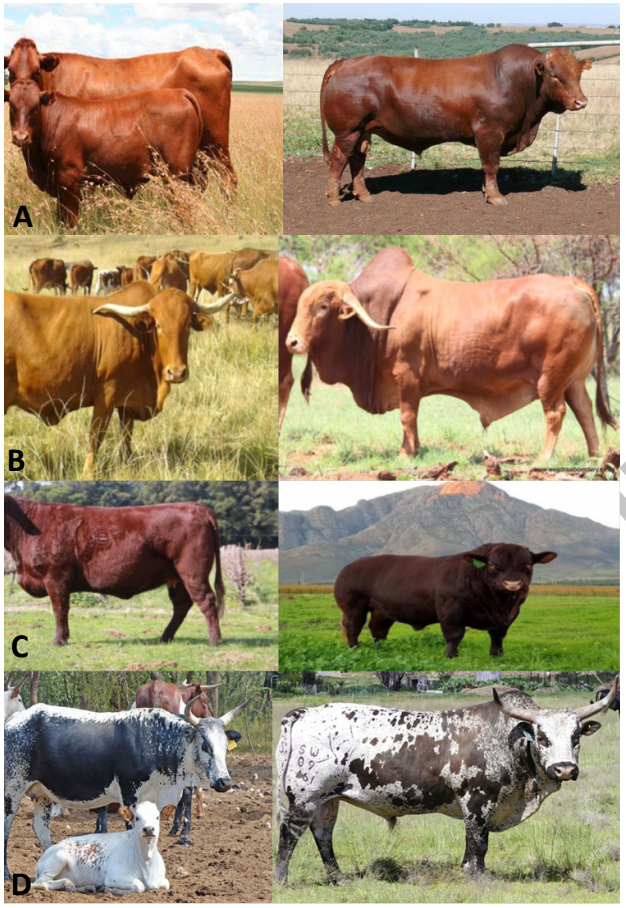

Fig. 3. Coat colour of selected South African cattle breeds. (A) Bonsmara, (B) Afrikaner, (C) Sussex, (D) Nguni.

Coat colour of selected South African cattle breeds

Results of coat colour on selected South African cattle breeds are presented in Table III and Figure 3. All the reviewed articles indicated that the colour red was common in the four (n = 4) selected South African cattle breeds. However, Sanarana *et al*. (2016), Bareki (2019) and Bila (2019) showed that the white colour was common in the coat of three (n = 3) selected South African cattle breeds such as Afrikaner, Nguni and Sussex, respectively (Fig. 3B, C, D). While on the other hand, Sanarana *et al*. (2016) indicated that there are multi-colour features found in Nguni cattle breed such as red, black, white, gray, brown and brindle (Fig. 3D).

Table III. Coat colour of selected South African cattle breeds.

Authors	Breed	Coat colour
Bareki (2019	Afrikaner	Yellow, red and white
SAS-AIS (2004)	Bonsmara	Red and brown
Sanarana *et al.* (2016	Nguni	Red, black, white, gray, brown and brindle
Annelie (2014); Bila (2019)	Sussex	Red to dark-red and white

SAS-AIS, SA Studbook and Animal Improvement Scheme.

Horn presence of selected South African cattle breeds

Results of horn presence on selected South African cattle breeds are presented on Table IV. All the reviewed articles indicated that all the four selected cattle breeds (Afrikaner, Bonsmara, Nguni and Sussex) have both horn and polled strains (Bareki, 2019; SAS-AIS, 2004; Sanarana *et al*., 2016; Annelie, 2014; Bila, 2019).

Table IV. Horn presence in selected South African cattle breeds.

Authors	Breed	Horn presence	
		Horned	Polled
Bareki (2019)	Afrikaner	X	X
SAS-AIS (2004)	Bonsmara	X	X
Sanarana *et al.* (2016)	Nguni	X	X
Annelie (2014); Bila (2019)	Sussex	X	X

X = Present. SAS-AIS, SA Studbook and Animal Improvement Scheme.

Quantitative characterization of selected South African cattle breeds

The quantitative characterization of the selected South African cattle breed are presented in Table V. Three articles measured the birth weight (BW) of the animals out of 23 reviewed articles. Three articles out of four articles found BW to range between 33 and 37 kg (SAS-AIS, 2004; Bareki, 2019; Bila *et al*., 2021). One article out of four articles measured BW, weaning weight (WW) and yearling weight (YW) (Bareki, 2019). Further more, three articles measured the quantitative traits such as hip height (HH), sternum height (SH), withers height (WH), body length (BL), rump length (RL), rump width (RW), hindquarters width (HW), heart girth (HG) and ear length (EL) of the animals out of 23 reviewed articles.

Table V. Quantitative characterization of selected South African cattle breed.

Breed	Sex	Quantitative traits											Authors
		BW	WW	YW	HH	SH	WH	BL	RL	HW	HG	EL	
Afrikaner	-	33kg	191kg	225kg	-	-	-	-	-	-	-	-	Bareki (2019)
	-	-	-	-	-	-	-	-	-	-	-	-	
Bonsmara	F	35kg	-	225kg	-	-	-	-	-	-	-	-	SAS-AIS (2004)
	M	-	-	-	-	-	-	-	-	-	-	-	
Nguni	F	-	-	-	127cm	68cm	53cm	210cm	42cm	-	46cm	13cm	Tyasi *et al*. (2020), Hlokoe and Tyasi (2022)
	M	-	-	-	115cm 117cm	66cm 70cm	62cm 109cm	147cm 147cm	41cm 40cm	- -	46cm -	13cm 15cm	
Sussex	F	37kg	-	437kg	128cm	124cm	-	149cm	47cm	53cm	-	-	Bila (2019), Bila *et al*. (2021)
	M	37kg	-	-	-	-	-	-	-	-	-	-	

Sex: M, male; F, female; BW, birth weight; WW, weaning weight; YW, yearling weight; HH, hip height; SH, sternum height; WH, withers height; BL, body length; RL, rump length; RW, rump width; HW, hindquarters width; HG, heart girth; EL, ear length; kg, kilogram; cm, centimetre and -, not specified.

Two cattle breeds (Nguni and Sussex) out of four selected South African cattle breeds measured some quantitative traits. Three studies reported on some quantitative traits were published between year 2020 and 2022 (Tyasi *et al*., 2020; Bila *et al*., 2021; Hlokoe and Tyasi, 2022). One article out of three articles measured some quantitative traits in the Sussex cattle breed (Bila *et al*., 2021). The results indicated that for male and female BL of Nguni cattle breed ranges from 147cm to 210cm (Tyasi *et al*., 2020; Hlokoe and Tyasi, 2022). While Nguni cattle breed EL reported to be higher in male animals as compared to female (Tyasi *et al*., 2020; Hlokoe and Tyasi, 2022). The reports of Tyasi *et al*. (2022) and Hlokoe and Tyasi (2022) indicated that HG (46cm) was same in both gender of Nguni cattle breed. Bila (2019) reported a higher RL (47cm) in Sussex female animals whereas Nguni female animals had a lower RL (42cm). Male Nguni animals had a higher WH (109cm) as compared to WH (53cm) reported in female animals (Hlokoe and Tyasi, 2022; Tyasi *et al*., 2020). Female Sussex animals reported higher HH (128cm), SH (124cm), RL (47cm) as compared to Nguni female animals (Bila, 2019). However, Nguni female animals had longer BL (210cm) in comparison to Sussex female animals which might be due to the environment and breed differences.

DISCUSSION

Phenotypic traits can describe a continuous growth process during the life of livestock (Tyasi *et al*., 2021). Morphometric characteristics can be measured and include traits such as weight, body length, withers height, hip height, sternum height, rump length and ear length (Bila *et al*., 2021; Hlokoe and Tyasi, 2022). This systematic review was conducted to explore phenotypic characteristics of selected South African cattle breeds such as Afrikaner, Bonsmara, Nguni and Sussex. Understanding the link between phenotypic characteristics and economic important traits might help farmers and researchers in the selection of beef cattle based on phenotypic traits for the improvement of economic production traits (Annelie, 2014; Ramalatsona, 2014; Bareki, 2019; Bila *et al*., 2021). The results of this systematic review indicated that five articles out of twenty-three reviewed articles showed that the colour red was common in the coat of the four selected South African cattle breeds (SAS-AIS, 2004; Annelie, 2014; Sanarana *et al*., 2016; Bareki, 2019; Bila, 2019). Three articles out of twenty-three reviewed articles reported that birth weight ranges between 33 and 37kg (SAS-AIS, 2004; Bareki, 2019; Bila, 2019). While Tyasi *et al*. (2020), and Hlokoe and Tyasi (2022) discovered that male and female body length of Nguni cattle breeds ranges between 147 and 210cm. However, two reviewed articles (Tyasi *et al*., 2020; Hlokoe and Tyasi, 2022) reported that ear length in Nguni cattle breed was higher in male animals as compared to female animals. Based to our knowledge this is the first systematic review addressing the phenotypic characterization of Afrikaner, Bonsmara, Nguni and Sussex. Therefore, no studies might be used for comparison of our findings. Our results shows that phenotypic characterization might be used for the selection during breeding program of cattle breeds. The contribution of this systematic review to the body of knowledge is that Afrikaner, Bonsmara, Nguni and Sussex cattle breed are unique yet share some similar qualitative and quantitative measures. The limitation of this systematic review

was that out of twenty-three reviewed articles, several quantitative traits are not yet explored in Afrikaner and Bonsmara cattle breeds for better understanding of the phenotypic uniqueness of the selected breeds. Hence, it is recommended that further studies need to be done for confirmation of phenotypic characterization of Afrikaner, Bonsmara, Nguni and Sussex cattle breed using larger population size.

CONCLUSION

South African beef cattle breeds are phenotypically characterized by a wide range of horn presence, coat colours and body conformation including body length, withers height, rump width, hip height, ear length. Despite this phenotypic diversity, the selected South African cattle breeds have few traits in common. It is important to continue research in this area, not only through empirical research but also by incorporating other types of methodological designs that allow researchers a broader vision of the intervention aimed at improving local cattle breeds. Thereby providing well founded conclusions.

DECLARATIONS

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IRB approval

The experimental procedures were conducted following the University of South Africa (UNISA) Ethics code for the use of live animals in research, ethics reference number: 2022/CAES_AREC/171.

Ethical statement

Plagiarism, misconduct, informed consent, data falsification, and fabrication were considered ethical issues by all authors when performing this systematic review.

Data availability statement

The data used in this review article was acquired from a number of published scientific literature from different journals. Databases were accessed using electronic data sources such as Science Direct, Google Scholar, PubMed and Webb of Science. Lastly, the citations included in the articles from the databases were used to search for relevant literature.

Statement of conflict of interest

The authors have declared no conflict of interest.

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