

3 Breeds of Cattle

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Introduction

Since domestication began more than 8000 years ago, cattle have become adapted to widely varying geographical areas and a multiplicity of breeding purposes (meat, dairy, draught, hides, ceremonial, etc.) (Ajmone-Marsan *et al.*, 2010). Since the 18th century, this diversification has been reinforced by systematic breeding of separate subpopulations, which we have come to refer to as 'breeds'.

In its most basic form, a breed is anything that is bred. This has often resulted in groups of animals with similar physical characteristics, such as colour, horns, body type, performance, etc. In Europe, breeds are developed in a highly directed fashion by organizations that protect the purity of the breed and pursue its further improvement. These 'breed societies' originated in the UK during the early part of the 19th century (Willham, 1987) and spread to other countries, most notably in Europe and the USA.

In contrast, many (sub)tropical populations are still managed by the owners of the animals and differ gradually from neighbouring populations. However, gene flow between breeds is also

normal for the developed breeds. Many breeding societies manage similar types of cattle and exchange breeding sires. Animals from most breeds have a relatively recent common ancestry yet several herdbooks have allowed entry of animals from exotic ancestry or even large-scale crossbreeding to exotic sires from a highly productive breeds. One step further is the emergence, mainly in the New World, of several synthetic breeds that combine traits from widely divergent parental populations.

More than 1000 different breeds have been described (Mason, 1969, 1996; Felius, 1985), but this counts many national derivatives of a breed imported from its native country. A restricted number of cosmopolitan breeds with high census numbers account for a large part of the dairy and beef production. On the other hand, many local breeds with low numbers are important either historically or as a source of unique genetic material. For breeds kept under extensive management this may include an adaptation to environmental conditions such as a local disease resistance. Breeds may therefore be conserved for economic, scientific or cultural reasons.

Bos taurus* and *Bos indicus

All cattle are contained within the genus *Bos* (Hassanin, Chapter 1). Most breeds can be assigned to the species *Bos taurus* or *Bos indicus* (Felius, 1985) or are of mixed taurindicine ancestry. This assignment to two species is common in scientific circles and among cattle producers. This is in line with the divergence of their mitochondrial (Achilli *et al.*, 2009) and Y chromosomal (Nijman *et al.*, 2008) DNA and with their separate domestication events (Lenstra and Felius, Chapter 2). However, because of their cross-fertility they should formally be described as subspecies of the extinct ancestor *Bos promigenius* (Hassanin, Chapter 1).

Bos taurus cattle evolved in Mesopotamia ~10,000 years ago and migrated into Europe and Africa between 5500 and 7000 years ago, adapting to both temperate and (sub)tropical climates. The tropically adapted *Bos indicus* cattle, commonly denoted as zebu or humped cattle, emerged on the Indian subcontinent ~8000 years ago and migrated ~2500 years later to West and East Asia and then to eastern Africa. Crossbreeding of indicine bulls and taurine cows in Africa resulted in indicine admixture in the taurindicine 'Sanga', the zebu-Sanga intermediate Zenga and the African zebu (Hanotte *et al.*, 2000; Ajmone-Marsan *et al.*, 2010). Import of Iberian cattle into the Americas started late in the 15th century and adaptation for several hundred years resulted in the American Criollo cattle. Import of zebu cattle into America started in the 19th century and several Criollo breeds are now also taurindicine (Ajmone-Marsan *et al.*, 2010; Ginja *et al.*, 2010; Delgado *et al.*, 2012; McTavish *et al.*, 2013). In the last century, numerous American and Australian taurindicine breeds have been developed, which combine characteristics of *Bos taurus* and *Bos indicus* cattle.

The distinction between taurine and indicine cattle has been supported by genome-wide analysis of genetic variation as revealed by almost 50,000 single nucleotide polymorphisms (SNPs) (Bovine Hapmap Consortium, 2009). The indicine Brahman, Gir and Nelore breeds formed a group that was distinct from all taurine cattle, while the African taurine N'Dama (African, *taurus*) was separate from the European taurine breeds. The taurindicine

Beefmaster and Santa Gertrudis were intermediate between the taurine and indicine breeds. These results also indicated that many of these breeds are experiencing rapid decline in effective population size since their descent from large ancestral populations.

Categorization According to Utility and Mode of Origin

In addition to the species categorization, cattle breeds may be divided by utility. The introduction of tractors has ended the use of cattle as draught animals in most production systems, while selection for fighting abilities is restricted to the Iberian fighting bulls and the Swiss Valais or Italian Valdostana fighting cows. Systematic selection facilitated by artificial insemination has now caused many European and North American breeds to excel in either meat or milk production. Dairy breeds such as the Holstein produce much more milk than can be consumed by a calf and have become well adapted to being milked twice, or even thrice, daily. Other breeds give only enough milk to sustain a calf but have highly developed muscularity, possibly originating from their former use as a draught animal, and are now important for meat production. The different breeding histories of dairy and beef cattle were confirmed by genome-wide survey of SNP variation suggesting different dairy and beef selection signatures (Hayes *et al.*, 2008; Utsunomiya *et al.*, 2013).

Another categorization of breeds considers the mode of origin, interaction with other breeds and international status (FAO, 2007). Felius *et al.* (2014) have refined the categorization of the FAO, differentiating: (i) authentic local breeds from the 18th century or earlier; (ii) local breeds derived from 19th- or 20th-century imports; (iii) highly productive cosmopolitan breeds; and (iv) breeds maintained by crossbreeding.

Classification and Phylogeny of Breeds

A final categorization of cattle breeds is based on a comprehensive classification. Since the 19th century, several classifications have been

proposed, focusing on European breeds and based on cranial and horn morphology, colour pattern, (supposed) history, geographical origin and molecular analysis (Alderson, 1992; Felius *et al.*, 2011). **Table 3.1** shows the integrative classification emphasizing geography and, within regions, history and morphology. Worldwide, 16 major groups are recognized comprising taurine, taurindicine and indicine breeds or cattle derived from other *Bos* species. Further subdivision of the major groups results in a comprehensive account of the global diversity of cattle (Felius 1995; Felius *et al.*, 2011).

This classification is largely recapitulated by a molecular-genetic classification of European taurine cattle (**Table 3.2**). This is based on genetic distances and model-based clustering

of microsatellite genotyping (Laloe *et al.*, 2011; Edwards *et al.*, 2011; Felius *et al.*, 2011), and is in good agreement with a classification based on protein polymorphisms (Baker and Manwell, 1980) and a clustering based on 50K SNP typing (Decker *et al.*, 2009). Both classifications demonstrate for the European breeds a major subdivision in northern (integrative groups 1 and 2; genetic cluster I), central (3 and 4; II), Iberian, Podolian and Balkan cattle. Northern European cattle also differ from other European breeds owing to the predominance of the Y chromosomal haplogroup Y1 (Edwards *et al.*, 2011).

Phylogenetic trees of breeds can be constructed as done for species, but with two major differences (Lenstra *et al.*, 2012). First, differences between breeds are not based on

Table 3.1. Integrative classification of cattle breeds (Felius *et al.*, 2011).

Number	Group	Subgroups
1	Northern Polled, Celtic	Nordic Polled, Longhorned Dairy, British Polled, Celtic
2	North-Western Lowland	Lowland Red, Lowland Pied Dairy, Lowland Pied Dual-Purpose, British Shorthorn, English Lowland, Channel Island and Northwest French
3	Western-Central Highland	Vosges and Black Forest, Highland Red, Shortheaded Alpine, Central European, Yellow and Blonde, Broadheaded Spotted, Charolais
4	Highland solid-coloured	Middle French, Southwest French, Pyrenean Grey and Blonde, North Italian Fawn-Brown, Central European Brown and Grey, Illyric Shorthorn
5	Iberian	West Mediterranean isolates, Northwest Iberian and Balearic Blonde-Brown, Northwest Iberian Chestnut, Central and Southwest Iberian Black, Central and Southwestern Iberian Red and Southeastern Iberian
6	Podolian	Italian White, Italian and Croatian Podolian, East European, Balkan, Anatolian
7	Southwest Asian and Egyptian Shorthorn	Caucasian, Anatolian, Levant Shorthorns, Damascus type
8	Indo-Pakistani zebu	Central West Asian, Convex foreheaded, Shorthorned, Longhorned, Mysore, small Deshi, Himalayan
9	Central and Northeast Asian	Turuano-Mongolian, Northeast Asian, yak and yak hybrids
10	Central and South China, Southeast Asian	Chinese yellow, Chinese and Southwest Asian zebu, banteng, gayal and their hybrids
11	North and West African taurine	North African Shorthorn, Lake Chad Longhorn, N'Dama, West African Dwarf Shorthorn
12	West African zebu	Sahel Shorthorn, Sahel Longhorn
13	East African zebu	Northeast African, East African Shorthorn, Madagascar
14	Sanga and zenga	Northeast African, Central African Ankole, Southern African
15	Iberian-American	Texas Longhorn, Gulf Coast, Criollo
16	Modern American, New Zealand, Australian; bison	Original imports, taurine (British, continental, Japanese), indicine, taurindicine, crossbreds, dairy, beef, dual-purpose

Table 3.2. Molecular-genetic classification. (From Edwards *et al.*, 2011; Felius *et al.*, 2011, Table S35.)

Number	Cluster	Description
I	North European breeds	
I.1	British	British dairy and beef breeds, including also the Channel Island breed (Jersey, Guernsey), but not the Shorthorn. Jersey tends to be different from the other breeds in this group and may have apparent affinity to Podolian or Alpine grey breeds
I.2	Nordic	Authentic Norwegian, Swedish, Finnish and Baltic breeds, including both polled as long-horned (Døle, Telemark) breeds
I.3	Nordic Ayrshire	Imported Finnish Ayrshire and Ayrshire crossbreds: Norwegian Red, Swedish Red-and-White, Ringamåla, Väne
I.4	Lowland-Pied	Black- and red-pied dairy cattle originating from the northwestern European lowlands. Also includes the solid Red Flemish
I.5	Baltic Red	Solid red dairy cattle from the Baltic coasts and the German Highland. Also includes the Russian Suksun, Byelorussian Red and Ukrainian Red Steppe
I.6	Northwest Intermediate	Cattle from northwestern Europe that are not closely related to each other, but are influenced to different degrees by surrounding breeds: Shorthorn, Maine-Anjou (similar to Shorthorn), Bretonne-Pie Noir, Normande, Parthenaise (close to southern French breeds), Vosges, Charolais. Charolais clustered with south French breeds and Vosges with central western breeds in a 50K SNP analysis (Decker <i>et al.</i> , 2009; Gautier <i>et al.</i> , 2010)
I.7	Eastern crossbred	Russian breeds heavily influenced by western breeds: Istoben (influenced by Lowland Black- and Red-Pied), Kazakh Whiteheaded (influenced by Hereford), Ukrainian Whitehead (influenced by Groningen Whiteheaded), Bestuzhev (influenced by several breeds)
I.8	Eastern	Russian and Siberian breeds: Kholmogory, Pechora (both influenced by I.4), Kalmyk, Yaroslav, Yakut
II	Central European cattle	
II.1	Central Western	Includes four subtypes (II.1.1–4) and Hinterwald; SNP data suggest inclusion of Charolais and Vosges
II.1.1	Central Spotted	Central European spotted dairy cattle with Simmentaler as prototype breed from which several other breeds have been derived
II.1.2	Central Blonde	Carinthian and Waldviertel Blonde, genetically close to the Central Spotted
II.1.3	West Alpine	French Alpine, Swiss Valais (Wallis) and Italian Valdostana breeds, AustrianTux-Zillertaler
II.1.4	Central Yellow	German Yellow breeds, Murbodner, Portuguese Minhota
II.2	South French	Southern French beef breeds and the Spanish Pirenaica, which is also influenced by Iberian cattle
II.3	Central Brown	Brown Swiss dairy cattle and derived breeds in Germany, Italy and Spain; including Murnau-Werdenfelder
II.3.1	Spanish Brown	Spanish breeds derived from Central Brown: Bruna dels Pirineus, Parda Montana and Serrana de Teruel

Continued

Table 3.2. Continued.

Number	Cluster	Description
II.4	Central Grey	Tyrolean Grey, Grigia Alpina
II.5	Central Eastern	Pinzgauer, Pustertaler, Cika
III	Iberian cattle	Authentic and morphologically diverse Spanish and Portuguese breeds. Relationships with the Mallorquina and Menorquina are unclear owing to the high degree of inbreeding of both Balearic breeds. The feral Betizu is genetically between the Iberian and southern French cattle. Contains regional clusters of breeds:
III.1.1	Cantabrian	Tudanca, Monchina, Betizu
III.1.2	Andalusian	Andalusian breeds: Berrenda, Cardena, Marismaña, Mostrenca, Pajuna, Fighting cattle (Lidia, Brava)
III.1.3	Iberian Black	Avileña, Morucha, Negra Andaluza, Preta
III.1.4	Morenas	Alistana, Barrosa, Cachena, Frieiresa, Caldelana, Limiana, Marinhoa, Maronesa, Mirandesa, Vianesa
III.1.5	South Portuguese Red	Alentejana, Garvonesa, Mertolenga
IV	Podolian cattle	Steppe cattle, presumed to originate from the Podolia region. Contains also Ukrainian Grey, Turkish Grey and Chianina
V	Balkan and Southwest Asian taurine cattle	Authentic taurine cattle smaller and less developed than most European breeds; Busha, Anatolian and Caucasian cattle

substitutions, but on differences in frequencies of alleles, most of which are shared by the breeds. Second, unlike well diverged species, breeds may keep interacting long after their divergence, which invalidates the hierarchical, tree-like phylogenies by introducing reticulations. Nevertheless, neighbour-joining trees are still popular as convenient, if incomplete visualizations of the breed phylogeny. Reticulations may be visualized by phylogenetic networks as in the NeighborNet graphs (see Fig 3.1).

After an early tree based on protein polymorphisms (Baker and Manwell, 1980), phylogenetic trees and networks of microsatellite genetic distances have been published for representative Asian, African and European (Cymbron *et al.*, 2005), British (Wiener *et al.*, 2004), Danish (Withen *et al.*, 2011), North Eurasian (Kantanen *et al.*, 2000; Li and Kantanen, 2010), Polish (Grzybowski and Prusak, 2004), French (Moazami-Goudarzi *et al.*, 1997; Maudet *et al.*, 2003), Alpine (Del Bo *et al.*, 2001), Iberian (Martín-Burriel *et al.*, 2007, 2011), Italian (D'Andrea *et al.*, 2011), Slovenian (Simcic *et al.*, 2013) Balkan (Medugorac *et al.*, 2009), Southwest Asian (Loftus *et al.*, 1999), Indian

(Shah *et al.*, 2012), Chinese (Zhang *et al.*, 2007), African (Moazami-Goudarzi *et al.*, 2001; Freeman *et al.*, 2004; Ibeagha-Awemu *et al.*, 2004; Zerabruk, 2012), Brazilian (Egito *et al.*, 2007), Cuban (Acosta *et al.*, 2013) and American (Delgado *et al.*, 2012; Martínez *et al.*, 2012) breeds. Combining several of these data with a Europe-wide database (Lenstra *et al.*, 2008) yielded a network covering most European breeds (Felius *et al.*, 2011).

Higher phylogenetic resolution has been achieved with a genome-wide analysis using 1536 SNPs for French and African breeds (Gautier *et al.*, 2007) or 50 K SNPs for a global (Decker *et al.*, 2009) and French (Gautier *et al.*, 2010) set of breeds.

These phylogenies show close relationships of recently diverged breeds as, for example, black-pied and Baltic red breeds (Withen *et al.*, 2011). However, recent genetic drift is reflected in long terminal branches (e.g. with the island breed Mallorquina and the Betizu A subpopulation, Martín-Burriel *et al.*, 2007) and obscures deeper phylogenetic relationships of the clusters of related breeds. These may be approached by pooling breeds from the same cluster as

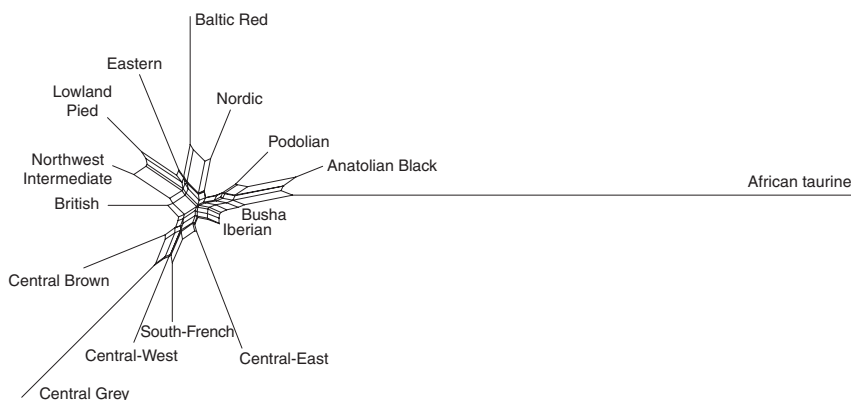


Fig. 3.1. NeighborNet graph illustrating microsatellite phylogenetic network of taurine cattle breeds.

reconstructions of the ancestral populations (Lenstra, 2008). **Figure 3.1** shows a phylogeny of Eurasian breed clusters, visualizing a genetic cline from eastern (Anatolian) to Balkan, Mediterranean and Nordic cattle, and then to the more developed breeds from central and northwestern Europe. It also shows the major subdivision of European breeds (see above).

Description of Cattle Breeds

Tables 3.3 to **3.9** give, for a selection of the cattle breeds worldwide, species origin (taurine, indicine, etc.), integrative and, for European breeds, genetic classification, category of origin, main and morphological traits (Rouse, 1970a, 1970b; Briggs and Briggs, 1980; Felius, 1985, 1995; Walker, 1989; Committee on Managing Global Genetic Resources, 1993; see also <http://dad.fao.org>, www.ansi.okstate.edu/breeds/cattle and http://en.wikipedia.org/wiki/List_of_cattle_breeds).

Where information is available, breeds are also described for the seven traits that have been used since the late 1960s for the Germ Plasm Evaluation (GPE) experiment: size, age at puberty, marbling, tenderness, lean to fat ratio, milk production and tropical adaptation (Cundiff *et al.*, 1986, 1993, 1997; Cundiff, 2003a, 2003b). Descriptors for breeds other than those in the GPE are subjective and reflect a performance that is dependent upon the environment in which the breeds are used instead of what would be achieved in a uniform environment for all breeds.

Table 3.10 provides references to research information about the most common breeds, listing for each of the papers the breeds that have been evaluated.

Plates 2–25 contain colour images of several breeds representing various breed categories.

Perspectives

The concept of a breed is likely to remain rather fluid. Several beef cattle breeds developed in North America during the 20th century and this may be indicative of a general effort to identify combinations of germplasm for use in the varied environments in which cattle are raised. These developments are, apparently, continuing. It is tempting to assume that the important breeds of today will continue to be important in the future. One has only to examine the history of breeds during the 20th century, in cattle and in other species of livestock to see the fallacy of this assumption. The evolutionary pace in both beef and dairy cattle may even speed up due to improved techniques for identification of superior genetic material such as genomic selection. This may very well create new breeds by recombining gene variants from different genetic stocks.

Acknowledgement

We thank Marleen Felius for her expert advice.

Table 3.3. Breeds from Asia.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Bengali	8	1	I	Bangladesh and Bengal, India	Asia	White, blonde, brown	Small		Tropical triple-purpose, tolerates poor food
Chinese Yellow	10	1	T, T/I, I	China	Asia	Yellow	Small		Comprising many local varieties
Dhanni	8	1	I	Pakistan	Asia	White, black spotted	Moderate		Tropical, triple-purpose
Gir	8	1, 2	I	Gujarat, India	Asia, South America	Red, red with white spots	Moderate	High	Large population in Brazil, tropical dairy
Guzerat	8	1, 2	I	India	Asia, South America	Steel-grey, black markings	Moderate-large	Moderate	Kankrej in India, tropical
Hissar	8	1	I	India	Asia	White	Moderate-large		Tropical
Krishna Valley	8	1	I	India	Asia	White	Moderate-large		Adapted to extreme conditions
Mongolian	9	1	T	Mongolia	Asia	Variable	Small		Derived from Ongole, tropical, low tenderness ^a , late puberty ^a , low marbling ^a
Nelore	8	2	I	India	South America, Australia	White, black markings	Moderate-large ^a	Moderate ^a	
Ongole	8	1	I	India	Asia	White, black markings	Moderate-large	Moderate	Tropical, work-dairy
Red Sindhi	8	1, 2	I	Pakistan	Asia, Africa, Australia	Red	Small	Moderate-high	Tropical, triple purpose
Sahiwal	8	1, 2	I	India	Asia, Africa, America, Australia	Red	Small- moderate ^a	Moderate-high ^a	Tropical, low tenderness ^a , late puberty ^a , low marbling ^a
Tharparkar	8	1	I	India	Asia	Grey to white	Moderate-large		Tropical, draught

Continued

Table 3.3. Continued.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Wagyu	9	1, 2	T	Japan	Asia, North America Europe	Both black and red strains	Small ^a	Moderate ^a	Very high marbling ^a high tenderness ^a , early puberty ^a , low lean-to-fat ^a
Xinjiang Brown	9	1	T	China	Asia	Variable	Small-moderate	Low-moderate	Derived from Hazake × Alpine Brown Mountain
Yakut	9, 1.8	1	T	Sakha Republic, Siberia	Asia	White, red or black spots	Small		Uniquely adapted to climate above polar circle

^aFor more details, see Cundiff, 2003. Breed names in bold refer to pictures in Plates 2–25.

^bcodes of integrative (Arabic numbers) and genetic (Roman followed by Arabic numbers) classifications, respectively, as in [Tables 3.1](#) and [3.2](#)

^c1, authentic local; 2, imported local.

^dSpecies: I, *Bos indicus*; T, *Bos taurus*; T/I, taurindicine.

Table 3.4. Breeds from Africa.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Abyssinian Shorthorned Zebu	13	1	I	Ethiopia	Africa	Variable	Small		Comprises several landraces adapted to the range of cool highlands to hot lowlands
Adamawa	12	1	I	Nigeria	Africa	Variable	Moderate		Bamenda in Nigeria, N'Gaoundéré in Cameroon, tropical, hanging hump
Africander	14	1, 2	S	South Africa	Africa, Australia	Red	Moderate		Tropical, moderate lean-to-fat, moderate to late age at puberty
Watusi	16	1, 2	I	DR Congo, Uganda, Rwanda, Burundi, Tanzania	Africa, North America	Dark brown, white spots	Moderate		Tropical, very large white horns, high fat milk, moderate-high lean-to-fat, tropical, in the US Texas Longhorn introgression
Arsi	13	1	I	Central Ethiopia	Africa	Variable	Small		Highland work-beef
Bonsmara	14	1, 2	T/I	South Africa	Africa, Australia, South America	Red	Moderate ^a	Moderate ^a	Afrikander–Hereford–Shorthorn hybrid, moderate lean-to-fat ^a , moderate marbling ^a
Boran	13	1, 2	I	Ethiopia	Africa, South America	White, grey, fawn, red	Moderate ^a	Moderate ^a	Tropical, low tenderness ^a , low marbling ^a , late puberty ^a , moderate lean-to-fat ^a
Brown Atlas	11	1	T	Algeria, Morocco	Africa	Brown	Small		Comprises several landraces
Butana	13	1	I	Sudan	Africa	Dark red	Moderate-large	Moderate-high	Tropical
Danakil	14	1	S	Ethiopia	Africa	Variable	Moderate-large	Moderate	Afar Sanga in Ethiopia, tropical
Dinka (Nilotic)	14	1	S	Sudan	Africa	White, also pied	Small-moderate		Tropical, very long horns
Fogera	14	1	S/I	Ethiopia	Asia	Variable	Moderate		Tropical

Continued

Table 3.4. Continued.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Kenana	13	1	I	Sudan	Africa	White	Small-moderate	Moderate	Tropical
Keteku	11	1	T/I	Nigeria	Africa	White, also black spotted	Small		Zebu–Shorthorn hybrid, tropical
Menufi	11	1	T	Egypt	Africa	Red	Small		Baladi variety, tropical
Muturu	11	1	T	Nigeria	Africa	Black and white spotted	Dwarf		Tropical, trypanotolerant
N'Dama	11	1	T	Guinea, West Africa	Africa	Fawn	Small		Tropical, trypanotolerant
Nguni	14	1	S	South Africa	Africa	Variable	Small-moderate		Amalgate of local varieties
Tuli	14	1,2	S	Zimbabwe	Africa, Australia	Yellow	Moderate ^a	Moderate ^a	Moderate marbling ^a , low tenderness ^a , moderate age at puberty ^a
White Fulani	12	1	I	Nigeria, Niger	Africa	White, also black spotted	Moderate		Tropical, triple purpose

^aFor more details, see Cundiff, 2003. Breed names in bold refer to pictures in Plates 2–25.

^bCodes of integrative classification as in Table 3.1.

^c1, authentic local.

^dSpecies: I, *Bos indicus*; S, Sanga; S/I, Zenga; T/I, taurindicine.

Table 3.5. Breeds from continental Europe.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Alentejana	5, III.1.5	1	T	Portugal	Europe	Red	Moderate-large		
Aubrac	4, II.2	1	T	France	Europe	Brown, white muzzle band	Moderate		
Belgian Blue	2, I.6	1, 3	T	Belgium	North America, Europe	White, blue roan, black pied	Moderate-large ^a	Moderate ^a	High frequency double-muscled, high lean-to-fat ^a , very low marbling ^a , moderate tenderness ^a
Blonde d'Aquitaine	4, II.2	1, 3	T	France	North America, Europe	Yellow to red	Large	Low-moderate	Recent local amalgate
Braunvieh	4, II.3	1, 3	T	Switzerland	America, Europe, Africa	Grey-brown, white muzzle band	Moderate-large ^a	Moderate-high ^a	Early-moderate puberty ^a , moderate-high lean-to-fat ^a , moderate marbling ^a
Brown Swiss	4, II.3	3	T	Switzerland	America, Europe, Asia, Africa	Light brown, white muzzle band	Large	High	American derivate of Braunvieh
Charolais	3, I.6	1, 3	T	France	America, Europe	Creamy white	Large ^a	Low ^a	High lean-to-fat ^a , late puberty ^a , low marbling ^a , low tenderness ^a
Chianina	6, IV	1, 3	T	Italy	North America, Europe	White, black points	Very large ^a	Low ^a	Podolian, high lean-to-fat ^a , late puberty ^a , low marbling ^a , low tenderness ^a , late puberty ^a
Danish Red	2, I.5	1	T	Denmark	Europe	Red	Moderate	Moderate to high	Brown Swiss, Red Holstein introgression
Danish Red and White	2, I.4	2	T	Denmark	Europe	Red and white	Moderate	Moderate	Shorthorn–Red-Pied composite

Continued

Table 3.5. Continued.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Dutch Belted	2, 1.4	1	T	Netherlands	Europe	Black and white belted	Moderate	Moderate	Hobby breed, Galloway introgression
Fighting Bull (Toro de Lidia)	5, III.1.2	1, 2	T	Spain	Europe, Latin American countries	Variable	Small-moderate		Bred for bullfighting several inbred lines
Flamande	2, I.6	1	T	France	Europe	Dark brown-black	Moderate-large	Moderate	
Fleckvieh	3, II.1.1	2, 3	T	Germany	America, Europe	Red and white, white head	Moderate-large	Moderate	Related to Simmental, dual-purpose or beef
Gelbvieh	3, II.1.2	1, 3	T	Bavaria, Germany	North America, Europe, Australia	Blond to red	Moderate-large ^a	Moderate-high ^a	Amalgate, low marbling ^a , low tenderness ^a , early puberty ^a
Holstein	2, 1.4	3	T	Netherlands	Global	Black and white, red-and-white	Large ^a	Very high ^a	Derived from Dutch Black-Pied, separate beef Friesian strain, moderate marbling ^a , early puberty ^a
Hungarian Grey	6, IV	1	T	Hungary	Europe	Grey	Large	Low	
Icelandic	1, I.2	1	T	Iceland	Iceland	Variable	Small-moderate	Moderate	Isolated since Viking import
Limousin	4, II.2	1, 3	T	France	America, Europe	Red	Moderate ^a	Low ^a	High lean-to-fat, low marbling ^a , late puberty ^a , low tenderness ^a
Maine-Anjou	4, I.6	2, 3	T	France	North America, Europe	Red and white	Large ^a	Moderate ^a	Influenced by British Shorthorn, high lean-to-fat ^a , low marbling ^a , low tenderness ^a , moderate puberty age ^a

Marchigiana	6, IV	1, 3	T	Marche, Italy	North America, Europe	White, black eye markings	Moderate-large		Podolian, moderate-high lean-to-fat, early-moderate age-puberty
Meuse-Rhine-Yssel	2, 1.4	1, 2	T	Netherlands	Europe	Red and white	Moderate-large		Ancestral to other lowland red-pied breeds
Montbéliarde	4, II.1.1	1	T	France	Europe	Red and white, white head	Moderate-large	Moderate-high	Related to Simmental
Normande	4, I.6	1, 3	T	Manche & Calvados, France	America, Europe	Red-brown spotted, pied, brindled, white face	Moderate-large	Moderate-high	Moderate-high lean-to-fat
Norwegian Red	1, I.3	2	T	Norway	Europe	Red-and-white	Moderate ^a	Moderate-high ^a	Ayrshire influence, moderate marbling ^a , early puberty ^a
Piedmontese	6	1, 3	T	Italy	North America, Europe	Grey-white, black markings	Low ^a	Low-moderate ^a	High frequency double-muscled, very high lean-to-fat ^a , low marbling ^a , moderate tenderness ^a , early puberty ^a
Pinzgauer	3, II.5	1, 3	T	Austria	North America, Europe, Africa	Red, defined white markings	Moderate ^a	Moderate ^a	Moderate lean-to-fat ^a , moderate marbling ^a , early age puberty ^a
Polish Red	2, I.5	2	T	Poland	Europe	Red	Small-moderate		Influenced by Danish Red
Romagnola	6, IV	1, 3	T	Italy	North America, Europe	Grey with black shades	Large		Podolian, high lean-to-fat, moderate age-puberty
Rotvieh (German Red)	2 or 4, I.5	1, 2	T	Germany	Europe	Red	Moderate		Influenced by Danish Red
Salers	4, II.2	1, 3	T	France	North America, Europe	Red	Moderate-large ^a	Moderate ^a	Moderate lean-to-fat ^a , low marbling ^a , moderate puberty age ^a

Continued

Table 3.5. Continued.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Simmental	3, II.1.1	1, 3	T	Switzerland	America, Europe, Asia	Red-and-white, white face, in America mostly black	Large ^a	Moderate-high ^a	Low marbling ^a , moderate puberty age ^a , moderate-high lean-to-fat ^a , in America influenced by Angus
Swedish Red and White	1, I.3	2	T	Sweden	Europe	Red and white	Moderate-high ^a	Moderate-high ^a	Moderate-high lean-to-fat ^a , moderate marbling ^a , early puberty ^a
Swedish Red Polled	1, I.2	1	T	Sweden	Europe	Red	Small		
Tarentaise	4, II.1.3	1, 3	T	France	North America, Europe	Red, white muzzle band	Moderate ^a	Moderate ^a	Moderate lean-to-fat ^a , low marbling ^a , early puberty ^a

^aFor more details, see Cundiff, 2003. Breed names in bold refer to pictures in Plates 2–25.

^bCodes of integrative (Arabic numbers) and genetic (Roman followed by Arabic numbers) classifications, respectively, as in Tables 3.1 and 3.2.

^c1, authentic local; 2, imported local; 3, cosmopolitan.

^dSpecies: T, *Bos taurus*.

Table 3.6. Breeds from Great Britain (and nearby islands).

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Angus	2, I.1	1, 3	T	Scotland	America, Europe, Australia	Black, also red strain	Moderate-high ^a	Moderate ^a	Polled, high marbling ^a , high tenderness ^a , low-moderate lean-to-fat ^a , early puberty ^a
Ayrshire	1, I.1	1, 3	T	Scotland	North America, Europe, Africa, Australia	Red-and-white	Moderate	Moderate-high	Exported to Finland, ancestral to several Scandinavian breeds
Belted Galloway	1, I.1	1, 3	T	Scotland	North America, Europe	Black with white belt	Small-moderate		Polled, curly hair
British White	1, I.1	1	T	England	Europe	White, black points	Moderate		Polled
Devon	2, I.1	1	T	England	North America, Europe	Red	Small-moderate ^a	Moderate ^a	Moderate marbling ^a , moderate tenderness ^a , moderate puberty age ^a , moderate lean-to-fat ^a
Dexter	1, I.1	1, 3	T	Ireland	North America, Europe	Black, also dun or red	Dwarf	Moderate	Ancestral to American miniature breeds, milk high in butterfat, small size by heterozygosity of chondrodysplasia mutation, bulldog calves by homozygosity
Galloway	2, I.1	1, 3	T	Scotland	North America, Europe	Black, also dun	Small-moderate ^a	Low-moderate ^a	Long, curly hair, polled, moderate tenderness ^a , moderate marbling ^a , moderate puberty age ^a
Guernsey	2, I.1	1, 3	T	Guernsey	North America, Europe	Fawn and white	Moderate	Moderate	Moderately high in butterfat, genetically largely isolated since 1789

Continued

Table 3.6. Continued.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Hereford	2, I.1	1, 3	T	England	North America, Europe, Australia	Red, white face and markings	Moderate-high ^a	Low-moderate ^a	Moderate marbling ^a , moderate tenderness ^a , moderate lean to fat ^a
Jersey	1, I.1	1, 3	T	Jersey	Global	Fawn, also pied	Small ^a	High ^a	High in butterfat, low lean-to-fat, high marbling ^a , moderate tenderness ^a , early puberty ^a , genetically largely isolated since 1789, used for dairy crossbreeding
Lincoln Red	2	1	T	England	Europe	Red	Large		Related to Shorthorn
Longhorn (English)	1, I.1	1	T	England	Europe	Red or grey colour-sided, also brindled or speckled	Moderate		Long downward horns
Red Angus	2, I.1	1, 3	T	Scotland	America, Europe, Australia	Red	Moderate-high ^a	Moderate ^a	Polled, moderate marbling ^a , moderate tenderness ^a , early puberty ^a , low-moderate lean-to-fat ^a
Red Poll	1	1, 3	T	England	North America, Europe, Africa, Australia	Red	Moderate	Moderate-high	Polled, moderate tenderness, moderate-high marbling, low-moderate lean-to-fat, early puberty
Scottish Highland	1, I.1	1, 3	T	Scotland	North America, Europe	Brown, black or red	Small		Long hair, long horns, rustic, cold adaptation

Shorthorn	2, I.6	1, 3	T	England	America, Europe, Australia	Dark red, red-and- white or roan	Moderate- high ^a	Moderate ^a	Low-moderate lean-to-fat ^a , moderate-high marbling ^a , moderate tenderness ^a , early-moderate age puberty ^a
South Devon	2, I.1	1, 3	T	England	North America, Europe	Light-red	Moderate ^a	Moderate ^a	Moderate lean-to-fat ^a , moderate-high marbling ^a , moderate tenderness ^a , early-moderate age puberty ^a
Sussex	2	1, 2	T	England	Europe, Africa	Blood-red	Small		
Welsh Black	1	1	T	Wales	Europe	Black	Moderate		
White Park	1, I.1	1, 3	T	England	Europe, North America	White with black points	Moderate		

^aFor more details, see Cundiff, 2003. Breed names in bold refer to pictures in Plates 2–25.

^bcodes of integrative (Arabic numbers) and genetic (Roman followed by Arabic numbers) classifications, respectively, as in [Tables 3.1](#) and [3.2](#).

^c1, authentic local; 2, imported local; 3, cosmopolitan.

^dSpecies: T, *Bos taurus*.

Table 3.7. Breeds from North America.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
American White Park	16	2	T	United States	North America	White with red points	Moderate		Introgressed with beef and dairy cattle
Amerifax	16	4	T	United States	North America	Red or black	Moderate-large	Moderate-high	Polled, Angus–Beef Friesian hybrid
Barzona	16	2	T/I	United States	North America	Dark red	Moderate		Africander–Hereford–Angus–Santa Gertrudis hybrid
Beefmaster	16	2	T/I	United States	North America, Africa	Red and other colours	Moderate-high ^a	Moderate ^a	Moderate lean-to-fat ^a , low marbling ^a , low tenderness ^a , moderate puberty age ^a
Braford	16	2	T/I	United States	North America, Australia	Red, white face and markings	Moderate	Moderate	Brahman–Hereford hybrid, tropical
Brah-Maine	16	2	T/I	United States	North America	Red and white markings	Moderate-large	Moderate	Brahman–Maine Anjou hybrid, tropical
Brahman	16	2	T/I	United States	America, Africa, Australia	Grey strains, red strains	Moderate-large ^a	Moderate-large ^a	Blending of Gir, Guzerat and Nelore, low tenderness ^a , late puberty ^a , moderate-high lean-to-fat ^a
Brahmousin	16	2	T/I	United States	North America	Red	Moderate		Limousin–Brahman hybrid, tropical
Bralers	16	2	T/I	United States	North America	Red	Moderate	Moderate	Brahman–Salers hybrid, tropical
Brangus	16	2	T/I	United States	North America, Africa	Black	Moderate-large ^a	Moderate ^a	Angus–Brahman hybrid, moderate lean-to-fat ^a , moderate marbling ^a , low tenderness ^a , moderate puberty age ^a , tropical

Canadienne	16	1	T	Canada	North America, Europe	Red	Small		16/17th century Breton/Normandy derivative+ since 1990 in France
Charbray	16	2	T/I	United States	North America, Australia	White-tan	Moderate-large	Moderate	Charolais–Brahman hybrid, tropical
Chiangus	16	4	T	United States	North America	Black	Moderate-large		Former Ankina, polled
Corriente	15	1	T	Mexico	North America	Variable	Small		Criollo of northern Mexico
Florida Cracker	15	1	T	United States	North America	Variable	Small		Criollo, adapted to humid tropics
Gelbray	16	2	T/I	United States	North America	Red	Moderate-large	Moderate-high	Gelbvieh–Brahman crossbred, tropical
Hays Converter	16	2	T	Canada	North America	Black or red with white face and markings	Moderate-large	Moderate-high	Holstein–Hereford–Brown Swiss crossbred
Red Brangus	16	2	T/I	United States	North America	Red	Moderate		Red Angus–Brahman crossbred, tropical
RX3	16	4	T	United States	North America	Red	Moderate	Moderate-high	Hereford–Holstein–Red Angus hybrid
Salorn	15	2	T	United States	North America	Red	Moderate		Salers–Texas Longhorn crossbred
Santa Cruz	16	4	T/I	United States	North America	Red	Moderate		Santa, Gertrudis, Red Angus, Gelbvieh hybrid
Santa Gertrudis	16	2	T/I	United States	North America, Africa	Red	Moderate ^a	Low-moderate ^a	Shorthorn–Brahman hybrid+, tropical
Senepol	16	2	T	Virgin Islands	North America	Red	Small-moderate		N'Dama/Red Poll crossbred, tropical

Continued

Table 3.7. Continued.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Simbrah	16	2	T/I	United States	North America	Red with white face and markings	Moderate-large		Simmental–Brahman hybrid, tropical
Texas Longhorn	15	1	T/I	Mexico and United States	North America	Variable	Small ^a	Small-moderate ^a	Criollo cattle of Southwestern United States, moderate lean-to-fat ^a , low-moderate marbling ^a , moderate puberty age ^a

^aFor more details, see Cundiff, 2003. Breed names in bold refer to pictures in Plates 2–25.

^bCodes of integrative classification as in [Table 3.1](#).

^c1, authentic local; 2, imported local; 4, continuously crossbred.

^dSpecies: T, *Bos taurus*; T/I, taurindicine.

Table 3.8. Breeds of cattle with origin in Australia, Southwest Asia and Oceania.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Bali Cattle	10	1	J	Bali	Australia, SW Asia Oceania	Dark-brown bulls, tan cows; white mirror and lower legs	Small		Tropical, work-beef, high fertility, adapted to extensive management
Grati	10	2	T	Indonesia	Oceania, tropical	Red or black-and-white	Moderate		Crossbred of Javanese, Black-pied and other dairy taurine breeds
Illawarra	16	1	T	Australia	Australia, Asia, America, Oceania	Red, some roans or white	Moderate		Crossbred of mainly Ayrshire and other dairy taurine breeds
Javanese	10	1	I/J	Indonesia	Oceania	Tan	Small-moderate		Banteng–Indochinese hybrid upgraded with Ongole
Kedah-Kelantan	10	1	I	Malaysia	Oceania	Tan-brown	Small		Indo-Chinese zebu
Local Indian Dairy	8	2	I	Malaysia	Asia, Oceania	White	Small		Kedah–Kelantan zebu crossbred, now × Holstein
Madura	10	1	I/J	Indonesia	Oceania	Tan	Small		Zebu (paternal)–Banteng cross, ‘racing bull’
Mandalong Special	16	4	T/I	Australia		Cream to red	Moderate-large		Charolais–Chianina–poll Shorthorn–British White–Brahman crossbred
Murray Grey	16	2	T	Australia	Australia, Europe, North America	Silver to dun-grey	Moderate		Shorthorn × Angus crossbred, polled

^aFor more details, see Cundiff, 2003.

^bCodes of integrative classification as in Table 3.1.

^c1, authentic local; 2, imported local; 4, continuously crossbred.

^dSpecies: I, *Bos indicus*; J, *Bos javanicus*; T, *Bos taurus*; I/J, mixed *B. indicus–javanicus* origin; T/I, taurindicine.

Table 3.9. Breeds of cattle with origin in South America.

Breed	Classification ^b	Category of origin ^c	Species ^d	Country of origin	Global range	Colour	Size and growth	Milk production	Other traits, remarks
Blanco Orejinegro	15	1	T/I	Colombia	South America	White with black points	Moderate		Colombian Criollo, longhorned or polled, tropical
Caracu	15	1	T/I	Brazil	South America	Blonde to light red	Moderate		Criollo cattle of Brazil, tropical
Indo-Brazil	16	2	I	Brazil	America	White or grey	Large		Guzerá, Nelore, Hissar, Gir crossbred, tropical, leaflike hanging ears
Romосinuano	15	1	T/I	Colombia	America	Tan to red	Small ^a	Moderate ^a	Colombian Criollo, polled, moderate lean-to-fat ^a , low marbling ^a , low tenderness ^a , moderate puberty age ^a

^aFor more details, see Cundiff, 2003.^bCodes of integrative classification, respectively, as in Table 3.1.^c1, authentic local; 2, imported local.^dSpecies: I, *Bos indicus*; T, *Bos taurus*; T/I, taurindicine.

Table 3.10. References for beef cattle breed comparison research.

Authors	Location	Breeds
Prayaga, 2003a,b, 2004	Australia	Africander, Boran, Brahman, Charolais, Hereford, Shorthorn, Simmental, Tuli
Chase <i>et al.</i> , 1997; Chenoweth <i>et al.</i> , 1996	Florida	Angus, Brahman, Hereford, Nelore, Romosinuano, Senepol
Koger, 1980	Florida	Zebu, Brahman, Santa Gertrudis, Beefmaster, Brangus, Braford, Barzona, Charbray, Simbrah, Bramousin
Arango, 2002b; Crouse <i>et al.</i> , 1975; Koch and Dikeman, 1977; Koch <i>et al.</i> , 1976, 1983; Laster <i>et al.</i> , 1972, 1976; Smith, 1976; Smith <i>et al.</i> , 1976c,d	Nebraska	Angus, Charolais, Hereford, Jersey, Limousin, Simmental, South Devon
Arango <i>et al.</i> , 2002a; Crouse <i>et al.</i> , 1989; Cundiff <i>et al.</i> , 1984; Gregory <i>et al.</i> , 1979a,b; Koch <i>et al.</i> , 1982a,b	Nebraska	Angus, Brahman, Hereford, Pinzgauer, Sahiwal, Tarentaise
Arango <i>et al.</i> , 2002c	Nebraska	Angus, Braunvieh, Chianina, Gelbvieh, Hereford, Maine Anjou, Red Poll
Arango <i>et al.</i> , 2004a; Cundiff <i>et al.</i> , 1990, 1998; Thallman <i>et al.</i> , 1999; Wheeler <i>et al.</i> , 1996, 1997	Nebraska	Angus, Charolais, Galloway, Gelbvieh, Hereford, Longhorn, Nelore, Piedmontese, Pinzgauer, Salers, Shorthorn
Arango <i>et al.</i> , 2004b; Cundiff <i>et al.</i> , 1986b; Cundiff <i>et al.</i> , 1993; Jenkins <i>et al.</i> , 1991b; Notter <i>et al.</i> , 1978a,b; Young <i>et al.</i> , 1978a,b	Nebraska	Angus, Brahman, Brangus, Braunvieh, Brown Swiss, Charolais, Chianina, Devon, Galloway, Gelbvieh, Hereford, Holstein, Jersey, Limousin, Longhorn, Maine-Anjou, Nelore, Piedmontese, Pinzgauer, Red Poll, Sahiwal, Salers, Santa Gertrudis, Shorthorn, Simmental, South Devon, Tarentaise
Casas and Cundiff, 2003; Casas <i>et al.</i> , 2011; Cundiff <i>et al.</i> , 1994; Freetly and Cundiff, 1997, 1998; Freetly <i>et al.</i> , 2011; Wheeler <i>et al.</i> , 2001	Nebraska	Angus, Belgian Blue, Boran, Brahman, Hereford, Piedmontese, Tuli
Casas and Cundiff, 2006; Casas <i>et al.</i> , 2007, 2012; Cundiff and Thallman, 2002; Wheeler <i>et al.</i> , 2004	Nebraska	Angus, Friesian, Hereford, Norwegian Red, Swedish Red and White, Wagyu
Casas <i>et al.</i> , 2010; Wheeler <i>et al.</i> , 2010	Nebraska	Angus, Beefmaster, Bonsmara, Brangus, Hereford, Romosinuano
Cundiff <i>et al.</i> , 1974a,b, 1992; Gregory <i>et al.</i> , 1965, 1966a,b,c; Long and Gregory 1974, 1975a,b; Núñez-Dominguez <i>et al.</i> , 1991, 1992; Olson <i>et al.</i> , 1978a,b,c; Smith and Cundiff, 1976; Smith <i>et al.</i> , 1976a,b; Wiltbank <i>et al.</i> , 1966, 1967	Nebraska	Angus, Hereford, Shorthorn
Cundiff <i>et al.</i> , 1981; Dearborn, 1986, 1987a,b; Gregory <i>et al.</i> , 1978a,b,c,d,e; Jenkins <i>et al.</i> , 1991a; Koch <i>et al.</i> , 1979, 1981; Laster <i>et al.</i> , 1979	Nebraska	Angus, Brown Swiss, Chianina, Gelbvieh, Hereford, Maine Anjou, Red Poll
Cundiff <i>et al.</i> , 1986a	Nebraska	Angus, Brown Swiss, Charolais, Chianina, Gelbvieh, Jersey, Limousin, Maine Anjou, Pinzgauer, South Devon, Tarentaise
Cushman <i>et al.</i> , 2007; Rodríguez-Almeida <i>et al.</i> , 1995a,b; Wheeler <i>et al.</i> , 2005	Nebraska	Angus, Charolais, Gelbvieh, Hereford, Limousin, Pinzgauer, Red Angus, Simmental

Continued

Table 3.10. Continued.

Authors	Location	Breeds
Ferrell, 1982; Laster <i>et al.</i> , 1973a,b	Nebraska	Angus, Brown Swiss, Charolais, Hereford, Jersey, Limousin, Red Poll, Simmental, South Devon
Ferrell and Jenkins, 1998a,b; Jenkins and Ferrell, 2004	Nebraska	Angus, Boran, Brahman, Hereford, Tuli
Gregory and Cundiff, 1980	Nebraska	Angus, Brahman, Charolais, Hereford
Gregory <i>et al.</i> , 1991a,b,c, 1992a,b,c, 1994; Jenkins and Ferrell, 1992, 1994, 1997	Nebraska	Angus, Braunvieh, Charolais, Gelbvieh, Hereford, Limousin, Pinzgauer, Red Poll, Simmental
Laster and Gregory, 1973	Nebraska	Angus, Charolais, Hereford, Jersey, Limousin, Red Poll, Simmental, South Devon
Laster <i>et al.</i> , 1973a,b	Nebraska	Angus, Charolais, Hereford, Jersey, Limousin, Simmental, South Devon
Amer <i>et al.</i> , 1992	Review	Angus, Charolais, Hereford, Limousin, Simmental
Cundiff, 1970	Review	Angus, Brahman, Brangus, Brown Swiss, Charolais, Hereford, Shorthorn
Franke, 1980	Review	Angus, Brahman, Brangus, Charolais, Devon, Shorthorn
Franke, 1997	Review	Beefmaster, Boran, Brahman, Brangus, Gir, Indu-Brazil, Nelore, Sahiwal, Santa Gertrudis, Tuli
Hetzel, 1988	Review	Africander, Angoni, Barotse, Boran, Mashona, Tuli
Long, 1980	Review	Angus, Blonde D'Aquitaine, Brahman, Brown Swiss, Charolais, Chianina, Gelbvieh, German Black and White, German Red and White, Hereford, Holstein, Jersey, Limousin, Maine Anjou, Normande, Marchigiana, Piedmontese, Pinzgauer, Red Poll, Romagnola, Sahiwal, Santa Gertrudis, Shorthorn, Simmental, South Devon, Tarentaise
Mason, 1971	Review	Angus, Blonde d'Aquitaine, Brown Swiss, Chianina, Charolais, Danish Red, Eastern Red Pied, French Brown, Friesian, Galloway, German Black Pied, German Brown, German Yellow, Hereford, Jersey, Limousin, Lincoln Red, Maine Anjou, Marchigiana, Montbeliard, Meuse-Rhine-Yssel, Normandy, Piedmontese, Red Poll, Romagnola, Shorthorn, Simmental, South Devon, Sussex, Swedish Red and White, Welsh Black
Plasse, 1983	Review	Brahman, Brown Swiss, Charolais, Criollo, Marchigiana, Red Poll, Simmental, Zebu
Roughsedge <i>et al.</i> , 2001	Review	Angus, Belgian Blue, Braunvieh, Blonde d'Aquitaine, Brown Swiss, Charolais, Chianina, Devon, Friesian, Gelbvieh, Galloway, Hereford, Holstein, Jersey, Limousin, Longhorn, Maine Anjou, Pinzgauer, Piedmontese, Red Angus, Red Poll, Simmental, Salers, South Devon, Shorthorn, Tarentaise
Sanders, 1980	Review	Brahman, Gir, Guzerat, Indu-Brazil, Nelore, Zebu

Continued

Table 3.10. Continued.

Authors	Location	Breeds
Thrift, 1997	Review	Beefmaster, Boran, Braford, Brahman, Brangus, Gir, Indu-Brazil, Nelore, Romana Red, Sahiwal, Santa Gertrudis, Senepol, Simbrah, Tuli
Thrift <i>et al.</i> , 2010	Review	Angus, Beefmaster, Bonsmara, Brahman, Brangus, Boran, Charolais, Gelbray, Gelbvieh, Gir, Hereford, Indu-Brazil, Nelore, Red Poll, Romosinuano, Sahiwal, Santa Gertrudis, Senepol, Simbrah, Tuli
Turner, 1980	Review	Boran, Brahman, other breeds
Turton, 1964	Review	Charolais and other breeds
Baker <i>et al.</i> , 1984, 1989; Jenkins <i>et al.</i> , 1981; Long <i>et al.</i> , 1979a,b; Nelson <i>et al.</i> , 1982a,b; Rohrer <i>et al.</i> , 1988; Sacco <i>et al.</i> , 1987, 1989a,b, 1990, 1991; Stewart <i>et al.</i> , 1980; Talamantes <i>et al.</i> , 1984	Texas	Angus, Brahman, Hereford, Holstein and Jersey
Baker <i>et al.</i> , 2001	Texas	Angus, Brahman, Hereford, Tuli
Paschal <i>et al.</i> , 1991, 1995	Texas	Angus, Brahman, Gir, Indu-Brazil, Nelore

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