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European Local Pig Breeds - Diversity and Performance

A study of project TREASURE

Edited by Marjeta Čandek-Potokar and Rosa M. Nieto Linan

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TREASURE

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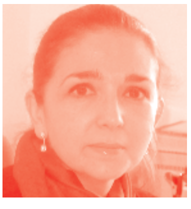
Meet the editors

Marjeta Čandek Potokar is a researcher at the Agricultural Institute of Slovenia. She graduated in Animal Science and has a PhD in Food Science. Her main research area is meat science. Current research topics comprise: (1) the local Krškopolje pig breed, (2) castration issues (boar taint, immunocastration, nutrition, product quality), (3) dry cured products, (4) carcass classification methods, and (5) use of NIRS for meat quality assessment. She has led seven national projects and participated in many EU projects (EUPIGCLASS, YOUNG-TRAIN, PIGCAS, TRUEFOOD, COST FAIM, COST IPEMA, ERA-NET SUSI); presently she coordinates H2020 project TREASURE. She is habilitted at the Faculty of Agriculture and Life Sciences of the University of Maribor as a lecturer of technology of animal products. She has authored over 60 SCI papers, numerous professional articles, conference contributions, and book chapters.



Rosa M. Nieto is a researcher at the Spanish National Research Council. She graduated in Biological Sciences and has a PhD in Animal Nutrition. Her research activity is nutrient metabolism of livestock (mainly swine), focusing on protein deposition in muscle. Over the last few years she has concentrated on Iberian pig metabolic characterization, investigating nutritional requirements (particularly amino acids and energy) during different growth phases. Her research interests include the effects of immunocastration on productivity and meat quality, links between amino acid and lipid metabolism, and consequences on meat quality. She has participated in nearly 30 research projects and contracts with international (including H2020 project TREASURE), national, and regional funding, in many of them as a research leader. She has authored over 70 SCI papers and many professional articles and congress contributions.

Contents

Preface

Local pig breeds, like many other traditional agricultural genetic resources, have been abandoned due to their lower productivity and competitiveness, which means that they do not correspond to the industrial concept of an agricultural system. Nowadays the majority of local pig breeds are still endangered despite increased awareness of the importance of biotic diversity and general societal support for the preservation of local genetic resources. The best strategy for preservation of breeds is the one that makes them self-sustaining; however, this is seldom attained in local pig breeds and the intervention of public bodies by means of subsidies is often considered indispensable. Increasing the market potential and value of their products is a key strategy to support in situ conservation of breeds. Exploitation of local pig breeds in their specific production systems, which makes use of local feeding resources and offers more resilience, also provides products with attributes that are demanded and appreciated by consumers, constituting the basis for sustainable pork chains. The economic potential of local breeds and their production systems is far from being optimally exploited and represents a challenge and opportunity for the future of the pig sector.

In the present work, which is part of the project TREASURE dedicated to multicriteria evaluation of local pig breeds, we collected essential available information about the history of breeds, and current census, geographical location, and production systems, as well as data on productive traits of the local pig breeds involved in the project. This information was collected by project partners from the available literature or unpublished data, or was generated within the experiments performed in the project. The book is divided into the introductory chapter presenting the concept and ambition of project TREASURE, followed by chapters presenting individual local breeds involved in the project. The concluding chapter provides an analytical review of their productive performance.

Local pig breeds together with their production systems represent a special value for the development of pig production that answers societal demands for sustainability and enables a diversification of agricultural activities, and thus development of regional agro-food sector economies. We hope that with this book, as one of the important results of the project, we have contributed to the knowledge needed for progress in the use of local pig breeds.

Finally, we would like to acknowledge the enormous efforts of the authors (project partners) who contributed to this collection of data and breed descriptions, as well as to the numerous reviewers who helped us with very valuable comments. This

work was possible due to funding received from the European Union's Horizon 2020 research and innovation program (grant agreement No. 634476).

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Section 1

Introduction

Chapter 1

Introductory Chapter: Concept and Ambition of Project TREASURE

Marjeta Čandek-Potokar, Luca Fontanesi, Bénédicte Lebret, José M. Gil, Cristina Ovilo, Rosa Nieto, Ana Fernandez, Carolina Pugliese, Maria-Angels Oliver and Riccardo Bozzi

1. Background

After the Second World War, agricultural systems in the western society undertook an "industrial strategy" of intensification, specialization and large-scale production. Having experienced negative side effects (social, ethical and environmental) of efficiency-driven animal production systems, the persistency or sustainability became important. "Sustainability of agricultural system" is based on holistic philosophy and denotes resource efficiency and functional integrity and concerns environment, genetic diversity, ethical and social aspects and economic value [1]. Capital-driven animal husbandry systems led to abandoning of many pig breeds (and other livestock species), which were not profitable and became endangered. In the context of the (internationally binding) preservation of biotic diversity, the interest for autochthonous (local) breeds was revived in the past 30 years. In spite of that, these breeds are still largely supported by special policy mechanisms in order to ensure their preservation [2]. This is one of the critical points for the future because most of the local breeds are presently not managed in a secure way and depend upon financial support from the governments for preservation programmes. The best conservation strategy is the one that makes the breed self-sustaining without the use of external subsidies [3]. Theoretically, the self-sustainable condition of a local pig breed should be reached by the exploitation (sale) of products characterized by an extra added value, which in return assures breeding of a sufficient number of animals to have an adequate genetic diversity [4]. Nevertheless, this condition is seldom attained in the local pig breeds, and the intervention of public bodies is often considered essential for preservation [5]. A sustainable use of local breeds is possible with better exploitation of the reputation of local breeds (extrinsic cues) as well as quality attributes associated with their products (intrinsic cues). Studies show that for consumers, the importance of extrinsic cues for quality inference is increasing [6], while the intrinsic cues are important as a limiting factor of the acceptability and repurchase. Therefore, the activities to increase market potential and value of products are the key strategy in support of *in situ* conservation of the breed. The link between local breed, geographical area, and the product quality (its intrinsic cues) is important for the success of commercial strategies as demonstrated by the examples in Spain or Portugal, where the traditional local pigs (Iberian in Spain and Alentejano in Portugal) are kept in special agro-sylvo-pastoral ecosystems ("dehesa" in Spain and "montado" in Portugal). There is a constant increase of general interest and research activities in local pig breeds, but also a clear gap between Iberian and many other local breeds in Europe, which remain untapped, characterized by small populations and reared in geographical areas where the availability of natural resources is not abundant [4]. Self-support in feeds and nutrients is an important issue of sustainability, particularly delicate in pig production as pigs are concurrent to human population for available crops. Exploitation of local pig breeds in their production systems, which are based on local feeding resources, providing products with attributes that are demanded and appreciated by the consumers is the basis for sustainable chains. The economic potential of local or traditional breeds and their production systems is far from being optimally exploited and represents a challenge and opportunity for the pig sector in the future.

2. Rationale

Modern intensive pig production is often confronted with bad public image due to animal welfare and environmental issues [7, 8], which casts doubts about its sustainability. As a consequence, a decline in pig production and self-supply is witnessed in many European regions. As around one-third of the global cereal production is supplied to animals [9], pigs as omnivores represent a direct competition with human population for the available crops. However, pork is the most consumed meat in the world and in Europe, accounting for more than 36% of world meat consumption [10]. Therefore, it can be expected that the future sustainability of pig production systems will depend on the use of locally available feeding resources [11] which differ according to agro-climatic conditions. Local pig breeds are better adapted to local conditions, and thus besides their value as a genetic resource, they represent the opportunity for developing the sustainable pork value chains, especially important for the regions where available arable land and/or cereal production is limited [12]. Local pig breeds are also raised in specific production systems which matches better the societal expectations regarding the environment (at least some environmental aspects, see [13]), animal welfare and food quality and healthiness [14]. The products they provide often represent the gastronomic heritage of various European areas and have an excellent image by consumers due to typical quality attributes, which cannot be assured with pigs from conventional intensive husbandry [15]. Presently, there are only few cases in Europe where pork-value breed chains were developed using local pig breeds, while the majority of the breeds remain untapped regarding the scientific evidence of their characteristics and market potential.

3. Project concept and ambitions

The overall concept of the project was based on a change in the paradigm of pig production systems suggesting a development of pork chains that would reside on better utilization of local resources (feeding and pig breeds). In addition, these breeds provide products with attributes related to production system that are appreciated by consumers [16], which is an asset of local pig breeds and their products with special sensory quality. Local pig breeds involved in the project (**Figure 1**) are for the most part unexploited and often endangered, thus enhancing the incomes from farming activities that would facilitate their conservation.

Figure 1.
Local pig breeds studied in the project TREASURE.

In order to improve the supply and their market potential, it is essential to acquire more scientifically based knowledge about their genetic singularity and adaptive capacity, to evaluate different management practices, their nutritional requirements and use of local feeding resources, the impact on environment, and to evaluate their socio-economic merit.

The ambitions were thus focused on:

- genotypic and phenotypic characterization of local pig breeds by studying genetic structure and diversity of local pig breed populations, their resilience and adaptive capacity;

- multi-criteria evaluation of local pig breeds in their respective production systems (performance, welfare, environmental impacts and nutritional requirements) and assessing local feeding resources and innovative approaches in management strategies;

- quality of traditional products from local pig breeds studying aspects of link with production systems, innovations to enhance their nutritional value and consumer acceptance, quality toolbox development and its application for breeding;

- cost-benefit analysis at farm and society level, consumer preferences and willingness to pay to evaluate market potential, and marketing strategies for local pig breed products;

- measures to maximize project's impact characterized by intense dissemination and communication activities along with ambition to create a joint umbrella trademark for products from local pig breeds.

4. Conclusion and perspective

The key motive of the project was to enhance knowledge, skills and competences for the benefit of a development of sustainable pork chains based on European local pig breeds, which are for the most part marginally used and their potential unexploited. Many local pig breeds and consequently many partners were involved in the project with multi-actor approach meaning that not only universities and research institutes but also non-academic partners take active role in the project. The emphasis of the project was on the untapped local pig breeds and products from different European regions. Still, some partners from the regions with already well established pork chains (Iberian, Schwäbisch-Hällisches pig) were engaged. On the one hand, these breeds and their value-chains also need further developments, while on the other hand, their experiences and "know-how" in science and in practice can be transferred to partners and regions where local pig breed value-chains are just at a start-up. European local pig breeds together with their respective production systems possess an inherent value that is exceptional in terms of agricultural biodiversity and unique taste of their products, and thus represent the opportunity to develop pig production that answers key societal concerns of today, the preservation of genetic resources, care for the environment and animal welfare and can contribute to diversified agricultural activities and to the economic growth of the regional agro-food sector.

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Section 2

Local Pig Breeds in Project TREASURE

Chapter 2

Alentejano Pig

Rui Charneca, José Martins, Amadeu Freitas, José Neves, José Nunes, Hugo Paixim, Pedro Bento and Nina Batorek-Lukač

Abstract

The present chapter presents the history and current status of Alentejano pig breed, a Portuguese autochthonous swine breed. A review of literature regarding reproductive and productive traits was carried out. Reproductive performance includes sow age at first parturition and at culling, litters per sow and per year, piglets born alive per litter, percentage of stillborn per litter, piglets birth weight, mortality rate until weaning, piglet weaned per litter, duration of lactation and farrowing interval. Growth performance includes average daily gain and average daily feed intake during lactation, early, middle and late growing stages and fattening stage. Carcass traits were evaluated using age and weight at slaughter, hot carcass weight, carcass yield, lean meat content, back fat thickness at withers and at the level of the last rib, muscle thickness at the cranial edge of *gluteus medius* muscle and loin eye area. Meat and fat quality traits of *longissimus* muscle were evaluated by means of pH at 45 min and 24 hours after slaughter, objective colour (CIE L*, a* and b*), intramuscular fat content and fatty acid composition of intramuscular fat. However, a considerable number of studies on Alentejano pig, data on reproductive performance and some parameters of meat quality are still scarce.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Portugal

1. History and the current status of the breed (census)

The Alentejano pig belongs to the Mediterranean group [1] and derives, as the Iberian breed pig, from the primitive *Sus scrofa mediterraneus*. Alentejano pig belongs to the Iberian type breeds, characterized by low prolificacy [2] and low growth rate (except under "*montanheira*" regime). It is also quite adipogenic [3]. Its meat and fat are considered as excellent for both fresh meat market and to process high-grade sausage and dry cured products. Alentejano pigs are well adapted to the environment and to the use of natural resources as feed. Already in the first century AD, Roman documents stressed out the importance of acorns from holm oak forests and in the outdoor rearing of these pigs from Lusitanos [4]. Before change and domination of indoors pig production system, Alentejano was the main pig breed in Portugal, representing over 45% of the total national pig population [5]. This breed was predominantly distributed by the regions south of the Tagus river. Due to several factors, this breed declined in numbers and importance, mainly since the second half of the twentieth century, and was on the edge of extinction in the 1980s.

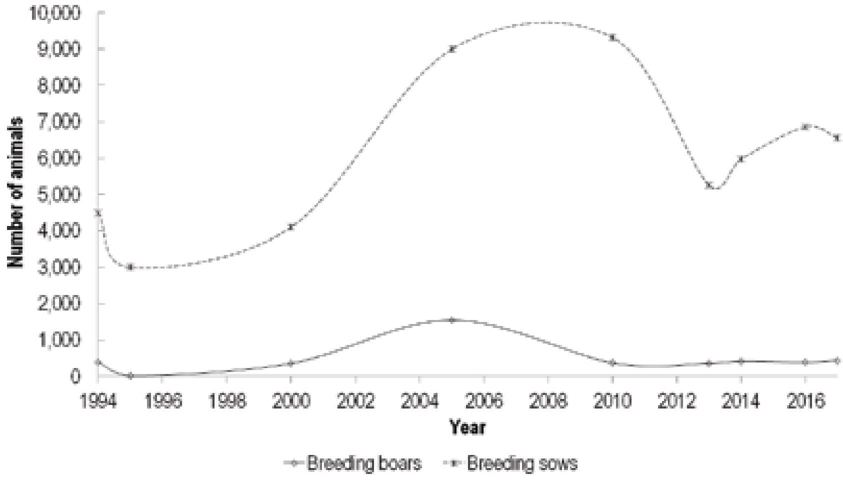

Figure 1.
Census of Alentejano pig breed from 1994 to 2017 [8].

Gradually, from the end of 1980s onward, a slight but consistent recovery of this breed and its traditional production system occurred, fostered by grants of several agents for conservational purposes [6, 7]. Nowadays, the Alentejano pig recovered and represent an economic, ecological and social add value to Alentejo region. Census of Alentejano pig breed is presented in **Figure 1**. By the end of 2017, 6464 breeding sows and 510 boars were registered in the breed herdbook, distributed by 137 herds. Each farm had, on average, 47 sows [8].

2. Exterior phenotypic characteristics

The information on the morphology of the Alentejano pig is summarized in **Table 1**. Alentejano is a medium-sized pig with a light bone structure, black coat colour and scarce black, blonde or reddish thin hair (**Figures 2** and **3**). It has a long, thin head with a pronounced frontonasal angle, and relatively small, thin, forward-facing ears, triangular in shape and slightly tipped out. The body is not too wide and deep; the back is of medium length and width, slightly arched; the shoulders and hams are regularly developed and medium in width; the extremities are short and slim, ending with small feet with uniform black pigmented hooves. Their temperament is considered energetic [4, 9]. Nowadays, the classifications used by the

Measurement (average)	Adult male	Adult female
Body weight (kg)	160	120
Body length[2,3] (cm)	126	
Ear length	Small to medium	Small to medium
Chest girth[3] (cm)	122	
Number of teats		10

[1]*Data provided by ANCPA (personal communication).*
[2]*Measured from the tip of the nose to the starting point of the tail.*
[3]*Entire males at 120 kg live weight [10].*

Table 1.
Summary of morphology information on Alentejano pig breed[1].

Figure 2.
Alentejano sows with piglets.

Figure 3.
Alentejano boar.

technicians from the breeders' association vary between placid and friendly to moderately tractable (ANCPA, personal communication), considering the differences found between farms.

3. Geographical location and production system

This breed's origin and present location is the southwest of the Iberian Peninsula. It is reared under extensive conditions, perfectly adapted to the environment and the use of natural feedstuff resources [7]. It participates into a well-defined agro-sylvo-pastoral system known as "Montado". As a strategic step of this production system, the intensive fattening of animals occurs in *Quercus* forests from late October to late February ("montanheira") [5].

Traditionally, the herds were divided into three categories: breeding sows, growing pigs and fattening pigs [11]. Breeding sows and growing pigs were fed with natural pastures and, when necessary (e.g., during summer) supplemented with cereal grains (barley, oats or corn), legumes (chickling vetch, faba bean or black chickpea), and local agricultural by-products, which conditioned the growth and duration of the production cycle. Pigs fattened with acorns and grass present very high average daily gains [7, 12].

Conversely, nowadays, there is no uniform production system. Breeding season, feeding management, weight and age at slaughter vary among farms, depending on the tradition and the production objectives [7]. However, most production systems usually use two farrowing seasons (spring-summer and fall-winter). Piglets born between April and September go to montanheira the following year. Piglets born between December and March supply the roast piglets' market, the fresh meat market with pigs weighing on average less than 120 kg, and are used for herd replacement when purebred [7, 13]. In some cases, alike the observed in Spain with the Iberian pig, in this last farrowing season, a terminal cross with Duroc breed is used to obtain crossbred pigs with better growth performances, higher yields and leaner carcasses (ANCPA, personal communication). The extensive and semi-extensive systems are the most common, and the presence of a free-range feeding period is obligatory for production of PDO and PGI products. However, Alentejano pigs are increasingly reared in semi-extensive systems where, to improve and standardize performance and productivity, most sows and growing pigs receive concentrated balanced feeds. Breeding farms are also abandoning the traditional concrete facilities ("malhadas") and in most cases, farrowing occurs outdoor, in a "camping" environment with huts and/or collective shelters [14].

4. Organisations for breeding, monitoring and conservation

The Alentejano pig is listed among the endangered Portuguese breeds of farm animals. In 2015, the national legislation (https://dre.pt/web/guest/pesquisa/-/search/66619894/details/maximized) categorized the Alentejano pig breed as in moderate risk of extinction. The names and contacts of the main organizations of the breed are presented in **Table 2**. The breeding program is run by ACEPA, A.C.E. (Alentejano Pig Complementary Consortium of Companies, A.C.E.), created in 2011, which also holds the Alentejano pig Herdbook. Besides ACEPA, two breeders' associations—the Association of the Alentejano Pig Breeders (ACPA), covering mainly the south of the Alentejo region, and the National Association of the Alentejano Pig Breeders (ANCPA), covering mostly the centre and north of the region—collect data that are stored and processed by the database GenPro (Ruralbit Lda.). More recently (in 2014 and 2017), each association created a Group of Producers (ALPORC SA and PACOOP, CRL) for commercial issues.

Name of organisation	Address	E-mail address
ACEPA—Agrupamento Complementar de Empresas do Porco Alentejano, A.C.E.	Rua Diana de Liz, Apartado 123, 7006-802 Évora	aceporcoalentejano@gmail.com
ANCPA—Associação Nacional dos Criadores do Porco Alentejano	Rua Diana de Liz, Apartado 71 7002-501 Évora	porcoalentejano@gmail.com
ACPA—Associação de Criadores de Porco Alentejano	Rua Armação de Pêra, 2 7670-259 Ourique	acpaourique@gmail.com

Table 2.
Contact details of the breeding organisations for Alentejano pig breed.

5. Productive performance

5.1 Reproductive traits

Despite the availability of commercial artificial insemination doses, in most cases females are naturally mated. At farm level, the ratio of boar:sow varies from 1:5 up to 1:15 (ANCPA, personal communication). **Table 3** summarizes the basic data available on the reproductive traits. The mean age of sows at first parturition ranges from 10.6 to 16.6 months, but the gilts management (especially feeding) in each farm can greatly influence this trait, justifying individual variations from 9 up to 24 months of age, at farm level (ANCPA, personal communication). Gestation is shorter than in other breeds or genotypes (111 days [2]). Regarding the litter characteristics, sows of Alentejano breed have a number of live born piglets ranging from 6.7 to 9.4 ([2, 15–19], Charneca R, personal communication), weighing between 1.0 and 1.3 kg at birth [2, 15–17, 20, 21]. The reported stillbirth rate varies between 1.2 and 11.3% [2, 15, 16]. The high rate on stillbirth in one of the studies [15] may be related to the high total prolificacy also observed in that trial. The reported values for stillbirth rate are lower than the reported in modern genotypes [22]. The mortality rate at weaning mentioned in two studies [2, 16] ranged from 18.8 to 27.5%. Both are relatively high values but in line with reported values for other Iberian pigs [23]. The average value for weaned piglets per cycle is 5.7 (ANCPA, personal communication), based on a sample of 2636 records from 20 farms, which is in accordance with the reported values for the prolificacy and mortality rate observed in other scientific studies [2, 15–17]. Due to the relatively low growth rate of sucking piglets [2, 15, 16, 18] and usual poor post-weaning conditions, the lactations are usually longer than the practiced in the modern intensive systems, ranging from 35 to 60 days ([15–17, 20, 21], Charneca R, personal communication). These long lactations increase the farrowing interval and reduce the breed productivity. Regarding the reproductive performance of the Alentejano breed, the information available only covers some data (e.g., number of litters per sow and per year, life production of sow and farrowing interval), representing data collected by the breeders' associations. In the authors' opinion, these data should be used for a clearer monitoring in this breed, after validation. The information available for the Alentejano suggests that this pig breed has a moderate reproductive efficiency.

5.2 Growth performance

Basic data available on growth performance of Alentejano pig are presented in **Tables 4** and **5**. Due to the big differences reported between studies regarding the live weight range covered, the stages for growth performance were defined as lactation (regardless of how long it was), early, middle and late growing stages (from weaning to approximately 30 kg, between 30 and 60, and between 60 and 100 kg live weight, respectively) and fattening stage (above 100 kg live weight). In some sources [17, 24–26], only the overall growth rate for the whole studied period (defined as overall) was provided. It should also be noted that only a small number of studies actually aimed at evaluating the breed potential for growth. In the studies mentioned in **Table 4**, the average daily gain in the lactation period ranged from 133 to 191 g/day. The lactation periods considered varied from 35 to 56 days, and in most cases, piglets were supplemented 15–21 days after birth. Still, all the values are lower than the ones

References	Age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)	Age at culling (mth)
[2]	–	–	8.0	1.1	1.7	27.0	–	–	–	–
[15]	–	–	9.4	1.1	11.3	–	6.3	35	–	–
[16]	–	–	7.3	1.2	1.2	18.8	11.0	50	–	–
[17]	–	–	7.0	1.3	–	–	11.0	53	–	–
[18]	10.6	–	6.7	–	–	–	–	–	–	–
[19]	–	–	7.9	–	–	–	–	–	–	–
[20]	–	–	–	1.0	–	–	9.0	56	–	–
[21]	–	–	–	1.2	–	–	12.0	60	–	–
Charneca R[1]	–	–	–	–	–	–	6.3	35	–	–
Charneca R[2]	–	–	6.9	–	–	–	–	–	–	–
Charneca R[3]	–	–	7.0	–	–	–	–	–	–	–
ANCPA[4]	16.6 (2247)	1.8 (1991)	–	–	–	–	–	–	206 (1991)	45 (2636)

No.—number; mth—month; d—days.
[1]*Charneca R, unpublished data, University of Évora, 2016.*
[2]*Charneca R, unpublished data from Experimental Centre of Ministry of Agriculture (CEBA), data from 2017.*
[3]*Charneca R, unpublished data from University of Évora experimental farm (Mitra), data from 2012 to 2015.*
[4]*ANCPA, 2018. Breed database values representing data collected from 20 farms computed specifically for this chapter. The number of animals considered for each trait is provided within brackets.*

Table 3.
Main reproductive traits in Alentejano pig breed.

References	Feeding regime and production system	No. of animals	ADG lactation[1]	ADG growing[2]			ADG fattening[3]	Overall ADG[4]
				Early	Middle	Late		
[2]	Ad Lib; extensive; outdoor	261	163	–	–	–	–	–
[15]	Ad Lib	60	149	–	–	–	–	–
[16]	Ad Lib	5974	191	–	–	–	–	–
[17]	Semi; intensive	15	–	–	–	–	–	556
[18]	Ad Lib; extensive	38	191	–	–	–	–	–
	Ad Lib; extensive	48	–	192	–	715	1000	715
[20]	Ad Lib	1203	142	–	–	–	–	–
[24]	Rest; intensive; indoor	14	–	–	–	–	–	481
[25]	Semi; intensive; indoor	24	–	–	–	–	–	471
[26]	Rest; intensive; indoor	15	–	–	–	–	–	494
[27]	Rest; intensive; indoor	18	–	–	–	450	–	450
	Rest; extensive; outdoor	12	–	–	–	533	–	533
[28]	Ad Lib; intensive; indoor	20	–	–	–	805	–	805
[29]	Ad Lib; intensive; indoor	30	–	–	–	801	–	801
[30]	Rest; intensive; indoor	30	–	–	346	439	–	393
[31]	Rest; intensive; indoor	24	–	–	489	–	–	446
[32]	Rest; intensive; indoor	51	–	–	251	–	–	251
	Ad Lib; intensive; indoor	36	–	–	–	617	–	617
[33]	Semi; intensive; indoor	48	–	–	–	–	–	505
		12	–	–	–	–	–	557
		12	–	–	–	–	336	453
	Ad Lib; extensive; outdoor	12	–	–	–	568	–	568

References	Feeding regime and production system	No. of animals	ADG lactation[1]	ADG growing[2]			ADG fattening[3]	Overall ADG[4]
				Early	Middle	Late		
[34]	Rest; intensive; indoor	24	–	–	–	187	–	187
	Ad Lib; intensive; indoor	12	–	–	–	442	–	442
	Ad Lib; extensive; outdoor	36	–	–	–	627	447	627
[35]	Rest; outdoor	15	–	–	–	671	–	671
[36]	Rest; intensive; indoor	30	–	277	363	502	–	432
[37]	Ad Lib	70	–	–	275	491	–	383
	Rest	22	–	–	–	331	–	331
	Ad Lib	39	–	–	421	461	838	441
	Rest	26	–	–	–	240	–	240
	Ad Lib	40	–	–	339	–	–	339
		20	–	–	339	–	–	339

No, number; ADG, average daily gain in g; w, weaning; Ad Lib, ad libitum feeding regime; Semi, semi ad libitum feeding regime; Rest, restrictive feeding regime.
[1]*ADG in period of lactation regardless of how long it was.*
[2]*ADG in growing period estimated from weaning to approximately 30 kg, between approximately 30 and 60 kg and between approximately 60 and 100 kg live body weight, respectively.*
[3]*ADG in a period of fattening is reported for above 100 kg live body weight.*
[4]*When the source provides only the overall growth rate for the whole studied period, this growth rate is defined as overall ADG.*

Table 4.
Growth performance in Alentejano pig breed according to different studies.

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References	Feeding regime and production system	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI growing[1]		ADFI fattening[2]	Overall ADFI[3]
					middle	late		
[17]	Semi; intensive	–	13.8	15	–	–	–	2.1
[24]	Rest; intensive; indoor	–	16.0	14	–	–	–	2.2
[25]	Semi; intensive; indoor	–	12.8	24	–	–	–	2.2
[27]	Rest; intensive; indoor	–	12.6	18	–	2.3	–	–
	Rest; extensive; outdoor	–	12.6	12	–	2.4	–	–
[29]	Ad Lib; intensive; indoor	13.5	14.6	30	–	3.2	–	–
[30]	Rest; intensive; indoor	–	15.0	30	1.6	2.6	2.5	–
[31]	Rest; intensive; indoor	–	15.0	24	–	–	–	2.2
[32]	Rest; intensive; indoor	–	13.2	51	1.6	–	–	–
[33]	Semi; intensive; indoor	–	17.4	48	–	–	–	2.5
		–	17.4	12	–	–	–	2.5
		–	17.4	12	–	–	2.7	2.6
	Ad Lib; extensive; outdoor	–	17.4	12	–	2.4	–	–
[34]	Rest; intensive; indoor	–	14.7	24	–	1.4	–	–
	Ad Lib; intensive; indoor	–	14.7	12	–	2.5	–	–
[35]	Rest; outdoor	–	15.0	15	–	2.9	–	–
[36]	Rest; intensive; indoor	–	15.0	156	1.7	2.4	–	–

References	Feeding regime and production system	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI growing[1]		ADFI fattening[2]	Overall ADFI[3]
					middle	late		
[37]	Ad Lib	–	17.5	39	2.0	2.8	–	–
	Rest	–	17.5	26	–	1.9	–	–
	Ad Lib	–	14.0	40	1.5	–	–	–
	Ad Lib	–	14.0	20	1.5	–	–	–

No., number; ADFI, average daily feed intake in kg/day; Ad Lib, ad libitum feeding regime; Semi, semi ad libitum feeding regime; Rest, restrictive feeding regime; ME, metabolisable energy; CP, crude protein.
[1]*ADFI in growing period estimated between approximately 30 and 60 kg (middle) and between approximately 60 and 100 kg live body weight (late), respectively.*
[2]*ADFI in a period of fattening is reported for above 100 kg live body weight.*
[3]*When the source provides only the overall average feed intake for the whole studied period, this feed intake is defined as overall ADFI.*

Table 5.
Average daily feed intake (in kg/day) in Alentejano pig breed in different studies.

observed in modern breeds [2]. Average daily gain in the early growing stage (192 g/day; [18]) is also considerably lower than those observed in modern breeds [38, 39], denoting lesser intensity of rearing and/or growth potential. Also, the middle and late growing stages, the fattening stage, and the overall stage are generally characterized by relatively slow growth and high heterogeneity (251–489, 187–805, 336–1000, and 187–805 g/day in middle and late growing stage, fattening stage, and overall stage [17, 18, 24–37]). These differences may be explained by the fact that studies covered distinct situations, where different rearing systems and/or environmental conditions (e.g., season) and also feeding levels were practiced. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potential of Alentejano pigs in *ad libitum* conditions of feeding (≈1000 g/day in the fattening stage [18]).

The information on the feed intake and feed nutritional value (**Table 5**) is scarce, which limits the evaluation of the breed´ growth potential. Nevertheless, as expected, average daily feed intake (ADFI) increased with body weight. In restricted animals, ADFI ranged from 1.6 to 1.7 kg in middle growing stage (from ~30 to 60 kg live weight), from 1.9 to 2.9 kg in late growing stage (from 60 to 100 kg live weight) and from 2.5 to 2.7 kg in the fattening stage (>100 kg live weight). The same tendency was observed in *ad libitum* fed animals even tough values are only available for middle (from 1.5 to 2.0 kg ADFI) and late growing stage (from 2.4 to 3.2 kg ADFI).

5.3 Body composition and carcass traits

In Portugal, in most common commercial conditions, Alentejano pigs are slaughtered at weaning for roasted piglet market, at 90–100 kg live weight for the fresh meat market, at 120–140 kg for the production of dry-cured sausages, and at 150–170 kg for the ham industry in Portugal or in Spain [7]. **Table 6** summarizes the available information on the most commonly encountered carcass traits obtained from research and field studies. Alentejano breed pigs involved in these studies were slaughtered at ages ranging from 120 to 360 d, and between 39 and 160 kg live weight. Dressing yields and lean meat contents were calculated based on commercial cuts obtained according to the Portuguese norm NP-2931. The backfat thickness at withers ranged from 45 to 78 mm, while at the level of the last rib it varied from 12 to 63 mm. Similarly, muscularity measured as lean meat content varied from 35.9 to 51.7%, the loin eye area from 15 to 32 cm^2, whereas the muscle thickness measured above *Gluteus medius* muscle varied from 36 to 43 mm, which indicates lower muscular development compared to modern breeds [39, 47, 48]. This variation in backfat and muscle thickness is a consequence of the wide range of final live weights of pigs and different feeding regimes applied in the considered studies.

5.4 Meat and fat quality

Table 7 summarizes the most commonly encountered meat and fat quality traits of Alentejano´ carcasses, as measured in *Longissimus* muscle. In the studies reporting meat quality in Alentejano pigs, pH measured in *Longissimus* muscle at 45 min post-mortem ranged from 5.89 to 6.45, while at 24 h *post mortem* it varied between 5.39 and 5.79. These pH 24 values reported in the carcasses of Alentejano pigs are slightly higher than those from modern breeds [52, 53], suggesting the existence of lower glycogen stores before slaughter and more

References	Feeding regime and production system	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		M[1] (mm)	Loin eye area (cm^2)
								At withers	At last rib		
[17]	Semi; intensive	6	–	98.0	75.0	76.5	–	–	–	–	–
[18]	Ad Lib; extensive	12	–	93.0	–	–	–	–	34.6	–	27.9
[24]	Rest; intensive; indoor	14	–	100.2	–	–	–	–	–	–	21.7
[25]	Semi; intensive; indoor	24	–	98.0	78.4	80.0	–	–	–	–	–
[26]	Rest; intensive; indoor	15	299	100.2	80.3	80.1	41.5	–	–	–	22.0
[27]	Rest; intensive; indoor	18	–	99.3	–	–	37.5	–	–	–	–
	Rest; extensive; outdoor	12	–	99.4	–	–	41.1	–	–	–	–
[28]	Ad Lib; intensive; indoor	20	220	93.0	–	–	–	–	28.9	–	–
[29]	Ad Lib; intensive; indoor	30	–	93.0	72.6	78.1	–	–	–	–	–
[30][2]	Rest; intensive; indoor	5	180	40.0	31.1	77.8	51.7	–	–	–	15.5
		5	256	70.0	55.9	79.8	45.0	–	–	–	17.9
		5	275	80.0	65.2	81.5	45.6	–	–	–	18.5
		5	297	90.0	74.1	82.3	42.9	–	–	–	20.0
		5	324	100.0	80.9	80.9	41.5	–	–	–	20.1
		5	360	110.0	88.1	80.1	42.6	–	–	–	20.4
[31]	Rest; intensive; indoor	24	–	99.7	82.7	83.0	42.1	–	–	–	22.1
[32]	Rest; intensive; indoor	15	–	71.8	55.3	77.1	45.9	–	–	–	–
	Ad Lib; intensive; indoor	15	–	113.5	87.1	76.7	35.9	–	–	–	–
[33]	Semi; intensive; indoor	12	–	98.1	74.3	75.7	–	–	–	–	–
	Semi; intensive; indoor	12	–	120.4	93.9	78.0	–	–	–	–	–

References	Feeding regime and production system	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		M[1] (mm)	Loin eye area (cm^2)
								At withers	At last rib		
	Ad Lib; extensive; outdoor	4	–	108.6	87.4	78.1	–	–	–	–	–
	Semi; intensive; indoor	12	–	98.1	74.3	75.7	–	–	–	–	–
	Semi; intensive; indoor	12	–	120.4	93.9	78.0	–	–	–	–	–
	Ad Lib; extensive; outdoor	8	–	108.6	84.8	78.1	–	–	–	–	–
	Rest; intensive; indoor	12	–	98.1	75.6	77.1	–	–	38.3	–	22.9
	Ad Lib; extensive; outdoor	12	–	92.1	76.4	83.0	–	–	41.8	–	24.8
	Semi; intensive; indoor	12	–	120.6	96.7	80.2	–	–	44.3	–	30.4
[34]	Rest; intensive; indoor	24	–	70.4	–	–	–	–	12.3	36.4	–
	Ad Lib; intensive; indoor	12	–	91.2	–	–	–	–	18.7	40.3	–
	Ad Lib; extensive; outdoor	36	–	108.9	–	–	–	–	23.2	42.6	–
[35]	Rest; outdoor	15	240	105.0	–	–	–	–	–	–	26.0
[36][2]	Rest; intensive; indoor	10	120	42.2	31.0	73.4	–	–	–	–	17.0
		10	180	70.9	55.6	78.4	–	–	–	–	20.1
		10	240	80.2	63.7	79.5	–	–	–	–	20.4
[37]	Ad Lib	4	–	38.5	29.5	76.5	–	–	–	–	16.4
	Ad Lib	4	–	92.8	71.7	77.3	–	–	–	–	21.5
	Rest	8	–	79.6	61.6	77.3	–	–	–	–	21.0
	Ad Lib	4	–	115.7	92.3	79.8	–	66.5	57.0	–	21.5
	Rest	8	–	115.3	92.1	79.9	–	–	–	–	21.0
	Ad Lib	4	–	130.1	103.6	79.6	–	71.5	61.8	–	21.8

References	Feeding regime and production system	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		M[1] (mm)	Loin eye area (cm^2)
								At withers	At last rib		
	Rest	8	–	132.2	104.6	79.1	–	75.9	60.2	–	22.6
	Ad Lib	4	–	115.4	88.9	77.1	–	61.3	45.7	–	21.3
	Rest	8	–	114.8	89.4	77.9	–	63.6	47.1	–	21.4
	Ad Lib	4	–	132.5	105.5	79.6	–	73.3	44.9	–	24.8
	Rest	8	–	129.7	101.2	78.1	–	67.7	46.1	–	22.4
	Ad Lib	4	–	93.8	74.2	79.1	–	52.8	37.4	–	21.6
	Rest	8	–	78.5	61.8	78.7	–	45.0	28.4	–	20.0
	Ad Lib	12	–	131.4	105.7	80.4	–	77.7	63.2	–	21.2
[40]	Rest; intensive; indoor	5	–	70.0	–	–	–	–	34.1	–	17.3
		5	–	80.0	–	–	–	–	34.3	–	17.7
		5	–	90.0	–	–	–	–	33.0	–	17.6
		5	–	100.0	–	–	–	–	31.7	–	19.4
		5	–	110.0	–	–	–	–	36.3	–	21.5
[41, 42]	Ad Lib; intensive; indoor	24	–	100.0	–	–	–	–	41.4	–	–
[43]	Rest; extensive; outdoor	5	–	89.1	70.3	78.9	–	–	–	–	–
		5	–	100.5	80.3	79.9	–	–	–	–	–
		5	–	109.8	89.4	81.4	–	–	–	–	–
[44][2]	Rest; intensive; indoor	5	–	42.2	29.3	69.4	–	–	13.0	–	15.3
		5	–	70.9	52.2	73.6	–	–	30.0	–	18.1
		5	–	80.2	59.9	74.7	–	–	41.0	–	19.0

References	Feeding regime and production system	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		M[1] (mm)	Loin eye area (cm^2)
								At withers	At last rib		
		5	–	89.6	66.7	74.4	–	–	51.0	–	20.3
		5	–	100.5	75.6	75.2	–	–	56.0	–	21.1
		5	–	110.0	82.5	75.0	–	–	56.0	–	21.3
[45]	Ad Lib; extensive; outdoor	29	–	160.0	130.4	81.5	–	–	–	–	31.7
[46]	Semi	6	–	96.0	75.7	78.9	–	–	–	–	18.9

No., number; BW, body weight; CW, carcass weight; Ad Lib, ad libitum feeding regime; Semi, semi ad libitum feeding regime; Rest, restrictive feeding regime.
[1]M muscle thickness measured according to ZP method (at the cranial edge of Gluteus medius muscle (mm).
[2]Groups differ in weight at slaughter; to see more details on study design, address to the corresponding source.

Table 6.
Body composition and carcass traits in Alentejano pig breed.

References	Feeding regime and production system	No. of animals	Final BW (kg)	pH		CIE[1]			IMF content (%)	Fatty acid composition[2] (%)			
				45 min	24 h	L*	a*	b*		SFA	MUFA	PUFA	n − 6/n − 3
[24]	Rest; intensive; indoor	14	100	–	5.51	43	13.8	6.5	3.1	–	–	–	–
[27]	Rest; intensive; indoor	18	99	–	–	–	–	–	5.9	38.7	57.2	4.1	16.2
	Rest; extensive; outdoor	12	99	–	–	–	–	–	3.1	38.4	57.5	4.1	13.4
[29]	Ad Lib; intensive; indoor	30	93	6.45	5.73	50	9.7	4.6	4.8	41.5	47.7	10.9	25.2
[33]	Rest; intensive; indoor	12	98	–	–	–	–	–	–	41.8	–	–	–
	Ad Lib; extensive; outdoor	12	92	–	–	–	–	–	–	35.0	–	–	–
	Semi; intensive; indoor	12	121	–	–	–	–	–	–	37.8	–	–	–
[40][3]	Rest; intensive; indoor	5	70	–	–	–	–	–	6.2	–	–	–	–
		5	80	–	–	–	–	–	6.4	–	–	–	–
		5	90	–	–	–	–	–	7.2	–	–	–	–
		5	100	–	–	–	–	–	7.2	–	–	–	–
		5	110	–	–	–	–	–	7.5	–	–	–	–
[41, 42]	Ad Lib; intensive; indoor	24	100	–	5.79	43	10.6	3.9	4.8	–	–	–	–
[46]	Semi	6	96	5.89	5.39	51	–	–	4.1	–	–	–	–
[49]	Ad Lib; extensive; outdoor	8	–	–	–	–	–	–	4.9	41.1	52.1	6.8	–
[50]	Rest Ad; extensive; outdoor	10	105	–	5.71	47	12.0	5.2	6.9	–	–	–	–
[51]	Ad Lib; intensive; indoor	16	96	–	5.76	48	14.0	8.8	4.8	43.7	51.8	4.8	–
	Rest; intensive; indoor	32	81	–	5.62	47	11.9	7.1	3.7	43.3	51.9	4.8	–

No., number; Ad Lib, ad libitum feeding regime; Semi, semi ad libitum feeding regime; Rest, restrictive feeding regime; pH 45, pH measured approximately 45 min post mortem; *pH 24, pH measured approximately 24 h* post mortem; *IMF, intramuscular fat; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.*

[1]*CIE, objective colour defined by the Commission Internationale de l'Eclairage; L*, greater value indicates a lighter colour; a*, greater value indicates a redder colour; b*, greater value indicates a more yellow colour.*

[2]*For fatty acid composition, only pigs on control diet were considered. Control diets differ among studies, to see diet composition address to the corresponding source.*

[3]*Groups differ in weight at slaughter; to see more details on study design, address to the corresponding source.*

Table 7.
Summary of collected literature data on meat quality traits measured in Longissimus muscle from pigs of Alentejano pig breed.

oxidative muscle metabolism. These high pH 24 values are also associated with lower drip loss [54], which corroborates with higher intramuscular fat content (ranging from 3.1 and 7.5%) and darker colour (high Minolta L* value; L* varying from 43 to 51). As previously observed, lower pH values are related with higher water losses by drip due to a reduction in the repulsive electrostatic forces between the myofilaments, partial denaturation of the myosin head (address to [55, 56] for review). On the other hand, higher values of intramuscular fat are generally associated to a decrease in the moisture diffusivity coefficient [57]. Intramuscular fat content is highly variable among studies (3.1 and 7.5%; [24, 27, 29, 40–42, 46, 49–51]), mainly due to study conditions (feeding

Product name[1]	**Type of the product**	**Status of the product**
Carne de Porco Alentejano	Raw meat	PDO
Presunto de Barrancos	Dry cured ham	PDO
Paleta de Barrancos	Dry cured shoulder	PDO
Presunto do Alentejo	Dry cured ham	PDO
Paleta do Alentejo	Dry cured shoulder	PDO
Presunto de Campo Maior e Elvas	Dry cured ham	PGI
Paleta de Campo Maior e Elvas	Dry cured shoulder	PGI
Presunto de Santana da Serra	Dry cured ham	PGI
Paleta de Santana da Serra	Dry cured shoulder	PGI
Cacholeira branca de Portalegre	Sausage	PGI
Chouriço de Carne de Estremoz e Borba	Smoked sausage	PGI
Chouriço de Portalegre	Smoked sausage	PGI
Chouriço Grosso de Estremoz e Borba	Smoked sausage	PGI
Chouriço Mouro de Portalegre	Smoked sausage	PGI
Farinheira de Estremoz e Borba	Smoked sausage	PGI
Farinheira de Portalegre	Smoked sausage	PGI
Linguiça de Portalegre	Smoked sausage	PGI
Linguiça do Baixo Alentejo	Smoked sausage	PGI
Lombo Branco de Portalegre	Dry-cured sausage	PGI
Lombo Enguitado de Portalegre	Smoked sausage	PGI
Morcela de Assar de Portalegre	Smoked sausage	PGI
Morcela de Cozer de Portalegre	Sausage	PGI
Morcela de Estremoz e Borba	Smoked sausage	PGI
Paia de Estremoz e Borba	Smoked sausage	PGI
Paia de Lombo de Estremoz e Borba	Smoked sausage	PGI
Paia de Toucinho de Estremoz e Borba	Smoked sausage	PGI
Painho de Portalegre	Smoked sausage	PGI
Paio de Beja	Smoked sausage	PGI

[1]*All related legislation and additional information about these products can be found at https://tradicional.dgadr.gov.pt/en/.*

Table 8.
List of certified products from Alentejano pig breed.

regime, intensity of rearing, age and body weight at slaughter) but generally increases with body weight at slaughter within specific study (e.g., from 6.2% at 70 kg to 7.5% in 110 kg [40]) and is higher when a restrictive feeding regime is applied. The extreme values obtained for SFA, MUFA and PUFA content of intramuscular fat in *Longissimus* muscle were 35.0–43.7, 47.7–57.5, and 4.1–10.9% [27, 29, 33, 49–51]. Due to big differences between studies with regard to the feeding regime, feed composition, final body weight/age, and fatness, which are all important factors influencing the fatty acid composition of meat, the results of the fatty acid composition should be interpreted with caution. Nevertheless, it can be concluded that the results reported in the considered studies indicate higher proportions of SFA and particularly of MUFA, in contrast to lower PUFA content, in comparison to the modern meaty type of pigs [27, 49, 58, 59]. This can be attributed to a higher synthesis of MUFA (which increases with age [60]) and SFA, caused by higher fat deposition, as shown by the results of body composition (backfat thickness at the level of the last rib = 40 mm on average, **Table 6**).

6. Use of the breed and main products

The Alentejano pig is bred for the production of high-quality meat, sausages and dry-cured products. This slow growing-fat local pig breed is mostly reared in extensive finishing conditions, using the different agro-forest resources at their disposal. The high slaughter ages and weights grants great maturity and better flavour to the meat and meat products obtained, as already recognized in ancient Roman documents [4]. Meat from the Alentejano pig has high contents of oleic acid-rich intramuscular fat, micronutrients and antioxidants [27, 61]. It must be produced according to the conditions established in the Portuguese legislation (Decreto-Lei no. 95/2014, 24th of June—MAM, 2014) to be certified under the Protected Designation of Origin ("Carne de Porco Alentejano DOP"). Meat, fat and offal from Alentejano pigs are also used for the production of high-quality products (**Table 8**). There are currently five PDO and 23 PGI certified products [62].

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Chapter 3

Basque Pig

Marie-José Mercat, Bénédicte Lebret, Herveline Lenoir and Nina Batorek-Lukač

Abstract

Local pig breeds are adapted to the specific local environment and fed with various locally available feedstuffs. Besides their genetic merit for agro-biodiversity, they represent the basis for sustainable local pork chains. The present chapter aims to present history and current status of the Basque pig breed, its exterior phenotypic characteristics, geographical location, production system and main products. This French autochthonous breed of pigs, which almost disappeared few decades ago, seems now consolidated, thanks to a chain organization and recognised high-quality products (Protected Designation of Origin). Reproductive performance data reviewed from the literature and estimated from the LIGERAL database (herdbook) are presented. Available data on production traits including growth (early, middle, late and overall growth), feed intake, body composition and carcass traits are also summarized. Meat quality traits (pH, colour, intramuscular fat content and fatty acid composition) and back fat tissue characteristics (fatty acid profile) are also described. Studies on the Basque pig breed are scarce. Different production systems, feeding regimes and feed composition used among studies can explain differences observed between studies, especially for productive traits. However, the current review gives insight into the reproduction, production and carcass and meat quality traits of this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, France

1. History and the current status of the breed (census)

The Basque pig (French, Pie Noir du Pays Basque) is a breed of pig native of the Basque Country (South-West of France). What is today called the Basque pig comes from the two historical breeds kept by Basque people. It was consolidated under the name only in the 1920s. With livestock sector modernisation, production of Basque pigs sharply declined in the 1960s. The breed was considered in the way of extinction in 1981 further to an inventory requested by the French Ministry of Agriculture. By this time, ITP (former IFIP name) and INRA counted only 50 sows and 5 boars left. Then, few pig breeders gathered by a dry-cured ham artisan producer, Pierre Oteiza, decided to revive the Basque breed and developed a local chain organisation. Their objective was to maintain peasant and butcher-processor artisan activities in Les Aldudes valley in the Basque Country. Afterwards, a specific farm for the preservation of Basque breed and genetic resources was developed, assisted by ITP. In 2001, the Basque chain association was created, and the instruction for further registration as protected designation of origin (PDO)

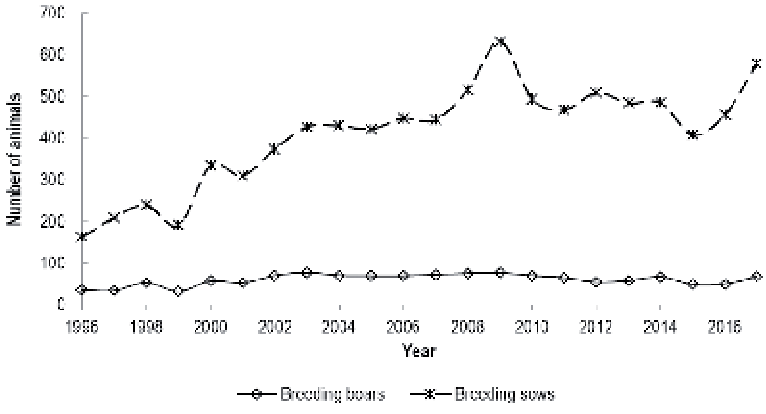

Figure 1.
Census of Basque pig breed, presenting the evolution of the number of sows and boars per year, starting with the year of heard book establishment.

was initiated. The Basque pork sector has progressively developed, based on the production of traditional and high-quality pork products. In 2016 the “Kintoa” fresh pork and Kintoa dry-cured ham (Jambon du Kintoa), produced from Basque pigs, obtained the French AOC (Appellation d’Origine Contrôlée) label. In October 2017, this national recognition was further translated at European level into the “Kintoa” PDO registration.

Presently the Basque pork chain gathers 80 members including 57 breeders or fatteners, 16 of them being also processors, 1 slaughterhouse, 4 butcher-processor artisans, and 2 processing plants for dry-cured products. The census of Basque pig breed is presented in **Figure 1**. Currently, there are 28 farms of Basque breeders registered in the LIGERAL herd book, with 580 breeding sows (01/01/2017).

2. Exterior phenotypic characteristics

The Basque pig breed morphology information is summarised in **Table 1**. As suggested by its name in French, pigs are piebald, black and white (**Figures 2** and **3**): black head and rump. The breed standard describes animals with a slightly convex back, some of them with large black areas and a sloping croup. Limbs are large and strong well suited for outdoor rearing in extensive hilly zones. The chest is large, ribs are round, and hams have an elongated shape. Pigs have large horizontal ears, tilted over the eyes, representing two thirds of the head length. Bristles are rare and fine with a circular aspect above the rump.

Measurement (average)	Adult male	Adult female
Body weight (kg)	250	200
Body length (cm)[1]	140	140
Height at withers (cm)	78	75
Number of teats	≥10	≥10

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Basque pig breed.

Figure 2.
Sow of Basque breed with piglets (photo credit B. Lebret).

Figure 3.
Boar of Basque breed (photo credit Kintoa).

3. Geographical location and production system

The Basque pig is originated from the Basque Country, a region located in the South-West of France and across Spain border. Nowadays farms producing Basque pigs are still located in this historical region of production. The geographical area and rearing conditions for Basque pigs dedicated to PDO Kintoa pork and dry-cured hams are detailed in specifications for AOC, the national label required before PDO registration [1]. Briefly, this region has a mild and humid climate under the influence of the Atlantic Ocean and warm winds from the South that are essential for the ripening process of the dry-cured hams. Located close to the Pyrénées mountains, this area exhibits a hilly landscape and includes grasslands and forests. To benefit from AOC/PDO registration, the pigs must be born, reared and slaughtered in the specified geographical area. Pigs (either castrated males or females before any lactation) are generally born and kept indoors with possible access to an outdoor area, up to a maximum of 5 months of age. They are then placed until slaughter in an extensive plot land that provides natural feeding resources (grass or herbaceous vegetation, roots, chestnuts or acorns) with a maximal animal density of 35 pigs/ha grassland

Figure 4.
Geographical localisation of the production of Basque pigs for the Kintoa protected designation of origin in France (BDCARTO-IGN, MAPINFO, INAO, 2014).

and 25 pigs/ha forest. Plot lands must be approved by the authorities responsible for quality sign management and control. Plots include a shed, water access and a feeding area. In addition to natural feeding resources that correspond to around 50% volume of feed intake, pigs are fed with complementary (without GMO) food up to a maximum of 3.2 kg per pig and per day between 3 and 8 months of age and 2.7 kg afterwards. From weaning, the allowed foodstuffs include wheat, corn, barley, rye, triticale, sorghum, oats, peas, faba beans, lupine, vetch, flax (as seeds or derived products), soybean, sunflower and rapeseed (as seeds, meal or oil), cane or beet molasses, alfalfa, beet pulp and whey only up to 2 months before slaughter.

Pigs are slaughtered at minimum 12 and maximum 24 months of age. Specifications for carcasses are minimum 100 kg hot weight and 25 mm back fat thickness (fourth/fifth lumbar vertebra level). Whole traceability is a guarantee for pigs and carcasses. A minimum green ham weight of 10 kg and minimum ripening duration of 16 months including 10 months in natural conditions are required for Kintoa hams (**Figure 4**).

4. Organisations for breeding, monitoring and conservation

All animals, boars, sows and piglets are individually identified and recorded in the LIGERAL herd book. A committee, composed of an expert and the technician in charge of following up the breed, validates each potential breeder considering the breed standard, the teats' number (minimum 10 functioning teats) and the inbreeding coefficient. Only pure breed reproduction is performed: natural mating usually. Also, for few years, few artificial insemination boars are available but just for slaughter pig production purposes. Usually, farms self-renew their sows and buy boars. Replacement breeding policy is based on relationship coefficients estimated by IFIP and the number of live animals per family (sows) or line (boars). One farm, dedicated to sow and boar rearing, has recently been created for the production of replacement animals and to facilitate the establishment of new farms. The number of breeders per family and line, reproductive performances and inbreeding are reviewed at least once a year. More complete analyses of the genetic variability based on probabilities of gene origin studies are occasionally performed [2]. In addition, Basque semen doses are preserved in the French National Cryobank which contains semen collected explicitly in the 1990s and the beginning of the 2000s. This heritage material is only dedicated to breed preservation (**Table 2**).

Name of organisation	Address	Web address
Filière Porc Basque Kintoa	64430 Les Aldudes, France	https://www.kintoa.fr/
LIGERAL—c/o IFIP	La Motte au Vicomte, BP 35104, 35651 Le Rheu Cedex, France	http://www.asp.asso.fr/

Table 2.
Contact details of breeding organisation for Basque pig breed.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. Averages are calculated from data recorded in the LIGERAL database. For the last available 5-year period (2012–2016), the average age of sows at the first parturition is 16.6 months. On average, sows of Basque pig breed have 1.6 litters per year with 7.5 piglets born alive [9]. The death rate of piglets until weaning in the considered study (last 5 years available period) of Basque pig breed averages 18.9%. Published data are also synthesised in **Table 3**. Without selection on reproductive performances, a progressive decline in litter size (born alive and weaned piglets) had been seen until 2003. Then, a slight improvement was observed [3]. Most recent

Reference	Sow age at the first parturition (mth)	Litters per sow per year[1]	No. of piglets alive per litter	Mortality at weaning (%)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling (mth)
[3]	—	1.5	7.2	20.8	—	243	—
[4][2]	—	—	8.3	25	—	—	—
[5]	—	—	7.4	23	—	—	—
[6]	—	1.4	7.4	16.2	—	261	—
[7]	16.4	1.6	7.7	18.6	33	228	38
[8]	—	1.4	7.6	21	—	261	—
[9][3]	**16.6**	**1.6**	**7.5**	**18.9**	**38.5**	**228**	**44**

No. = number, mth = month, d = days.
[1]*Litters per sow per year calculated as the average number of litters per sow having at least one litter in the year.*
[2]*Least squares mean with a GLM model including breed (five local breeds), parity season as a fixed effect, breed*parity interaction, the age of the sow and birth year as a covariate.*
[3]*Five-year average value from the herd book data (LIGERAL database between 2012 and 2016).*

Table 3.
Summary of collected literature data on reproduction traits in Basque pig breed.

TREASURE data confirm this tendency with +0.5 born alive and +0.6 weaned piglets in the last 10 years. Technical improvement of farming can explain this. Duration of lactation is prolonged in comparison to modern intensive systems to 38.5 days, which is also reflected in the prolonged farrowing interval (228 days on average). Thus, it can be concluded that Basque pig breed has moderate fertility compared to the most prevalent breeds.

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that a big part of the collected studies tries to simulate to some extent practical conditions of the production systems used and that only a smaller part of the studies actually aimed at evaluating the breed potential for growth. In the considered studies, the weight gain in the growing stage (around 320 g/day in the three studies) is lower than observed for modern breeds denoting lesser intensity of rearing and lower growth potential. It also reflects the fact that no selection is undertaken on growth in the Basque breed, unlike modern breeds. Also the early, middle, late and overall fattening stages are characterised by much slower growth than in "modern" selected breeds and big heterogeneity (358–640, 452–560, 236–499 and 335–544 g/day in early, middle, late and overall growing stage, respectively), related to the fact that this review comprises studies where different systems and feeding levels were practised. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values,

Reference	Feeding	No. of animals	ADG growing[1]	ADG fattening[2]				ADG birth to slaughter[3]
				Early	Middle	Late	Overall	
[10, 11]	Ad lib	28	—	560	560	—	—	—
	Semi	16	—	—	—	316	443	—
[12]	—	309	—	—	—	—	539	—
[13]	Ad lib	18	—	—	—	—	488	—
[14–16]	Ad lib	20	316	599	481	429	498	437
	Ad lib	20	321	640	508	499	544	467
	Semi	20	325	358	452	236	335	333

No. = number, ADG = average daily gain in g, Ad lib = ad libitum feeding regime; Semi = semi ad libitum feeding regime.
[1]*ADG in growing period estimated from weaning to approximately 30 kg live body weight.*
[2]*ADG in period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively, in studies 1–2 and between approximately 30 and 75 kg, 75 and 110 kg and above 110 kg live body weight, respectively, in study 4. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall); in study 3 this is between 26 and 86 kg LW.*
[3]*ADG from birth to slaughter was calculated from the individual data, considering the birth weight as 1.00 kg.*

Table 4.
Summary of collected literature data on growth performance in Basque pig breed.

Reference	Feeding	NE content of feed[1] (MJ/kg)	CP content of feed[1] (%)	No. of animals	ADFI fattening[2]			
					Early	Middle	Late	Overall
[11, 15]	Semi	10.3	15.5	20	—	—	—	2.1
[12]	—	—	—	—	—	—	—	3.70
[13]	—	—	17.7	—	—	—	—	2.30
[14–16]	Ad lib	10.3	14.7	20	2.23	2.51	2.41	2.39
	Ad lib	10.3	14.7	20	2.43	2.64	2.85	2.67

No. = number, ADFI = average daily feed intake in kg/day, Ad lib = ad libitum feeding regime, Semi = semi ad libitum feeding regime, NE = net energy, CP = crude protein.
[1]*NE and CP content of the feed is reported for the finishing diet distributed from 75 up to 145 kg.*
[2]*ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 75 kg, 75 and 110 kg and above 110 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).*

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Basque pig breed.

because it can be assumed that the maximum figures exhibit the growth potential of Basque pigs in ad libitum conditions of feeding (≈544 g/day in overall fattening stage).

In considered studies, the information on feed intake and feed nutritional value were scarce (max five available values), which limits the evaluation of growth potential. Average daily feed intake increased from 2.3 kg/day in the early growing stage up to max 2.9 kg/day in the late fattening stage when ad libitum feeding regime was applied.

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness[1] (mm)	Loin eye area (cm^2)
[8]	—	458	130	114	—	39	—
[10, 11]	12	—	105	77	72.9	41	—
	16	—	154	113	73.2	48	—
[13]	18	202	86	65	75.4	26	18.1
[14–16]	20	320	140	118	81.8	47	—
	20	312	146	117	81.3	51	—
	20	423	142	116	80.4	39	—
[17]	10	—	145	—	—	45	—

No. = number, BW = body weight, CW = carcass weight.
[1]*Backfat thickness was either measured at the level of the last rib, reported as the average of measurements taken along the carcass, or between the fourth and fifth lumbar vertebra level (in agreement with specifications for AOC Kintoa studies [14–16]).*

Table 6.
Summary of collected literature data on body composition and carcass traits in Basque pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	FA composition of IMF (%)				FA composition of BFT (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[10, 11]	16	6.27	5.76	47	11	—	—	—	—	—	—	—	—	—	—
	12	—	—	—	—	—	3.9	—	—	—	—	43.1	45.2	11.7	—
[13]	18	—	—	43	6.0	8.0	5.7	42.9	43.4	13.8	—	—	—	—	—
[14–16, 18]	20	6.48	5.59	51	9.6	6.6	3.8	38.2	54.0	7.6	9.3	38.9	48.6	12.4	9.5
	20	6.52	5.54	52	9.7	6.9	4.1	38.5	53.6	7.6	9.3	37.5	49.8	12.5	9.1
	20	6.63	5.67	48	9.3	4.9	3.3	35.7	54.0	10.0	11.0	35.7	49.0	15.0	10.0
[19]	12	—	—	—	—	—	3.4	34.6	56.1	9.3	15.9	—	—	—	—

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem, pH 24 = pH measured approximately 24 h post-mortem, IMF = intramuscular fat, BFT = back fat tissue, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, n6/n3 = the proportion between n-6 and n-3 polyunsaturated fatty acids.

[1]CIE, objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

Table 7.
Summary of collected literature data on meat and fat quality in Basque pig breed.

In considered studies, pigs of Basque breed were slaughtered between 202 and 458 days of age (n = 5 studies) and between 86 and 154 kg live weight (over 130 kg in 6 out the 8 references). In the six listed references, dressing yield was in the 72.9–81.8% interval. The back fat thickness value measured at the level of the last rib, reported as the average of measurements taken along the carcass or between the fourth and fifth lumbar vertebra level (according to AOC specifications), spanned from 26 to 51 mm (n = 8 studies), whereas muscularity measured as loin eye area was 18.1 cm^2 [13]. These values indicate lower muscular development and greater carcass fatness compared to modern breeds which can be explained by the absence of selection on fatness and muscle in the Basque breed. This variation in back fat and muscle thickness is also a consequence of the wide range of final live weight of pigs and different feeding regimes applied in considered studies.

5.4 Meat and fat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *longissimus* muscle and subcutaneous back fat tissue that could be compared are presented in **Table 7**. In the studies reporting meat quality of Basque pigs, pH measured in *longissimus* muscle at 45 minutes and 24 h *post-mortem* was between 6.27 and 6.63 and between 5.54 and 5.76, respectively (n = 4 studies). Loin meat from Basque pigs also exhibited high intramuscular fat content (over 3.3% and with a maximum of 5.7%; n = 6) and a dark colour (high Minolta a^* value over 9.3 in four out of five studies and moderate lightness with L^* value within the 43–52 interval). Big differences in the SFA, MUFA and PUFA content of intramuscular fat in *longissimus* muscle were observed between the considered studies (n = 5 studies). These are due to differences concerning the feeding regime, feed composition, final body weight/age and fatness, which are all important factors influencing the fatty acid composition of meat.

6. Use of breed and main products

The Basque pig breed is intended for the production of traditional high-quality pork and processed products that have been now protected at national (AOC) and European (PDO) levels. The main products are listed in **Table 8**. The low growth rate of animals, low lean growth potential and high fatness, associated with the extensive production system including natural feeding resources, strongly interact and lead to muscle and meat phenotypic traits that are favourable for the high sensory and technological quality of pork and pork products [20]. Notably, the meat of Basque pigs exhibits a red colour, very low drip loss, low rate and moderate amplitude of *post-mortem* pH decline and high intramuscular fat content, all these traits playing an important and positive role on the appearance, tenderness and juiciness of pork products [18]. The high intramuscular fat associated with the high content of monounsaturated fatty acids of ham muscles is also of great interest for sensory (tenderness, flavour) and nutritional quality of dry-cured hams [15]. The very high sensory quality of pork and products from Basque pigs is recognised at both national and international levels, with the export of dry-cured hams to Japan and Hong Kong. The recent AOC/PDO official label certification will be helpful to improve consumer awareness and knowledge about these specific products and production systems and thereby should enhance the sustainability of the local Basque pork chain (**Figure 5**).

Product name	Type of the product	Status of the product	Label
Jambon du Kintoa	Dry-cured ham	AOC (French label) and PDO Kintoa	*AOC Kintoa, PDO in progress*
Viande fraîche Kintoa	Carcass and meat	AOC (French label) and PDO Kintoa	*AOC Kintoa and PDO*
Saucisson sec	Dry sausage	No specific status; "from Basque pork"	
Pâté	Pâté	No specific status; "from Basque pork"	
Boudin noir	Black blood pudding	No specific status; "from Basque pork"	
Chichons	Kind of rillettes	No specific status; "from Basque pork"	

Table 8.
Main products from Basque pig breed.

Figure 5.
New logo (2018) of Kintoa pork produced from Basque pigs: On the left, French logo for AOC label on dry-cured ham (AOC, French label mandatory before PDO registration at EU level) and on the right AOP on fresh pork (AOP, French translation for PDO).

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Chapter 4

Bísaro Pig

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Abstract

Local pig breeds are adapted to the specific local environment and fed with various locally available feedstuffs. So besides their genetic merit for agro-biodiversity, they represent the foundations of sustainable local pork chains. Thus, the aim of the current chapter is to present the history and current status of the Bísara breed (Bísaro pig), its exterior phenotypic characteristics, geographical location, production system and main products from this Portuguese autochthonous breed of pigs. Moreover, a collection and review of available literature data, set until August 2017, on reproductive and productive traits (growth, carcass, meat and fat quality) of Bísaro pig breed were carried out. Reproductive performance has been estimated by means of sow's age at the first parturition, annual litters per sow, piglets alive per litter, piglet live birth and weaning weight, percentage of stillborn per litter, mortality to weaning, lactation length and farrowing interval. Growth performance has been estimated through the average daily gain and feed intake in both the growing stage and the early, middle, late and overall fattening stage. Carcass traits have been evaluated by means of age and weight at slaughter, hot carcass weight, carcass yield, lean meat content, backfat thickness at withers, last rib, above the muscle *gluteus medius* and the loin eye area. Meat and fat quality traits of *longissimus* muscle have been evaluated by means of pH at 45 minutes and 24 h after slaughter, objective colour (CIE L*), intramuscular fat content and fatty acid composition of intramuscular fat. Although a considerable number of studies on Bísaro pig were included in the current review, data on meat and fat quality are scarce.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Portugal

1. History and the current status of the breed (census)

The Bísaro pig is a Portuguese native breed belonging to the Celtic line—*sus Celtics* [1, 2]—that was maintained in its primitive state throughout the North of Portugal until the mid-twentieth century [3, 4]. This breed presents a slow growth, unfavourable carcass conformation and medium fat and has always been recognized for its high prolificacy, excellent sensorial quality of meat and aptitude for processing typical products. In the second half of the last century, industrialization of the livestock production has changed meat consumption patterns, and the Bísara breed has declined to be replaced by more productive breeds originating from the centre and north of Europe and Asia. In the 1990s, this breed was practically extinct and reduced to only about 100 breeding stock in small farmers in the North of Portugal. The first conservation and recovery programme for the Bísaro breed was approved and supported by the

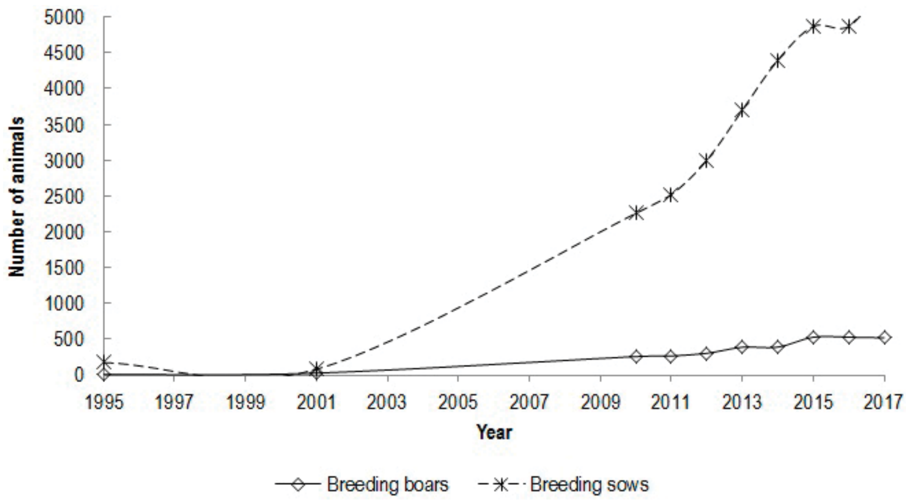

Figure 1.
Census of Bísara breed, presenting a number of sows and boars per year, starting with the year of the herdbook establishment.

Portuguese government in the 1990s [5]. From here, and following the establishment of the National Association for Bísaro Pig Breeders (ANCSUB) in 1994, the Bísaro pigs increased in number once again. In 1996, a national plan for conservation and characterization of the breed was launched (project PAMAF 7173). This plan allowed the first regional census of the breed and the selection of some of the few existing breeding animals to form the two experimental conservation nuclei "in vivo" and "in situ" (in Guimarães and Montalegre, respectively). From these two nuclei, some descending piglets were sent to the National Zootechnical Station (EZN, in Santarém), where individual performance tests were performed to characterize the growth and quality of the meat. The results of the performance tests, together with DNA analysis on animals, allowed the selection of some Bísaro pigs to return to the conservational nuclei for breeding and made available to the producers for commercial use. After the PAMAF programme, others followed (AGRO 247 and AGRO 339), which allowed the work of characterization to continue and assist the producers' knowledge and to develop the breed until the present day. The census of Bísaro pig breed is presented in **Figure 1**. In August 2017, according to the breed herdbook, there were 189 registered farms of Bísaro pigs with 5460 breeding sows and 520 boars and an average heard size of 29 animals.

Today this breed is indexed to a diversity of European protected products (https://tradicional.dgadr.gov.pt/pt/pesquisa?searchword=bisaro&searchphrase=all), and the maintenance or an increase of the Bísaro population is expected. Nowadays the Bísaro pig is reared in a variety of production systems, mainly in small family farms or in medium-sized outdoor or semi-extensive farms.

2. Exterior phenotypic characteristics

The Bísaro pig breed has a large body and long legs, with flat sides, strong shoulders and a big head. They have very long and floppy ears covering the eyes, a long and concave snout and a convex back. This local pig breed has several varieties of skin colour; they can be grey or black and white or spotted. The Bísaro has a docile temperament, is slow and somewhat clumsy and is characterized by a convex back and large drooping ears. There are two varieties of Bísaro pig in Portugal: a white-spotted one, common in Minho, and a black- to grey- or black-spotted one, found in Minho, Trás-os-Montes and Beiras [6]. The average live weight of adult Bísaro pigs varies between 180 kg in males and 150 kg in females; the values of the height at withers vary between 97 and 89 cm, respectively (**Table 1**; **Figures 2** and **3**).

Measurement (average)	Adult male	Adult female
Body weight (kg)	180	150
Body length[1] (cm)	190	170
Head length (cm)	45	40
Tail length (cm)	60	55
Ear length	Extra large	Extra large
Chest girth (cm)	170	150
Height at withers (cm)	97	89
Number of teats	—	≥12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Bísara breed.

Figure 2.
Bísaro sow with piglets.

Figure 3.
Bísaro boar.

3. Geographical location and production system

The Bísara breed is scattered throughout the northern of Portugal, from the Tagus River to the border with Galicia (in Spain), but the highest concentration of farms and animals can be observed over the Douro River (Trás-os-Montes and Minho regions). Traditionally, Bísaro pigs were kept in very small family farms (1–2 sows per farm) where the pig is often considered an economic supplement for self-consumption and/or for processing artisanal products, sold directly to consumers and/or in small regional fairs (short supply chains) [7]. The traditional Bísaro feeding system includes diets based on a mixture of cereals (corn, wheat, barley, bran, triticale, others) and a large variety of forage foods, such as tubers (potatoes, turnips, beets), vegetables (cabbages, pumpkins, carrots) and grazing areas, where pigs can pasture different kinds of herbs and wild fruits (chestnuts and acorns). The nature of the raw feeds used in the traditional diets is a limiting factor of the herd size. Thus, the very small scale of the pig farms and the rudimentary buildings and animal facilities, which are poorly dimensioned, are the main weakness of this production system, limiting the farms' productivity and possibly impairing animal welfare.

Nowadays, the average number of sows per farm is 30 (ANCSUB, personal communication), raised in traditional family farms (50%) and kept in semi-intensive outdoors or semi-extensive systems. In some cases, the housing systems combine housed (confined) and outdoor rearing systems according to the different physiological stage of the animals. Normally, lactating sows and piglets are confined (housed) in maternities, while pregnant sows are reared outdoors or in semi-confinement [7]. Typically, fattening of Bísaro pigs to obtain high-quality meat products includes two growing phases: first, a fast to moderate growth up to 70–75 kg live weight (LW) and, second, a fattening-finishing phase until 120–180 kg LW, with variable diets depending on the availability of local food resources on specific farm and region. As alternatives to improve the traditional food, the incorporation of external input, for instance, cereals and food concentrates, has been developed. Growers and finishing pigs can be reared in mixed systems where animals are confined in an open-air park or in an enclosed stable with access to grazing areas of various sizes, depending on the availability of pastures and clumps. The growing-finishing phase can be classified as intensive, semi-extensive or extensive depending on the available pasture area and the stocking rate. The goal of the TREASURE project for the Bísaro pig in Portugal was to study the effect of outdoor production systems and to test some traditional agricultural crops in the fattening of Bísaro pigs and their impact on the quality of pork.

4. Organisations for breeding, monitoring and conservation

The National Association for Bísaro pig breeders (ANCSUB[1]) was created in 1994, and in March 1995, the Ministry of Agriculture recognized it to establish the herdbook and its regulation. ANCSUB aims to preserve and enhance the production of the Bísaro pig and meat products and to conduct the genetical management of the Bísaro breed and its herdbook. ANCSUB ensures technical support and animal management services to breeders, such as animal identification and health services (vaccination and deworming), technical support in protection and certification of PGI and PDO products and organization of technical meetings.

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5. Productive performance

5.1 Reproductive traits

The use of a boar in small pig farms entails high economic costs. This is why some farms (less 5% of the farm and less of 20% of sows) are using A.I. with semen purchased from a semen collection centre. However, due to the great distance from the pig farms, there are logistic problems related with the shipment of the seminal doses that affect the efficiency of A.I. [8]. To improve the results of A.I., it is advisable to improve the transport and storage of semen to the farms, as well as to promote training of farmers in reproductive management, namely, the identification of the best moment for insemination. In contrast, in small family farms (1–2 breeding sows), mating of Bísaro sows takes place in community facilities, by "the village boar". The sow is moved to the community farm for several days, until pregnancy is confirmed. Despite being economically advantageous, this reproduction system brings other technical problems such as increased inbreeding and farrowing interval and the risk of contagious diseases [9].

Table 2 summarizes some available data on the breeding characteristics of the Bísara breed. For each study, the number of animals tested and the mean values recorded for each trait are given. In general, the analysed studies report that the first parturition of Bísara sows occurs between 10 [9] and 12 months of age [10] (11.2 months in average). On average, Bísara sows have 1.9 litters per year (ranging from 1.5 [9] to 2.2 [12]) with 9.3 piglets born per litter (variation 6.9 [10] to 12 [9]), weighing approximately 1.8 kg at birth [5, 10, 12] and 7.2 [12] to 11.1 kg at weaning [10]. Traditionally weaning is performed 60 days after birth [9], but can vary from 28 [12] to 60 days, depending on the intensity of breeding practices. The mortality rate of piglets is very variable in the available studies, ranging from 5 [12] to 11% at birth [10] and 14 [12] to 35% at weaning [10]. In the traditional and extensive production systems, the interval between parturitions is prolonged as a consequence of farmer's management decisions, such as the increase in the age at weaning (from 28 days usual for intensive systems [12] to 60 days in the traditional system [9]) and more extensive rearing and feeding conditions. In this case the piglets are sold with higher weights and for higher price. However, this system is more demanding for sows which are forced to mobilise body reserves to a much greater extent, during lactation and the first third of gestation.

5.2 Growth performance

In the traditional farms, Bísaro pigs are fed with local agricultural crops, usually produced on farm. The feed regime for fattening animals is closely linked to the products and by-products of plants and forages of each region which is dependent on the annual cycles and harvests. Generally, in traditional system Bísaro pigs are fattened slowly and slaughtered between 1 and 2 years of age, reaching a high but variable slaughter weight (between 120 and 180 kg), which is scheduled for the coldest months of the year (between November and February).

Basic data on growth performance are presented in **Tables 3** and **4**. For each study the number of animals used is presented. Large differences have been found between studies with regard to the live weight range covered. Therefore, we defined the stages for growth performance as growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (herein defined as overall). It should also be noted that most collected studies simulated the conditions of the production system used and that only a small part of the studies

Reference	Production system	No. of sows	Age at the first parturition (mth)	Litters per sow per year	No. piglets alive per litter	Piglet live weight (kg)	Still born per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[5]	Intensive, outdoor	21	11.6	1.6	9.1	1.8	9.8	29.4	8.6	42	200
[9]	Traditional	4	10.0	1.5	12.0	—	8.3	16.6	—	60	232
[10]	Intensive, outdoor	14	11.9	—	6.9	1.7	11.0	34.8	11.1	52	—
[11]	Intensive, outdoor	32	—	1.8	8.7	—	—	20.5	—	—	203
[12]	Semi-intensive, outdoor	11	11.3	2.2	10.0	1.7	5.0	14.3	7.2	28	162

No. = number, mth = month, d = days.

Table 2.
Summary of collected literature data on reproduction traits in Bísara breed.

Reference	Feeding regime and production system	No. of animals	ADG growing[1]	ADG fattening[2]			
				Early	Middle	Late	Overall
[10]	Semi; outdoor	13	—	—	—	—	514
[13]	Semi (100% concentrate)	6	—	513*	641	—	577
	Rest (75% concentrate +4 kg/day herb)	8	—		467	—	490
	Rest (50% concentrate +4 kg/day herb)	8	—		356	—	435
[14]	Semi; individual housing—performance test	24	—	—	559	534	559
[15]	Semi; closed pavilion	38	—	—	—	—	593
	Semi; outdoor	10	—	—	—	—	460
	Semi; traditional stable	30	—	—	—	—	653
	Rest; outdoor	20	—	—	—	—	345
	Rest; outdoor	20	—	—	—	—	343
[16]	Semi; outdoor	22	—	—	431	—	431
[17]	Semi; hoop-barn, outdoor	10	546	—	—	—	535
	Semi; traditional stable	10	563	—	—	—	505

No. = number, ADG = average daily gain in g, Semi = semi ad libitum feeding regime, Rest = restrictive feeding regime.
[1]ADG in growing period estimated from weaning to approximately 30 kg live body weight.
[2]ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).
**Recorded on 22 animals.*

Table 3.
Summary of collected literature data on the average daily gain (in g) in Bísara breed.

actually aimed at evaluating the breed potential for growth. In the considered studies, data on growth performance during lactation are missing. Daily gain in the growing stage varies between 546 and 563 g/day [17]. The early, middle and late fattening stages are characterized by moderate growth (513 g/day [13], 356–641 g/day [14] or 534 g/day [16]). In the overall fattening stage, for which data are available in most studies, moderate growth and big heterogeneity are observed (ranging between 343 and 653 g/day) [10, 13–17] which could be due to the fact that this review comprises studies performed in different production systems and using varying feeding levels.

The available information on Bísaro's feed intake and feed nutritional value is scarce, which limits the evaluation of the Bísaro growth potential. Average daily feed intake increases from approximately 1.7 kg/day in the growing stage to a maximum of 2.7 kg/day in the middle fattening stage [16] and 2.6 kg/day in the late fattening stage [14] when a *semi* ad libitum feeding regime was applied. In contrast, in the overall fattening stage, the average feed intake varied between 1.8 and 2.6 kg/day [10, 14, 15, 17].

5.3 Body composition and carcass traits

Table 5 presents the basic data regarding some of the most commonly measured carcass traits. The number of animals included in each study is given whenever possible. In general, the breed, age and weight at slaughter, the climatic conditions,

Reference	Feeding regime and production system	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI growing[1]	ADFI fattening[2]		
						Middle	Late	Overall
[10]	Semi; outdoor	13	13.8	13	—	—	—	2.04
[13]	Semi; outdoor	12	16	6	—	2.70	—	—
	Semi; traditional stable	12	16	8	—	1.80	—	—
	Rest; outdoor	12	16	8	—	0.90	—	—
[14]	Semi; individual housing—performance test	12	16	24	—	2.05	2.62	2.05
[15]	Semi; individual housing—performance test	—	—	38	—	—	—	2.06
[16]	Semi; outdoor	12	15	22	—	2.70	—	—
[17]	Semi; hoop-barn outdoor	—	—	10	1.70	—	—	1.84
	Semi; traditional stable	—	—	10	1.76	—	—	1.78

No. = number, ADFI = average daily feed intake in kg/day, Semi = semi ad libitum feeding regime, Rest = restrictive feeding regime, ME = metabolisable energy, CP = crude protein.
[1]*ADFI in a growing period estimated from weaning to approximately 30 kg live body weight.*
[2]*ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on average daily feed intake (in kg/day) in Bísara breed.

the use of regional raw materials (acorns, oaks, chestnuts, grass and agricultural by-products) and the exercise of animals during grazing are the main differentiating factors of meat quality compared to modern pig breeds reared in intensive system. Traditionally, Bísaro pigs are slaughtered at weights well above the age of sexual maturity, when muscle growth has stabilized at the expense of greater capacity of deposition and infiltration of intramuscular fat (+60% monounsaturated fatty acids), an essential condition in order to develop the organoleptic characteristics that are highly valued by consumers [19].

Three studies report that Bísaro pigs were slaughtered between 282 and 333 days of age [15, 16, 18], while in the other studies, the age of pigs is missing. Considering information available in all studies, animals are slaughtered between 88 and 124 kg live weight, and dressing yield ranges from 73.4 to 77.6% [10, 13–16, 18]. The backfat thickness at withers ranged from 45 to 62 mm [10, 18] and at the level of the last rib from 19 to 42 mm [10, 13–16, 18]. Also, muscularity, measured as the lean meat content (either by SEUROP classification or dissection), varied from 46.1 to 51.0% [10, 13, 15, 16] and the loin eye area from 29 to 40 cm^2 [13, 14], which indicates good muscular development compared to other traditional breeds. Variation in backfat and muscle thickness may be a consequence of the wide range of final live weight of pigs and different feeding regimes applied in different experiments.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			Loin eye area (cm²)
							S¹	At withers	At the last rib	
[10]	13	—	99	75	76.3	46.1	—	45	25	—
	6	—	88	68	76.7	46.8	—	—	—	—
[13]	6	—	116	90	77.6	46.3	—	—	31	40
	8	—	108	82	75.9	48.5	—	—	24	40
	8	—	102	76	74.7	49.4	—	—	22	36
[14]	12	—	106	81	77.0	—	—	—	20	29
[15]	13	333	105	81	76.9	51.0	—	—	19	—
	10		112	83	74.0	49.9	—	—	20	—
	20		106	78	73.4	48.7	—	—	19	—
[16]	22	325	106	78	73.4	48.6	—	—	21	—
[18]	18	282	124	94	75.5	—	46	62	42	—

No. = number, BW = body weight, CW = carcass weight.
¹Backfat thicknesses measured according to ZP method (above the gluteus medius muscle (mm)).

Table 5.
Summary of collected literature data on body composition and carcass traits in Bísara breed.

5.4 Meat and fat quality

Table 6 summarizes the basic data available for some of the most commonly measured meat and fat quality traits in *longissimus* muscle. In studies reporting the Bísaro meat quality, pH measured in *longissimus* muscle at 45 minutes and 24 h *post-mortem* varied between 5.95 and 6.34 and 5.32 and 5.56, respectively [13, 14]. Other data on meat quality were scarce. The intramuscular fat content was determined only in two studies and range from 2.6 to 2.7% [14, 16], whereas only one study referred to meat colour (Minolta L value; L* = 54 [14]). Regarding fat composition,

Reference	No. of animals	pH 45	pH 24	CIE L¹	IMF content (%)	Fatty acid composition² (%)			
						SFA	MUFA	PUFA	n-6/n-3
[13]	6	6.04	5.32	—	—	—	—	—	—
	8	6.23	5.37	—	—	—	—	—	—
	8	6.34	5.38	—	—	—	—	—	—
[14]	12	5.95	5.56	54	2.6	—	—	—	—
[16]	22	—	—	—	2.7	—	—	—	—
[20]	—	—	—	—	—	40	47	13	12

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem, pH 24 = pH measured approximately 24 h post-mortem, IMF = intramuscular fat, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids.
¹CIE = objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour.*
²For fatty acid composition, only pigs on control diets were considered. Control diets differed among studies, to see diet composition address to the corresponding source.

Table 6.
Summary of collected literature data on meat and fat quality traits measured in longissimus muscle from pigs of Bísara breed.

one study discriminates the fatty acid content in MUFA (47%), PUFA (13%) and SFA (40%), together with a n-6/n-3 ratio of 12 [20]. It should be noted that the values mentioned in the experiments respect to Bísaro pigs under controlled conditions, which may be quite different from those obtained in traditional production systems and at heavier weights, around 160 kg.

6. Use of breed and main products

Bísaro pork is much appreciated in Portugal, with many gastronomical uses. Meat is consumed in fresh on a wide variety of traditional dishes or transformed into a large number of traditional smoke cured products, such as *chouriços, salpicões, presunto* (ham) and other traditional products. Besides the diverse PDO and PGI products created from Bísaro pork (**Table 7**), Bísaro meat is valued in the traditional cuisine, such as roast piglets or *cozido à portuguesa* cooked from heavy pigs.

Type of the product	Name of the product	Status of the product
Fresh meat	*Carne de Bísaro Transmontano*	*PT/PDO*
Cured meat product	*Alheira de Barroso-Montalegre*	*PT/PGI*
	Alheira de Vinhais	
	Butelo de Vinhais; Bucho de Vinhais; Chouriço de Ossos de Vinhais	
	Chouriça de Carne de Barroso-Montalegre	
	Chouriça de Carne de Melgaço	
	Chouriça de Carne de Vinhais; Linguiça de Vinhais	
	Chouriça de sangue de Melgaço	
	Chouriça Doce de Vinhais	
	Chouriço Azedo de Vinhais; Azedo de Vinhais; Chouriço de Pão de Vinhais	
	Chouriço de Abóbora de Barroso-Montalegre	
	Presunto de Barroso	
	Presunto de Melgaço	
	Presunto de Vinhais/Presunto Bísaro de Vinhais	
	Salpicão de Barroso-Montalegre	
	Salpicão de Melgaço	
	Salpicão de Vinhais	
	Sangueira de Barroso-Montalegre	

Table 7.
List of products from Bísara breed.

7. Conclusion

Although we may know the Bísara breed a little better today, much is still to be done, especially in the development of production systems and environmental and husbandry strategies that may improve the effectiveness and quality of the Bísaro products.

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Chapter 5

Apulo-Calabrese Pig

Riccardo Bozzi, Maurizio Gallo, Claudia Geraci, Luca Fontanesi and Nina Batorek-Lukač

Abstract

The aim of the present chapter is to present history and current status of Apulo-Calabrese pig breed, one of the local pig breeds investigated in the project TREASURE. Apulo-Calabrese breed is one of the Italian autochthonous pig breeds. Its origin dates back to the Roman times, but it suffered a drastic decline during the past century and the recovery started in the 1990s. A herd book for this breed was established in 2001, but its performances and products are practically untapped. There are 45 registered farms with around 500 breeding sows and 100 boars. Apulo-Calabrese pig is characterised by black coat colour. On average sows of Apulo-Calabrese pig breed have 1.7 litters per year with 6.9 piglets. Regarding growth performances, the potential of Apulo-Calabrese pigs in ad libitum conditions of feeding is high (≈762 g/day in middle fattening stage) although information on feed intake and feed nutritional value was scarce, which limits the evaluation of growth potential. Data on body composition, carcass traits and meat and fat quality are scarce. The present review gives a first insight into this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Italy

1. History and the current status of the breed (census)

The Apulo-Calabrese is a breed of black domestic pig from Calabria, in Southern Italy [1]. Census of the Apulo-Calabrese pig breed is presented in **Figure 1**. Presently, there are 45 registered farms of Apulo-Calabrese pigs with about 489 breeding sows and 93 boars in the latest available status (August 2015 [2]). From the historical point of view, already in pre-Roman times, the migratory flows from Central Italy to the South favoured the spread of pig breeding along the Apennine ridges [3]. The Apulo-Calabrese breed is, therefore, a swine population that has been established over the centuries and has spread with the transhumance of the flocks on the road routes dating back to Roman times [3]. In the past century, black coat pigs, capable of using poor food resources, were present along the Apennine foothills. The abandonment of the lands and the uncontrolled introduction of cosmopolitan breeds provoked a rapid decline of this breed too, until, eventually in the 1990s, a recovery action started [3, 4]. The conservation programme has progressively been consolidated, and the herd book was established in 2001 [5].

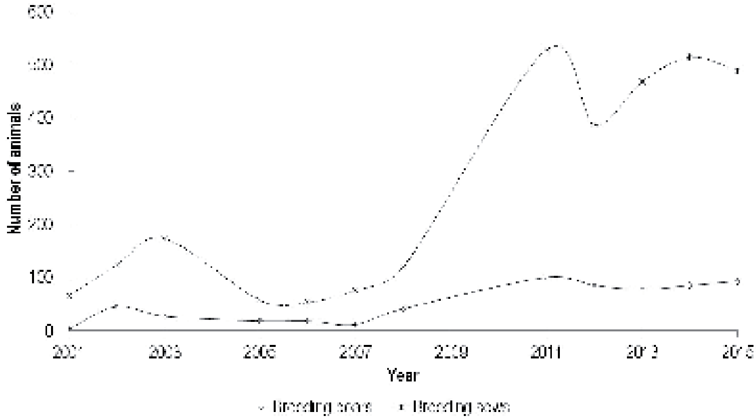

Figure 1.
Census of Apulo-Calabrese pig breed, presenting a number of sows and boars per year, starting with the year of heard book establishment.

2. Exterior phenotypic characteristics

The Apulo-Calabrese pig breed morphology information is summarised in **Table 1**. It is medium- to small-sized breed with plain black coat colour (**Figures 2** and **3**). The bristles are black, straight, robust and longer in the dorsal region even if white spots on the lower extremities of the legs are allowed [3, 5]. Long and thin snout with a straight head profile, droopy ears projected forwards and a straight tail [3, 5]. Not less than ten nipples normal and well pronounced [5].

Measurement (average)	Adult male	Adult female
Body weight (kg)	150	130
Body length[1] (cm)	130–145	130–142
Head length (cm)	32–48	32–48
Ear length	Large	Large
Chest girth (cm)	120–134	125–133
Height at withers (cm)	72–82	71–79
Number of teats	13	13

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Apulo-Calabrese pig breed.

Figure 2.
Apulo-Calabrese sow with piglets.

Figure 3.
Apulo-Calabrese boar.

3. Geographical location and production system

The Apulo-Calabrese breed is present in the southern regions of Italy with the primary concentration of herds in Calabria, Basilicata and Lazio. The breed has been recovered by a regional agricultural development company, which had kept a few animals in a structure located in the municipality of Acri in the province of Cosenza. A not insignificant quantity of Calabrian black pigs was always present in the area of Polsi (Aspromonte) where it is still grazed-free, fed mainly with acorns and chestnuts. Currently, the breed has a recovery, albeit slow, thanks to some small Calabrian pig farms, mostly family-run, with the relative production of its precious sausages. The breed is maintained mainly by peasant farming system using the agroforestry practices. Most of the animals are kept continuously confined, and the basic heat protections are available even if the housing parts are not completely climate controlled.

4. Organisations for breeding, monitoring and conservation

The Italian Pig Breeders Association (ANAS) is responsible for monitoring the breeds, controlling the "registry" that represents the tool for the conservation of breeds not interested in a national selection scheme. The activity is aimed at the conservation of the breed with particular regard to the maintenance of genetic variability while promoting economic exploitation. A private association (Associazione Nero di Calabria) founded with the aim of enhancing, promoting and protecting the products and breeders of the Apulo-Calabrese is also present. The association also aims to expand the culture and tradition of all those typical products of Calabria derived from the transformation of the black pig. In January 2007 the "Consortium for the protection of Calabria PDO cured meats", a nonprofit organism that carries out functions of protection, control, promotion, development, customer information and general interests for Calabria PDO-cured meats, was also established (**Table 2**).

Name of organisation	Address	Web address
Associazione Nazionale Allevatori Suini (ANAS)	Via Lazzaro Spallanzani 4, 00161 Rome, Italy	www.anas.it
Associazione Nero di Calabria	C.da Taverna snc, 87,040 Paterno Calabro (CS), Italy	—

Table 2.
Contact details of breeding organisation for Apulo-Calabrese pig breed.

5. Productive performance

5.1 Reproductive traits

The basic data obtained on reproductive traits in this review are presented in **Table 3**. The average age of sows at the first parturition varies from 13 to 23.5 months of age [1, 10], whereas, according to ANAS heard book data, age at culling is 52.3 months [2]. Sows of Apulo-Calabrese pig breed have 1.2–2.2 litters per year [1, 7, 9, 11] with 6.1–8.0 piglets [2, 6, 7, 11] of approximately 1.0 kg live body weight [1, 6, 11, 13]. Stillborn percentage of piglets varies from 6.2 to 7.1% [2, 6, 11], whereas piglet mortality rate until weaning in the considered studies ranged from 8.6 to 20.8% [2, 6, 7, 11]. Duration of lactation is prolonged in comparison to modern intensive systems (to 40 days [11]), which leads to a longer farrowing interval (171–300 days [1, 7, 9, 11]) but variable piglet weaning weight (3.4–8.1 kg [11, 13]).

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth–slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. In the considered studies, a daily gain in the early growing stage that corresponds to lactation period varied from 134 to 155 g/day [9, 11]. Generally, growing and fattening stages are characterised by slower growth, but also high variability, especially in fattening stage, among studies can be observed. The average daily gain in growing stage was approximately 280 g/day, whereas in overall fattening stage, it ranges from 300 to 706 g/day [1, 9, 11, 14]. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Apulo-Calabrese pigs in ad libitum conditions of feeding (≈762 g/day in middle fattening stage [14]).

The information on feed intake and feed nutritional value were reported only in one study conducted on Apulo-Calabrese pigs, which limits the evaluation of their growth potential. Average daily feed intake reported was 2.2 kg/day in early fattening stage and 3.6 kg/day in the late fattening stage (declared as ad libitum feeding [14]).

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. Pigs of the Apulo-Calabrese breed were slaughtered at approximately 336 days of age [14] and 149 or 175 kg live weight [1, 14]. Approximately 81.1% dressing yield [1, 14] and only 44.8% lean meat content (SEUROP classification [14]) is reported in Apulo-Calabrese pigs. Accordingly, relatively high backfat thickness of 68 mm at the withers and 48 mm at the level of the last rib was measured [14]. No other data providing measurements of muscularity were found in considered studies.

Reference	Sow age at the first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling (mth)
[1]	13.0	1.2	—	0.6	—	—	—	—	300	—
[2]	—	—	6.3	—	6.2	8.6	—	—	—	52.3
[6]	—	—	6.1	1.0	7.1	13.2	—	—	—	—
[7]	—	1.3	8.0	—	—	20.8	—	—	281	—
[8]	—	—	—	—	—	—	—	—	—	—
[9]	—	2.2	—	—	—	—	—	—	174	—
[10]	23.5	—	—	—	—	—	—	—	—	—
[11]	—	2.1	7.1	1.3	6.3	19.9	8.1	40.1	171	—
[12]	—	—	—	—	—	—	—	—	—	—
[13]	—	—	—	1.2	—	—	3.4	—	—	—

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on reproduction traits in Apulo-Calabrese pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]				ADG birth–slaughter
					Early	Middle	Late	Overall	
[1]	—	—	—	—	—	—	—	300	—
[9]	—	95	155	326	329	388	486	359	—
[11]	—	200	134	229	297	298	220	277	247
[14]	Ad lib	72	—	—	733	762	608	706	—

No. = number, ADG = average daily gain in g, Ad lib = ad libitum feeding regime.
[1]ADG in a period of lactation regardless of how long it was.
[2]ADG in a growing period estimated from weaning to approximately 30 kg live body weight.
[3]ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in Apulo-Calabrese pig breed.

Reference	Feeding	CP content of feed (%)	No. of animals	ADFI fattening[1]			
				Early	Middle	Late	Overall
[14]	Ad lib	15	72	2.2	3.3	3.6	3.1

No. = number, ADFI = average daily feed intake in kg/day, Ad lib = ad libitum feeding regime, CP = crude protein.
[1]ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively, and as the overall daily feed intake for the whole studied period.

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Apulo-Calabrese pig breed.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)	
							S[1]	At withers
1 [1]	—	—	175	140	80.0	—	—	—
2 [14]	72	336	149	122	82.2	44.8	48	68

No. = number, BW = body weight, CW = carcass weight.
[1]S backfat thickness measured according to ZP method (above gluteus medius muscle (mm)).

Table 6.
Summary of collected literature data on body composition and carcass traits in Apulo-Calabrese pig breed.

5.4 Meat and fat quality

Data on meat and fat quality in Apulo-Calabrese pigs are missing, the only information found was measurements of pH in longissimus muscle. The pH at 45 min and 24 h *post-mortem* were 6.30 and 5.85, respectively, measured in 40 animals slaughtered at 149 kg [14].

6. Use of breed and main products

Apulo-Calabrese pigs are used to enhance poor food showing rusticity and adaptability to grazing, with the good maternal ability for the sow. This breed of pigs adapts very well to outdoor breeding both with extensive and semi-extensive systems, feeding on acorns, chestnuts, tubers and roots that can be found in the wooden areas where it is bred. The breed is currently fully market-oriented interesting both regional and national markets. The most famous product derived from Apulo-Calabrese is the "soppressata" which derives from the meat of the ham and shoulder, the "capocollo" obtained from the top of the boned loin and with a layer of about 3–4 mm of fat and the lard derived from the dorsal part. Other relevant products are the black pudding mixed with chocolate and the "nduja of Spilinga", an exceptional type of soft spread and very spicy salami. As for Apulo-Calabrese pig, it is among those authorised for the production of the four PDO-cured meat products, salsiccia, soppressata, Pancetta and Capocollo di Calabria, all certified by the "Consortium for the protection of Calabria PDO cured meats".

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Chapter 6

Cinta Senese Pig

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Abstract

Cinta Senese is an Italian autochthonous pig breed, one of the local pig breeds investigated in the project TREASURE. The present chapter aims to present history and status of Cinta Senese pig breed, its phenotypic characteristics, geographical location, production system and the quality of its main products. Reproductive performance was estimated by several data: sow age at first parturition, litters/sow/year, piglets alive/litter, weaning weight, stillborn/litter, death rate percentage at weaning, duration of lactation, length of farrowing and sow age at culling. Growth performance was estimated by means of average daily gain in lactation and from birth to slaughter, growing at early, middle, late and overall fattening stage and average daily feed intake in late and overall fattening stage. Carcass traits were evaluated by means of age and weight at slaughtering, hot carcass weight, carcass yield, loin eye area and back fat thickness at the first thoracic vertebra, last rib and above *gluteus medius* muscle. Meat quality traits of the *longissimus* muscle were evaluated by means of the following: pH at 45 minutes and 24 hours after slaughtering, instrumental measurements of colour (CIE L*, a*, b*) and intramuscular fat content. Fatty acid composition was evaluated in back fat tissue.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Italy

1. History and current status of the breed (census)

The Cinta Senese breed has ancient origins, as evidenced by its presence in the fresco of the "Buon Governo" of Ambrogio Lorenzetti which is in the Sala del Consiglio dei Nove of the Palazzo Pubblico of Siena [1]. It has spread for its robustness, rusticity and easy adaptability to breeding outdoor. This breed is well adapted at Tuscany land because of the type of available feeding resources from these territorial peculiarities that also derive the taste of the meat protected by PDO label since 2012 [2]. In the 1950s, most peasant families raised this breed. The introduction of improved breeds has reduced the Cinta Senese breeding to bring this breed, at the beginning of the eighties, to the brink of extinction. Due to the intervention of local breeders and Protection Consortium and the active support of the public institutions as well as a detailed research activity carried out by the University of Florence, to date, 140 farms and about 5000 animals can be recognised (**Figure 1**) [3, 4]. Almost all Cinta Senese breeders are part of the Consortium of Protection of the Cinta Senese obtaining the protected denomination of origin of fresh meat, exclusively for pigs born, reared and slaughtered in Tuscany, and deriving from the

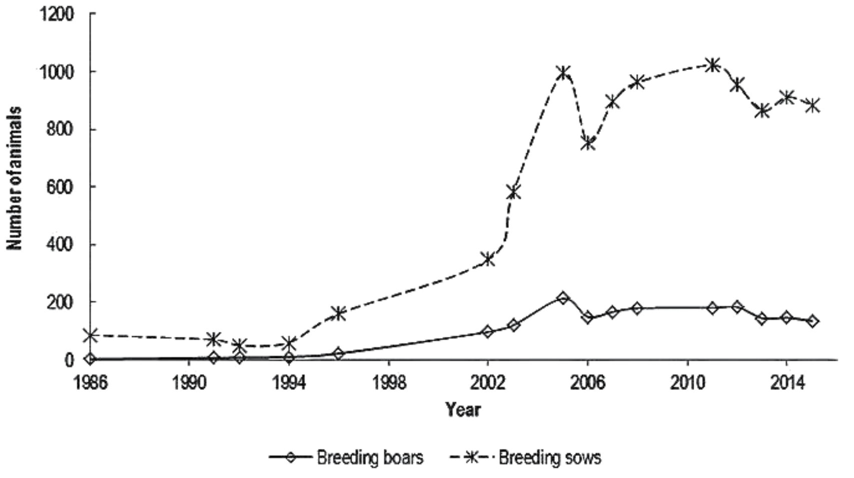

Figure 1.
Census of Cinta Senese pig breed, presenting a number of sows and boars per year, starting with the year of herdbook establishment.

mating of subjects recorded in the Register of the Cinta Senese genetic type. According to the PDO rule, after the fourth month of age, during which the piglets can receive daily food supplementation, the animals must be reared in extensive conditions [2]. The permitted daily feed supplement cannot exceed 2% of live weight; additionally, at least 60% of the feed constituents must come from the geographical area of production.

2. Exterior phenotypic characteristics

The Cinta Senese is a medium-sized pig, with a light but solid skeleton (**Figures 2** and **3**). The weight is 300 and about 250 kg for boars and sows, respectively. The skin and bristles are black, except for a white band that surrounds the trunk at shoulder level, including the forelimbs. The head is of medium size with ears directed forward and down. The limbs are thin but solid. In the female the breasts must be not less than 10, regularly spaced, with normal nipples (**Table 1**).

Measurement (average)	Adult male	Adult female
Body weight (kg)	200	170–180
Body length[1] (cm)	107	104
Ear length	Medium	Medium
Chest girth (cm)	132	126
Height at withers (cm)	82–90	82–90
Number of teats (average)	12	12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Cinta Senese pig breed.

Figure 2.
Cinta Senese sow with piglets.

Figure 3.
Cinta Senese boar.

3. Geographical location and production system

The farms of Cinta Senese pigs are located throughout the Tuscany region even though most of them are in the province of Siena. Pasture on wood is carried out in more than half of the farms. The sows are mainly raised outdoors, but, frequently, in case of part, single boxes are used. The fattening is always done outdoors, with various degrees of extensification. The forest, when present, is used for grazing throughout the year from farmers. It is noted that neither the farming area nor that used for grazing are related to the number of animals bred. There are indeed farms of large dimensions with a reduced number of animals, as well as farms with many animals but with little available area, both for grazing and for the crops, to be dedicated for breeding. Finally, farms with many animals, even when they have a large surface available, dedicate a very small part of the land to pigs [5]

4. Organisations for breeding, monitoring and conservation

The Cinta Senese conservation programme involves regional and national associations (ARA, ANAS) as well as research institutes (University of Florence) (**Table 2**). The conservation programme includes:

Name of organisation	Address	E-mail address
Consorzio di tutela della Cinta Senese	Strada di Cerchiaia, 41/4–53100 Siena, Italy	cinta-senese@libero.it
Associazione Nazionale Allevatori Suini (ANAS)	Via Lazzaro Spallanzani 4, 00161 Rome, Italy	www.anas.it

Table 2.
Contact details of breeding organisation for Cinta Senese pig breed.

- The morphological evaluation of all young animals.
- Registration at Anagraphic Register of eligible boars.
- Registration of the main productive and reproductive traits.
- Choice of male young boars.
- Planning of mating and assistance to farmers in choosing the boars.
- Monitoring the level of consanguinity in the population.

The conservation programme foresees financial support for Cinta Senese breeders within a larger project aimed at the maintenance of indigenous breeds threatened by the risk of abandonment.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. According to herdbook data recorded by ANAS, the age of sows at first parturition is approximately 20 months, whereas age of culling is 54.3 months on average. Sows of Cinta Senese pig breed have 1.3–1.8 litters per year with 6.3–8.2 piglets per litter of approximately 1.2 kg of live body weight. Stillborn percentage of piglets varies from 2.1 to 9.6%, whereas piglet mortality rate until weaning ranged from 4.7 up to 20.4% in the considered studies. Duration of lactation is prolonged in comparison to modern intensive systems (up to 60 days), which leads to a longer farrowing interval (from 203 to 281 days) and also higher piglet weaning weight (8.5–13.0 kg).

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth-slaughter, which is often calculated from the data given on live

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling (mth)
[3]	13.0	1.7	–	0.8	–	–	–	–	210	72.0
[4]	20.9	–	7.2	–	2.1	7.1	–	–	–	54.3
[6]	–	1.3	8.2	–	–	6.4	–	–	281	–
[7]	–	–	–	–	–	–	–	–	–	–
[8]	–	–	6.3	1.1	8.2	4.7	–	–	–	–
[9]	–	–	–	1.3	–	–	11.5	60	–	–
[10]	–	–	7.9	1.2	7.6	20.4	8.5	44	–	–
[11]	–	–	–	–	–	–	–	–	–	–
[12]	–	–	–	–	–	–	–	–	–	–
[13]	–	1.8	7.9	1.2	–	–	8.5	44	203	–
[14]	–	–	–	–	–	–	–	–	–	–
[15]	–	–	7.3	1.4	9.6	6.9	9.4	38	–	–
[16]	–	–	–	1.3	–	–	13.0	60	–	–
[17]	–	–	–	1.3	–	–	–	–	–	–
[18]	–	1.6	6.8	–	–	9.7	–	58	230	–
[19]	–	1.6	6.8	–	–	9.7	–	–	–	–

No., number; mth, month; d, days.

Table 3.
Summary of collected literature data on reproduction traits in Cinta Senese pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]				ADG birth-slaughter
					Early	Middle	Late	Overall	
[3]	–	–	–	–	–	–	–	500	–
[9]	–	3028	158	–	–	–	–	185	–
[10]	–	7	133	174	–	–	–	–	–
	–	8	196	396	–	–	–	–	–
[13]	–	922	133	–	–	–	–		–
	–	–	196	–	–	–	–	–	–
[16]	–	–	196	267	211	–	–	–	–
[17]	Semi	29	–	–	–	–	–	430	–
	Rest	17	–	–	–	–	–	248	–
[17, 20, 21]	Semi	29	–	–	–	–	–	433	–
[19]	–	–	–	–	–	–	–	–	276
[22]	–	277	235	–	–	–	–	–	–
[23]	Rest	16	–	473	–	–	310	519	–
[24]	–	29	–	–	–	–	–	531	–
[25]	Semi	29	–	–	–	–	–	438	–
	Rest	16	–	–	–	–	–	250	–
[26, 27]	Semi	27	–	–	432	334	334	372	–
[28]	Semi	17	–	–	–	–	–	387	–
[29]	Semi	60	–	–	–	–	–	417	–
[30]	Semi	24	–	–	–	–	–	419	–
[31, 32]	Rest	8	–	–	–	–	323	–	–
	Semi	8	–	–	–	–	297	–	–
[33]	Semi	33	–	–	–	–	346	–	–
[34]	–	24	–	–	–	–	–	370	
[35]	Ad Lib	12	–	–	674	–	–	674	–

No.—number; ADG, average daily gain in g; Ad Lib—ad libitum feeding regime; Semi—semi ad libitum feeding regime; and Rest—restrictive feeding regime.
[1]ADG in period of lactation regardless of how long it was.
[2]ADG in growing period estimated from weaning to approximately 30 kg live body weight.
[3]ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in Cinta Senese pig breed.

weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. In the considered studies, daily gain in lactation period varied from 133 to 235 g/day. Growing and fattening stages are characterised by a slow growth rate (approximately 370 g/day in growing and 412 g/day in overall fattening stage) but also high variability between studies (from 147 to 473 g/day growing and from 185 to 674 g/day in fattening stage). Slower growth rate can be contributed to the fact that

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]	
					late	overall
[24]	–	–	17	29	–	2.4
[33]	Semi	10.7	18	33	2.7	–
[34]	–	–	–	24	–	2.2

No.—number; ADFI—average daily feed intake in kg/day; Semi—semi ad libitum feeding regime; ME—metabolisable energy; and CP—crude protein.
[1]ADFI in a period of fattening is reported late fattening stage estimated above 100 kg live body weight and for the overall daily feed intake in the whole fattening period (estimated from 30 kg body weight onwards).

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Cinta Senese pig breed.

according to PDO rules, Cinta Senese pigs should be reared in extensive conditions. However, in the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Cinta Senese pigs in *ad libitum* conditions of feeding (≈674 g/day in early fattening stage).

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. In accordance to PDO rule that feed distribution should not exceed 2% of body weight, average daily feed intake reported in the considered studies was 2.7 kg/day in late fattening stage and 2.2–2.4 kg/day in the overall fattening stage.

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of Cinta Senese breed were slaughtered at approximately 381 days of age and from 125 to 175 kg of live weight. In agreement with high slaughter weight, dressing yield was around 81%; back fat thickness span from 47 to 65 mm measured on the withers, from 32 to 58 mm at last rib level and 35–67 mm at *gluteus medius* muscle level. Muscularity measured as loin eye area was 28 cm^2 in the only available

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness (mm)			Loin eye area (cm^2)
						S[1]	At withers	At last rib	
[3]	–	–	175	140	80.0	–	–	–	–
[17]	29	312	135	110	81.2	–	–	–	–
	17	509	127	104	81.6	–	–	–	–
[17, 20, 21]	29	312	136	110	81.2	49	–	–	–
[23]	16	330	147	–	–	35	47	32	–
[25]	29	312	136	110	81.2	46	58	40	–
	16	510	128	104	81.5	49	65	37	–
[26, 27]	27	336	125	98	78.6	35	–	–	–

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness (mm)			Loin eye area (cm^2)
						S[1]	At withers	At last rib	
[28]	17	430	155	–	–	43	–	41	–
[29]	60	419	147	121	82.2	46	52	41	28
[30]	24	340	136	110	80.6	–	–	49	–
[31, 32]	8	–	142	121	84.7	44	50	46	–
	8	–	143	123	86.5	44	52	49	–
[33]	33	378	130	–	–	41	–	–	–
[36]	50	–	141	110	78.0	67	78	58	–
[37]	14	–	145	–	–	–	–	30	–

No.—number; BW—body weight; and CW—carcass weight.
[1]S back fat thickness measured according to ZP method (above the gluteus medius muscle (mm)).

Table 6.
Summary of collected literature data on body composition and carcass traits in Cinta Senese pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)	Fatty acid composition[2] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n-6 / n-3
[13]	–	–	–	48	12.3	4.2	4.0	–	–	–	–
	–	–	–	46	11.8	4.5	3.3	–	–	–	–
[17]	29	6.22	5.78	50	–	–	3.2	–	–	–	–
	17	6.24	5.83	46	–	–	4.2	–	–	–	–
[17, 20, 21]	29	6.22	5.78	50	11.4	4.6	3.2	36.2	53.4	10.4	25.7
[26, 27]	27	6.50	5.63	48	12.7	4.0	2.5	–	–	–	–
[28]	17	6.51	5.68	46	12.3	3.0	6.0	–	–	–	–
[29]	60	6.40	5.83	46	11.0	2.9	4.7	–	–	–	–
[30]	24	6.51	5.78	47	11.2	3.3	4.1	39.0	52.8	8.2	36.4
[31, 32]	8	6.33	5.55	–	–	–	–	37.6	50.6	11.8	14.2
	8	6.40	5.50	49	13.9	4.5	5.9	36.7	51.6	11.7	20.0
[33]	33	6.42	5.55	49	11.4	4.0	3.3	38.9	49.9	11.2	24.4
[37]	14	–	–	47	13.7	4.2	3.2	35.4	47.6	17.0	12.8
[38]	–	–	–	47	12.4	3.8	4.0	–	–	–	–
[39]	17	6.51	5.69	45	12.2	3.0	5.7	–	–	–	–

No.—number; pH 45—pH measured approximately 45 minutes post-mortem; pH 24—pH measured approximately 24 hours post-mortem; IMF—intramuscular fat; SFA—saturated fatty acids; MUFA—monounsaturated fatty acids; PUFA—polyunsaturated fatty acids.
[1]CIE—objective colour defined by the Commission Internationale de l'Eclairage; L—greater value indicates a lighter colour; a*—greater value indicates a redder colour; b*—greater value indicates a more yellow colour.*
[2]For fatty acid composition, only pigs on control diet were considered. Control diets differed among studies, to see diet composition address to the corresponding source.

Table 7.
Summary of collected literature data on meat and fat quality in Cinta Senese pig breed.

study, whereas data providing other measurements of muscularity (i.e. lean meat content or muscle thickness measured at the cranial edge of the *gluteus medius* muscle) were not available in the considered studies.

5.4 Meat and fat quality

Basic data obtained in this review with some of the most commonly encountered meat quality traits measured in the *longissimus* muscle that could be found and fatty acid composition of back fat tissue are presented in **Table 7**. In the studies reporting meat quality of Cinta Senese pigs, pH measured in the *longissimus* muscle at 45 minutes and 24 hours post-mortem was approximately 6.4 and 5.7, respectively. The intramuscular fat content was highly variable in considered studies and ranged from 2.5 to 6.0%. Colour measured in CIE/Lab colour space spans from 45 to 50, 11.0 to 13.9 and 2.9 to 4.6 for L, a* and b*, respectively. Altogether six studies were found reporting fatty acid composition of back fat tissue; however, due to big differences between studies in feeding regime, feed composition, final body weight and fatness, which are all important factors influencing the fatty acid composition of meat, this result should be interpreted with precaution. Saturated fatty acid content ranges from 35.4 to 39.0%, MUFA content from 47.6 to 53.4% and PUFA content from 8.2 to 17.0%, with very high n-6 to n-3 ratio (12.8–36.4).

6. Use of breed and main products

The quality of the raw material of the Cinta Senese represents a strong point of the system. The sensory characteristics of meat are mainly influenced by the acidic composition of the adipose tissue which is affected, as well as the genetic component, also by the diet. Extensive breeding, if practised with rational exploitation of forest resources (acorn and chestnut), can lead to the development of favourable aromas and, therefore, to products with excellent sensory properties. The main cured meats produced with the Cinta Senese breed are dry-cured ham, Tuscan salami, Pancetta, Lardo and Capocollo. These products have reached a high level of quality without, however, reaching the standardisation of flavours. Although the cured meat market is expanding, the Consortium focused on the PDO label of fresh meat, obtaining it. The recognition of protected designation of origin is reserved exclusively for the meat of pigs born, reared and slaughtered in Tuscany, which meet the requirements of the specification, drawn up by EU Reg. 510/2006. To certify the meat, the pigs must derive from the pairing of pigs registered in Anagraphic Register of the Cinta Senese genetic type.

Animals cannot be slaughtered before the twelfth month of life. After slaughtering the half-carcass can be cut to produce cured meats. The seal consortium represents the identifying mark of the processed products.

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Chapter 7

Black Slavonian (Crna slavonska) Pig

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Abstract

Black Slavonian (Crna slavonska) pig was created during the second part of the nineteenth century using planned crossing between four pig breeds. It is an autochthonous pig breed in the Republic of Croatia and one of the local pig breeds investigated in the project TREASURE. The present chapter aims to present history and current status of Black Slavonian pig breed, its exterior phenotypic characteristics, reproductive traits, geographical location, production system and main products from this breed of pigs. Also, a collection and review of available literature data, available until August 2017, on productive traits of Black Slavonian pig breed were carried out. Growth performance was estimated utilising average daily gain and average daily feed intake in the overall fattening stage as this was the information mostly provided in considered studies. Carcass traits were evaluated by means of age and weight at slaughter, hot carcass weight, carcass yield, muscularity and back fat thickness. Meat quality traits of the longissimus muscle evaluated were objective colour and intramuscular fat content. Although a considerable number of studies on Black Slavonian pig were included in the current review, data on growth performance and some parameters of carcass, meat and fat quality are scarce.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Croatia

1. History and current status of the breed (census)

Black Slavonian (Crna slavonska) pig is an autochthonous pig breed in the Republic of Croatia. It was created during the second part of the nineteenth century on the estate of Count Pfeifer, Orlovnjak, near Osijek. It is also known by the name "Fajferica". It is a result of planned crossing between four pig breeds: Mangalitsa, Berkshire, Poland China and Large Black pig. This crossing aimed to create a pig with better meat and fertility traits. The first phase of crossing includes ten gilts of Mangalitsa and Berkshire boars. Additionally, Poland China boars were included in crossing schemes every 10 years. These systematic crossings were carried out from 1870 to 1910 [1]. The final phase of creation of Black Slavonian breed was during 1920 when crossing with English black breed-large black occurred. The success of crossing and breeding was confirmed in 1873 by winning gold medals at the Vienna Agricultural Fair [2]. At the end of the nineteenth and early twentieth centuries, Black Slavonian pig was the most common and, from an economic standpoint, the

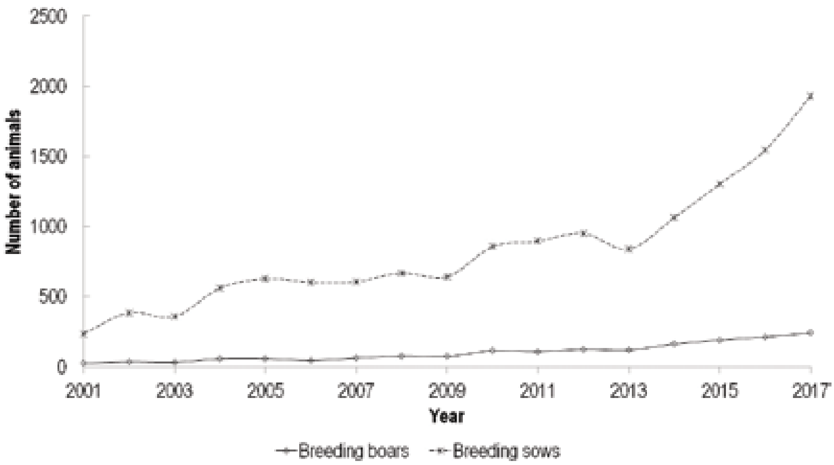

Figure 1.
Census of Black Slavonian pig breed, presenting number of sows and boars per year.

most important pig in what is now eastern Croatia. Thus, it is nowadays rightly considered an indigenous breed. Census of Black Slavonian pig breed is presented in **Figure 1**. Presently there about 209 registered farms with 1930 breeding sows and 242 boars of Black Slavonian pig breed in the latest available status ([3], December 2017).

2. Exterior phenotypic characteristics

The Black Slavonian pig breed morphology information is summarised in **Table 1**. By morphological characteristics, Black Slavonian pig breed is similar to Mangalitsa, although regarding physiological characteristics it is more similar to the Berkshire and Poland China pig breed. The most important characteristic of Black Slavonian pig breed is its black coat colour. The peas and snout are also dark. Black Slavonian pig is a medium-sized pig. The height of the ridge is 65 to 70 cm. The head is medium long with a dense profile and with medium-sized and semi-circular drooping ears. The muscular neck is medium wide and medium in length. The chest is deep and wide. The body and legs are relatively short, whereas the hips are wide and fallen [3] (**Figures 2** and **3**).

Measurement (average)	Adult male	Adult female
Body weight (kg)	250	200
Body length[1] (cm)	130	120
Head length (cm)	50	50
Tail length (cm)	30	30
Ear length	Large	Large
Chest girth (cm)	110	100
Height at withers (cm)	75	70
Number of teats	10–14	10–14
Other specific visible traits		
Hair	Curly, straight, short, long	
Tusks	Present	

Measurement (average)	Adult male	Adult female
Snout	Long and thin	
Coat colour pattern	Plain	
Coat colour type	Black	
Head profile	Concave	
Ear type	Droopy (pendulous)	
Ear orientation	Project forwards	
Skin	Smooth	
Tail type	Straight, curly (kinked)	
Backline	Straight, swaybacked	

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Black Slavonian pig breed.

Figure 2.
Black Slavonian sow with piglets.

Figure 3.
Black Slavonian boar.

3. Geographical location and production system

Black Slavonian pig is bred in the area of Slavonian counties: Brodsko-Posavska, Požeško-Slavonska, Osječko-Baranjske and Vukovarsko-Srijemska. Today the Black Slavonian pig is bred, also, in the area of Sisak-Moslavačka County. Black Slavonian pig breed is suitable for keeping under extensive, intensive and semi-intensive conditions. Breeding under semi-intensive conditions is the traditional production system for Black Slavonian pig [4, 5]. In this system, pigs are kept in pastures and woods where they exploit the food they find. On 1 ha of pasture area, 15 to 20 sows can be reared, depending on available nutrition and amount of the soil. To emphasise the traditional meaning of Black Slavonian pig, it is advisable to build facilities in a traditional style typical for the breeding area. Facilities for gilts and sows should be semi-open object (30 m^2). Size of farrowing pen should be at least 6×1.5 m. After the farrowing, piglets should be placed together. Fattening period is a final stage of production system. This period must last at least 18 months and during this period pigs can reach from 130 to 150 kg [6]. Under extensive rearing conditions, pigs are kept on pastures where all the food is available to the pigs. The basis of nutrition in the system is acorn with additional feeding during the winter period [7]. Exceptionally before farrowing, sows are placed in semi-open facilities whose floors are filled up with straw. Sows and piglets in such facilities remain until weaning [2].

4. Organisations for breeding, monitoring and conservation

The conservation and breeding programme began in 1994 and is carried out by the Croatian Agricultural Agency (Hrvatska poljoprivredna agencija, HPA). The agency is in charge of keeping the register, marking the pigs and assessing the breeding value of breeding male and female animals. Monetary funds support the breeding of Black Slavonian pigs (150 EUR per year per breeding animal). The pedigree issuance is carried out in cooperation with the association of breeders of Black Slavonian pig "Fajferica", which is also responsible for the implementation of the breeding programme (**Table 2**).

Name of organisation	Address	Web address
Hrvatska poljoprivredna agencija/ Croatian Agricultural Agency	Ilica 101, 10,000 Zagreb, Croatia	http://www.hpa.hr/sektori/sektor-za-razvoj-stocarske-proizvodnje/odjel-za-svinjogojstvo/izvorne-pasmine/
Udruga uzgajivača crne slavonske svinje Slavonije, Baranje i zapadnog Srijema/ Association of breeders of Black Slavonian pig	Vladimira Nazora 1, 31,400 Đakovo, Croatia	www.fajferica.hr

Table 2.
Contact details of breeding organisation for Black Slavonian pig breed.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. The average age of sows at first parturition is 15 months [13, 15]. According

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Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Piglet live weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[3]	—	1.2	5.5	—	10.3	11.2	—	—	—
[8]	—	—	6.1	—	—	15.9	—	—	—
[9]	—	1.8	7.4	—	—	10.3	—	—	201
[10]	—	—	6.3	—	11.1	9.5	—	—	—
[11]	—	—	6.1	—	—	—	—	—	—
[12]	—	—	6.0	—	—	—	—	—	—
[13]	—	2.0	6.5	1.3	13.3	7.7	9.5	49	183
	15.0	2.2	—	1.3	—	—	—	—	165
[14]	—	—	6.1	—	—	—	—	—	—
[15]	14.6	—	—	1.2	—	—	11.0	56	—
[16, 17]	—	—	6.1	—	—	—	—	—	—
[17, 18]	—	1.1	6.5	—	6.8	12.4	—	—	326
[19, 20]	—	—	6.9	1.3	8.7	8.8	11.3	—	—
[21]	—	—	5.0	—	15.9	7.1	—	57	—
[22]	—	—	6.8	—	1.0	5.4	—	—	—
[23]	—	—	6.6	—	3.5	6.8	—	—	—

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on reproduction traits in Black Slavonian pig breed.

to the collected literature, sows of Black Slavonian pig breed have 1.1 to 2.2 litters per year [3, 9, 13, 17, 18] with 5.0 to 7.4 piglets [3, 8, 9–14, 16–23] of approximately 1.3 kg live body weight [13, 15, 19, 20]. Stillborn percentage of piglets is very variable and ranges from 1.0 to 15.9% [3, 10, 13, 17–21]; similarly piglet mortality rate until weaning spans from 5.4 to 15.9% [3, 8–10, 13, 17–21]. Duration of lactation is prolonged in comparison with modern intensive systems up to 57 days [21], which leads to a longer farrowing interval (165 to 326 days [9, 13, 17, 18]) and also higher weaning weight (9.5 to 11.3 [13, 15, 19, 20]). According to Uremović et al. [8], the number of live-born piglets in litter is determined by the number of farrowings, breeding system and characteristics of the boar, while the number of weaned piglets depends on seasonality, breeding system and boar characteristics. Sows have good motherly characteristics. It can be concluded that the reproduction traits of Black Slavonian pig breed are modest, but sows have good motherly characteristics. Uremović et al. [9] suggest that increasing of fertility can be achieved by crossbreeding with Duroc.

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. However, in the case of Black Slavonian pig breed, studies mostly provided the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. A considerably slower growth rate characterises the overall fattening stage of Black Slavonian pigs compared to modern pig breeds (approximately 335 g/day) but also by high heterogeneity among studies (189 to 567 g/day [8, 13, 15, 19, 20, 24–32]). In extensive keeping conditions, average daily gain was lower when it is compared with intensive system where pigs are fed with corn, because production system affects the average daily intake, food utilisation and pig growth rate. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Black Slavonian pigs in ad libitum conditions of feeding (≈ 567 g/day in the overall fattening stage). Generally, the Black Slavonian pig can achieve the final weight of 100 kg in the period of 8 months, while the weight of 170 to 200 kg can be achieved in 18 to 24 months. The food conversion in these conditions ranges from 4.5 to 5 kg.

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. Average daily feed intake reported ranges from 1.3 to 2.3 kg/day in the overall fattening stage [13].

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of Black Slavonian breed were slaughtered when reaching the final age of 359 to 550 days [27, 28, 32]. The final live weight covered in the studies spans from 21 to 230 kg [8, 13, 15, 24, 27, 28, 32, 34–38] because some studies aimed to

Reference	Feeding	No. of animals	ADG lactation and growing[1]	ADG fattening[2]		
				Early and middle	Late	Overall
[8]	Rest	20	—	—	—	478
[13]	—	24	—	—	—	567
	—	24	—	—	—	509
	—	27	—	—	—	224
	—	27	—	—	—	206
	—	120	165	225	325	220
[15]	—	—	—	—	—	350
	—	—	—	—	—	550
[19, 20]	—	20	—	—	—	189
	—	20	—	—	—	211
[24]	Rest	10	—	—	—	250
[25, 26]	—	10	—	—	—	285
[27, 28]	—	10	—	—	—	376
	—	10	—	—	—	251
[29]	Rest	19	—	—	—	285
[30]	Rest	5	—	—	—	285
	Rest	5	—	—	—	285
[31]	Rest	20	—	—	—	480
[32]	Rest	30	—	—	—	245

No. = number; ADG = average daily gain in g; Rest = restrictive feeding regime.
[1]ADG in a period of lactation and growing period estimated from birth to approximately 30 kg live body weight.
[2]ADG in a period of fattening is reported for early and middle fattening stage estimated between approximately 30 and 100 kg and late fattening stage estimated above 100 kg live body weight. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in Black Slavonian pig breed.

Reference	No. of animals	ADFI lactation and growing[1]	ADFI fattening[2]		
			Early and middle	Late	Overall
[13]	24	—	—	—	2.3
	24	—	—	—	1.9
	27	—	—	—	2.2
	27	—	—	—	1.8
	120	0.5	1.0	1.3	1.3

No. = number, ADFI = average daily feed intake in kg/day.
[1]ADFI in a period of lactation and growing estimated from birth to approximately 30 kg live body weight.
[2]ADFI in a period of fattening is reported for early and middle fattening stage estimated between approximately 30 and 100 kg and late fattening stage estimated above 100 kg live body weight. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Black Slavonian pig breed.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		M[2] (mm)	Loin eye area (cm^2)
							S[1]	At last rib		
[8]	20	—	106	85	80.3	43.0	—	—	—	—
[13]	24	—	228	—	84.5	—	—	71	71	38
	24	—	207	—	83.6	—	—	67	72	36
	27	—	126	—	79.9	—	—	40	65	31
	27	—	116	—	80.7	—	—	32	62	34
	8	—	23	—	68.6	39.6	—	—	—	—
	8	—	21	—	66.6	38.6	—	—	—	—
	8	—	40	—	66.2	43.4	—	—	—	—
	8	—	39	—	68.8	44.1	—	—	—	—
	8	—	103	—	77.4	32.7	—	—	—	—
	8	—	84	—	71.0	40.1	—	—	—	—
	8	—	163	—	81.5	29.2	—	—	—	—
	8	—	130	—	80.7	37.6	—	—	—	—
	8	—	230	—	84.2	27.9	—	—	—	—
	8	—	207	—	83.0	28.4	—	—	—	—
	8	—	30	—	74.2	40.6	—	—	—	—
	8	—	28	—	74.1	40.2	—	—	—	—
	8	—	51	—	77.9	43.4	—	—	—	—
	8	—	41	—	78.8	43.0	—	—	—	—
	8	—	73	—	80.8	44.2	—	—	—	—
	8	—	60	—	81.7	42.8	—	—	—	—
	8	—	96	—	83.0	44.9	—	—	—	—
	8	—	83	—	82.8	41.4	—	—	—	—
	8	—	125	—	85.1	39.0	—	—	—	—
	8	—	116	—	84.1	37.3	—	—	—	—
[15]	—	—	101	81	79.8	33.0	49	51	—	27
[19, 20]	20	—	—	—	—	39.7	—	41	57	—
	20	—	—	—	—	44.1	—	34	63	—
[24]	10	—	136	112	82.4	41.0	—	50	—	33
[27, 28]	10	359	135	112	83.0	38.5	—	55	—	32
	10	540	136	112	82.4	41.0	—	50	—	33
[31]	20	—	—	116	—	—	41	—	64	—
[32]	30	550	95	78	—	—	22	—	58	—
[33]	—	—	—	79	—	32.6	—	—	—	—
[34]	16	—	110	86	77.8	47.1	—	—	—	—
	16	—	130	102	78.4	47.2	—	—	—	—

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		M[2] (mm)	Loin eye area (cm^2)
							S[1]	At last rib		
[35–37]	16	—	130	102	78.4	—	47	—	—	—
	16	—	130	102	78.5	—	46	—	—	—
[38]	30	—	140	—	78.0	—	—	35	—	—

No. = number, BW = body weight; CW = carcass weight.
[1]*M muscle thickness measured according to ZP method (at the cranial edge of the* gluteus medius *muscle (mm)).*
[2]*S backfat thickness measured according to ZP method (above the* gluteus medius *muscle (mm)).*

Table 6.
Summary of collected literature data on body composition and carcass traits in Black Slavonian pig breed.

estimate tissue deposition rates by comparative slaughter technique [13]. Also dressing yield ranges from 66.2 to 85.1% [8, 13, 15, 24, 27, 28, 34–38] and lean meat content from 27.9 to 47.2% (SEUROP classification or dissection [8, 13, 15, 19, 20, 24, 27, 28, 33, 34]). However, when taking into consideration studies with only final body weight higher than 100 kg, dressing yield is around 81% and lean meat content around 38%. The backfat thickness values measured at the level of the last rib ranges from 32 to 71 mm [13, 15, 19, 20, 24, 27, 28, 38] and at the level of the *gluteus medius* muscle from 22 to 49 mm [15, 31, 32, 35–37]. Muscularity measured as loin eye area is between 27 and 38 cm^2 [13, 15, 24, 27, 28] and as muscle thickness at the cranial edge of the *gluteus medius* between 57 and 72 mm [13, 19, 20, 31, 32]. Comparing the proportions of fat and muscle tissue in Black Slavonian pig and modern pig breeds, it can be concluded that Black Slavonian pigs have a significantly higher proportion of fatty tissue. Karolyi et al. [26] reported that the ratio of muscle parts and fat tissue was 32% versus 27%.

5.4 Meat and fat quality

Basic data obtained in this review with some of the most commonly encountered meat quality traits measured in the *longissimus* muscle that could be found are presented in **Table 7**. In the studies reporting meat quality of Black Slavonian pigs, pH measured in the *longissimus* muscle at 45 min and 24 h *post-mortem* ranged from 6.11 to 6.75 [13, 15, 19, 20, 24–32, 34–37] and from 5.57 to 5.91 [13, 15, 19, 20, 24–30, 32, 34–37], respectively. The intramuscular fat content was highly variable, ranging from 5.0 to 12.3% [15, 24, 27, 28, 30, 33–37, 39], but in average (app. 7%) considerably higher than in modern pig breeds where this percentage is usually up to 2%. The colour measured in CIE L, a and b colour space was around 49, 16.1 and 3.3 for L, a* and b* [13, 25, 26, 29, 30, 32, 35–37, 39], respectively, demonstrating visually darker and redder colour of Black Slavonian pig breed meat. Water holding capacity, which affects the processing ability of meat, ranges from 3.98 to 4.50 cm^2 [24, 27] measured by compression method and 1.68% [32] measured by the bag method. In the considered studies, no data on the fatty acid composition was found.

6. Use of breed and main products

Black Slavonian pigs are today used for the production of piglets for sale, production of fattening pigs for fresh meat consumption and especially for the

Reference	No. of animals	pH 45	pH 24	CIE[1]			Intramuscular fat content (%)
				L*	a*	b*	
[13]	24	6.44	5.87	46	12.1	1.1	—
	24	6.44	5.91	45	9.6	0.5	—
	27	6.53	5.75	48	10.5	1.7	—
	27	6.49	5.70	47	10.9	1.7	—
[15]	—	6.75	5.62	—	—	—	7.9
[19, 20]	20	6.21	5.61	48	—	—	—
	20	6.28	6.63	54	—	—	—
[24]	10	6.60	5.80	—	—	—	5.9
[25, 26]	10	6.18	5.87	50	20.0	4.7	—
[27, 28]	10	6.60	5.70	—	—	—	5.0
	10	6.70	5.80	—	—	—	5.9
[29]	19	6.44	5.77	48	9.3	3.0	—
[30]	5	6.11	5.88	51	20.3	6.2	7.2
	5	6.25	5.86	49	19.7	3.2	6.6
[31]	20	6.32	—	—	—	—	—
[32]	30	6.41	5.78	45	19.5	3.1	—
[33]	—	—	—	—	—	—	7.9
[34]	16	6.36	5.57	51	—	—	6.8
	16	6.23	5.61	51	—	—	6.9
[35–37]	16	6.23	5.61	51	18.4	6.0	6.9
	16	6.47	5.75	48	19.3	5.5	12.3
[38]	30	6.51	—	45	—	—	—
[39]	20	6.65	5.75	48	21.6	—	5.4
	16	6.23	5.61	51	18.4	—	6.9

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem*; pH 24 = pH measured approximately 24 hours* post-mortem.
[1]*CIE = objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

Table 7.
Summary of collected literature data on meat quality in Black Slavonian pig breed.

production of traditional pork products such as ham, kulen, bacon, sausage, dry cured neck and fat. More recently, the production of dry-cured ham from the Black Slavonian pigs has also begun. At present, the procedure for protection of the product "Meso crne slavonske svinje" with PDI mark is being carried out. The quality of meat and products from Black Slavonian pig has also been investigated. Results show correlations between production system and quality of smoked ham from Black Slavonian pigs; the quality was significantly better when hams were produced from pigs kept outdoors and fed with green alfalfa as the feed basis [37]. Also, the research from Karoly et al. [26] shows that Black Slavonian pigs have poorer production characteristics, but significantly improved qualitative and technological properties of meat, and that the kulen produced from Black Slavonian pigs has better quality. In the future, the production systems of Black Slavonian pigs must be improved and harmonised. An increase in production of quality traditional value-added products is expected

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Chapter 8

Gascon Pig

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Abstract

The present chapter aims to present history and current status of Gascon pig breed, one of the local pig breeds investigated in the project TREASURE. This French autochthonous breed of pigs, which almost disappeared, now enjoys a new boom. The quality of its product is recognized by the consumers and by official quality labels (Protected Designation of Origin). Exterior phenotypic characteristics of the breed, geographical location, production system and main products are described. Reproductive performance data available in the literature and estimated from the LIGERAL database (herdbook) are presented. Literature data on production traits are also summarized for growth (early, middle, late and overall growth), feed intake, body composition and carcass traits. Meat quality traits (pH, colour, intramuscular fat content and composition) and fat tissue characteristics (fatty acid profile) are also described. Studies on Gascon pig breed are scarce and variability between studies, especially regarding productive traits, can be explained by differences in production systems, feeding regimes and feed composition according to studies. Nevertheless, the current review gives updated insights into the reproduction, production and quality traits of this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, France

1. History and the current status of the breed (census)

The Gascon is a rare breed of domestic pig which has survived at the foot of the Pyrénées mountains in the southwest of France. This pig breed was already present in this region from ancient times: traces from the Gallo-Roman period were found. Like many other local breeds, its production declined during the second part of the twentieth century up to only 34 sows and 2 boars registered in 1981. However, a group of farmers, pork butchers and processors, with the help of technical advisors, gathered together with the objective of reviving the Gascon breed and its high-quality products. A breed conservation programme was developed with the help of IFIP and local agricultural chamber. Census of Gascon pig breed and its evolution over the last 20 years are presented in **Figure 1**. Presently there are 64 registered farms of Gascon pigs with 1423 breeding sows and 177 breeding males in the latest available status (year 2017).

Farms are either related to the Association des Eleveurs de Porcs Gascons des Hautes Pyrénées (AEPGHP), adhering to the Consortium du Noir de Bigorre (CNB), or the Association Nationale de Sauvegarde du Porc Gascon (ANSPG) or

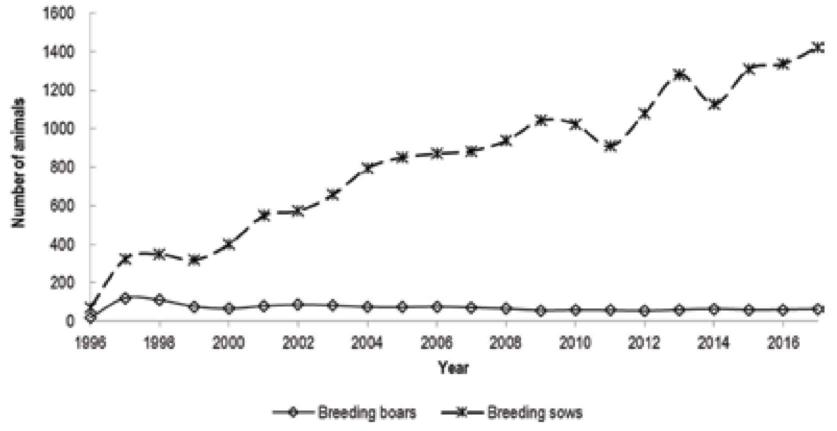

Figure 1.
Census of Gascon pig breed, presenting number of sows and boars per year, starting with the year of herdbook establishment.

unrelated to any breeder group. AEPGHP represents 77% of the sows recorded in the LIGERAL herdbook.

In 2002, the CNB initiated process for further registration of their products as Protected Designation of Origin (PDO) quality label. With the Gascon breed, the CNB has progressively developed based on the production of local, high-quality pork products and vigorous efforts to communicate on their local pig production system as well as the high eating quality of their products. In 2015 the “Noir de Bigorre” fresh loin and “Noir de Bigorre” dry-cured hams, produced from Gascon pigs, obtained the French AOC (Appellation d’Origine Contrôlée) label, which is the national step towards registrations as PDO at European level. Both products obtained PDO registration in September 2017.

2. Exterior phenotypic characteristics

The Gascon pig breed morphology information is summarised in **Table 1**. The Gascon is a resistant, slow-growing breed able to live outdoors all year round. As described in the breed standard, animals have a cylindrical shape with thin and tough limbs. They have black skin and are black wire-haired with thicker hair along the dorsal stripe finishing in a swirl on the rump beside a cowlick on the top of the

Measurement (average)	Adult male	Adult female
Body weight (kg)	300	250
Body length1 (cm)	120	120
Head length (cm)	40	—
Ear length (cm)	20	—
Chest height (cm)	40	—
Height at withers (cm)	75	75
Number of teats	≥12	≥12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Gascon pig breed.

Figure 2.
Gascon sow with piglets (photo credit of consortium noir de Bigorre).

Figure 3.
Boar of Gascon breed (photo credit of consortium noir de Bigorre).

back. Gascon pigs face is characteristically pointed "like a mole" with narrow ears close to the base, slightly tilted over the eyes with length equal to half the length of the head (**Figures 2** and **3**).

3. Geographical location and production system

Gascon pigs produced in the local production system (Noir de Bigorre pork chain) are raised outdoor in extensive conditions at least during a 6-month finishing period. They consume large quantities of grass and fruits (acorns, chestnuts) depending on the season.

The CNB breeding area and pig production system are defined in the AOC specifications [1]. The ANSPG area is wider but predominantly located in the southwest of France, the cradle of the breed.

To benefit from AOC/PDO Noir de Bigorre registration, pure Gascon pigs must be born, reared and slaughtered in the specified geographical area. Pigs (either castrated males or females before any lactation) are generally born and kept indoors on straw with possible outdoor access, up to a maximum of 6 months of age. They are then placed until slaughter on natural or cultivated grassland (max. 20 pigs/ha) providing various grass species or leguminous plants, with possible access to a forest plot (e.g. acorns and chestnut). Plot lands must be approved by the authorities responsible for quality sign management and control. In addition to natural feeding resources, pigs are fed with complementary food based on a minimum of 70%

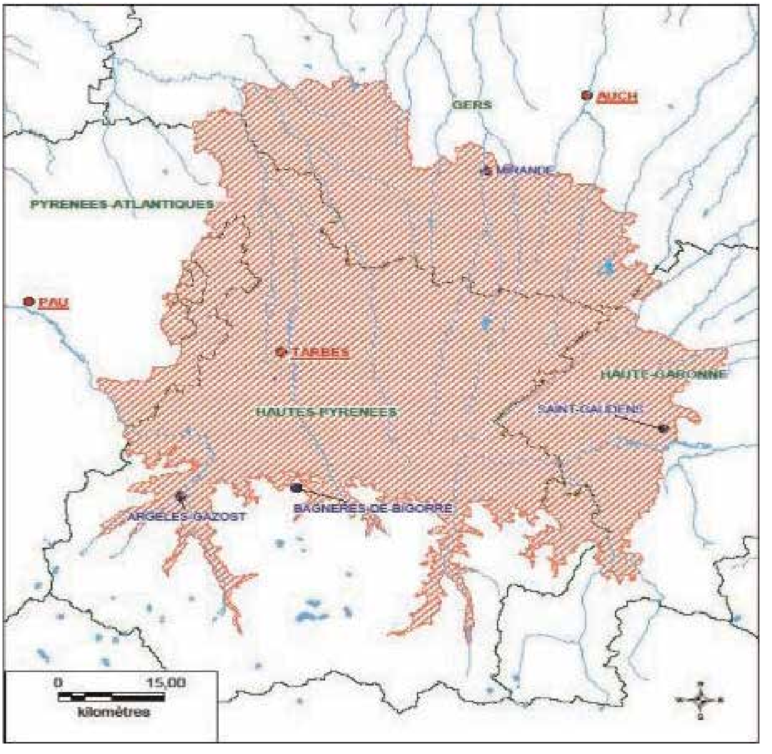

Figure 4.
Geographical localisation of the production of Gascon pigs for the noir de Bigorre protected designation of origin in France (https://www.inao.gouv.fr/fichier/CDCPorcNoirDeBigorre2016.pdf).

cereals (wheat, oat, barley, rye and triticale) produced on the geographical area, with potential protein resources (faba beans, peas, rapeseed or sunflower meal), minerals and vitamins. Maize, sorghum and sunflower are not allowed. The farmers themselves often produce complementary food.

Pigs are slaughtered at a minimum of 12 and maximum of 24 months of age. Specifications for carcasses are a minimum of 100 kg of hot carcass weight, minimum 25 mm of fat depth over the *gluteus medius* muscle (ZP point) and 45 mm of muscle depth (ZP muscle). Whole traceability is guaranteed for pigs and carcasses. Minimum green ham weight of 10 kg and ripening duration of 20 months are required for AOC/PDO Noir de Bigorre hams (**Figure 4**).

4. Organisations for breeding, monitoring and conservation

All animals, boars, sows and piglets, are individually identified and recorded in the LIGERAL herdbook. An accreditation committee, composed of an expert and the technician in charge of following-up the farms, validates each potential breeder considering the breed standard, the teats number (minimum of 12 functioning teats) and the inbreeding coefficient. Only pure-bred reproduction is performed using 100% natural mating. Usually, farms self-renew their sows and buy boars. Replacement breeding policy is based on relationship coefficients estimated by IFIP and on the number of live animals per family (sows) or line (boars). One farm belonging to the AEPGHP is dedicated to boars rearing from 2 to 3 months of age (25–30 boars a year). Number of breeders per family or line, reproductive performances and inbreeding are reviewed at least once a year. More

Name of organisation	Address	Web or e-mail address
Association des éleveurs de porcs gascons des Hautes Pyrénées (linked to the Consortium du Noir de Bigorre)	Pyrène Aéropôle, 65290 Louey, France	—
Consortium du Noir de Bigorre	Pyrène Aéropôle, 65290 Louey, France	http://www.noirdebigorre.com/
Association Nationale de Sauvegarde du Porc Gascon (ANSPG)	—	anspgascon@gmail.com
LIGERAL—c/o IFIP	La Motte au Vicomte, BP 35104, 35651 Le Rheu cedex, France	www.asp.asso.fr

Table 2.
Contact details of breeding organisation for Gascon pig breed.

complete analyses of the genetic variability based on probabilities of gene origin studies are performed occasionally [2]. AEPGHP and ANSPG adopt common decisions related to the management of the breed in a single pilot committee. There are common people in the accreditation committee and there are exchanges of animals occasionally. Besides, Gascon semen doses are preserved in the French National Cryobank which contains semen collected specifically in the 1990s and the beginning of the 2000s. This heritage material is only dedicated to breed preservation (**Table 2**).

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. Averages are calculated from data registered in the LIGERAL database. For the last available 5-year period (2012–2016), the age of sows at first parturition is 17 months [11]. On average, sows of Gascon pig breed have 1.7 litters per year with 8.1 piglets born alive. The death rate of piglets until weaning in the considered recent 5-year period is correct and averages 9.8% [11]. Published data are also synthetized in **Table 3**. Without selection on reproductive performances, litter size (born alive and weaned piglets) tended to degrade between 1997 and 2003. Then a slight improvement was observed until 2007 [8]. Most recent data obtained within TREASURE project confirm that litter size seems now stable [10]. Duration of the lactation is prolonged in comparison with modern intensive systems to 38 days, which is also reflected in the prolonged farrowing interval, 214 days on average. Thus, it can be concluded that Gascon pig breed has moderate fertility compared to the most prevalent breeds.

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages

Reference	Sow age at first parturition (mth)	Litters per sow per year[1]	No. of piglets alive per litter	Mortality at weaning (%)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling (mth)
[3]	—	—	9.4	11.8	—	—	84
[4]	—	—	9.0	42.2	—	—	—
	—	—	8.2	25.6	—	—	—
	—	—	8.5	27.1	—	—	—
	—	—	9.6	26.0	—	—	—
[5]	—	1.4	8.0	15.0	—	261	—
[6]	—	—	8.1	14.8	—	—	—
[7]	—	1.5	8.2	15.9	—	243	—
[8][2]	—	1.6	8.0	11.3	—	228	—
[2]	—	—	8.0	11.3	—	—	—
[9]	—	—	8.1	11.1	—	—	—
[10]	17.0	1.6	8.1	9.0	37	228	50
[11][3]	**17.4**	**1.7**	**8.1**	**9.8**	**38**	**214**	**49**

No. = number, mth = month, d = days.
[1]*Litters per sow per year calculated as the average number of litters per sow having at least one litter in the year.*
[2]*Least squares means with a GLM model including breed (5 local breeds), parity season as a fixed effect, breed*parity interaction, the age of the sow and birth year as a covariate.*
[3]*Five-year average value from herdbook data (LIGERLA database between 2012 and 2016).*

Table 3.
Summary of collected literature data on reproduction traits of Gascon pig breed.

Reference	Feeding	No. of animals	ADG fattening[1]				ADG Birth slaughter
			Early	Middle	Late	Overall	
[4]	—	—	—	—	—	529	—
	—	—	—	—	—	500	—
	—	—	—	—	—	498	—
	—	—	—	—	—	384	—
[6, 12]	—	16	—	—	362	455	—
	—	18	—	—	—	342	—
[13, 14]	Ad lib	24	—	—	—	537	—
[15]	Semi	39	336	486	337	384	—
[16, 17]	Semi	8	408	—	—	439	378
	Semi	18	458	387	432	428	409
	Semi	7	346	—	—	460	424
	Semi	16	502	462	346	409	389
[16]	Semi	8	—	—	—	469	455
	Semi	20	—	—	—	432	414

No. = number; ADG = average daily gain in g; Ad lib = ad libitum feeding regime; Semi = semi-*ad libitum feeding regime.*
[1]*ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on growth performance in Gascon pig breed.

estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. In the considered studies, data for performance in the stage of lactation and growing stage are missing. The early, middle, late and overall fattening stage is characterised by slower growth than "modern" selected pigs and big heterogeneity for each of these growing stages as well as for the overall growing-finishing stage (342–537 g/day), related to the fact that this review comprises studies where different systems and feeding levels were considered. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Gascon pigs in ad libitum conditions of feeding (≈537 g/day in overall fattening stage).

In considered studies, the information on feed intake and feed nutritional value were rather scarce (max n = 9 studies), which limits the evaluation of growth potential. Moreover, in some studies, values correspond to the daily feed distributed but not the actual feed intake due to waste of feed by the animals around the feeder. Average estimated daily feed intake increased from 2.5 kg/day [15] in the middle growing stage to max of 3.6 kg/day [16, 17] in the overall fattening stage, above values being probably overestimated and corresponding to daily feed distributed, whereas feed "intake" in overall fattening stage averaged 3.0 g/day (n = 9 studies).

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]			
					Early	Middle	Late	Overall[2]
[4]	—	—	—	—	—	—	2.5	—
	—	—	—	—	—	—	—	2.5
	—	—	—	—	—	—	—	2.4
[6, 12]	—	—	—	16	—	—	2.5	—
	—	—	—	18	—	—	2.0	—
[13, 14]	Semi	12.6	17.0	24	—	—	—	2.4
[15]	Semi	11.5	—	39	—	2.5	2.5	—
[16, 17]	Semi	—	9.9	8	—	—	—	3.7[2]
	Semi	—	12.3	18	—	—	—	2.7
	Semi	—	13.4	7	—	—	—	4.2[2]
	Semi	—	12.8	16	—	—	—	2.6
[16]	Semi	—	12.9	8	—	—	—	3.9[2]
	Semi	—	13.1	20	—	—	—	2.4

No. = number, ADFI = average daily feed intake in kg/day, Semi = semi-*ad libitum feeding regime, ME = metabolisable energy, CP = crude protein.*
[1]ADFI in period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).
[2]Values in studies from refs. [16, 17] that are rather high correspond to average daily feed supply but not actual daily feed intake.

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Gascon pig breed.

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of Gascon breed were slaughtered between 183 and 442 days of age (n = 11 studies) and between 98 and 181 kg live weight (n = 16 studies) and had a dressing yield around 80% (n = 8 studies). The backfat thickness measured at the level of the *gluteus medius* muscle (official site for fat depth measurement in the Noir de Bigorre AOC specification) was high (over 46 mm, n = 8 studies) but variable (reported average value calculated within studies between 38 and 49 mm). Backfat thickness was over 38 mm at the level of the last rib (n = 6 studies) and 42 mm (n = 6 studies) at the level of the first rib (neck). In the studies undertaken within TREASURE project [16, 17], muscle thickness measured at ZP point (minimum depth from the vertebral channel to the cranial end of the *gluteus medius*) was 69 mm on average. Muscularity assessed as lean meat content was between 35 and 40% in the only two available studies [14, 15]. Overall, values of fat and muscle depths indicate lower muscular development and greater carcass fatness compared to modern breeds, which can be explained by the absence of selection against fatness and on carcass muscle content in the Gascon breed. Variations observed

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			M[1] (mm)
							S[2]	At first rib[3]	At last rib[4]	
[3]	17	—	166	—	—	—	—	—	43	—
[4]	—	253	100	—	—	—	—	—	—	—
	—	183	98	—	—	—	—	—	—	—
	—	—	113	89	79.2	—	—	—	—	—
[6, 12]	8	—	100	—	—	—	—	—	—	—
	16	—	146	—	—	—	49	—	—	—
	18	—	146	—	—	—	38	—	—	—
[13, 14]	24	283	125	—	—	40.0	—	—	46	—
[15]	39	407	140	116	83.2	35.0	—	—	—	—
[16]	8	377	173	138	80.0	—	47	46	66	69
	20	435	181	144	79.4	—	46	38	58	68
[16, 17]	8	410	156	123	78.7	—	49	54	47	68
	18	416	171	138	81.0	—	45	59	42	68
	7	388	166	133	80.0	—	46	44	57	71
	16	424	166	135	81.4	—	46	39	56	71
[18]	12	442	170	—	—	—	—	—	—	—

No. = number, BW = body weight; CW = carcass weight.
[1]*M muscle thickness measured according to ZP method (from the vertebral canal to the cranial edge of the* gluteus medius *muscle (mm)).*
[2]*S backfat thickness measured according to ZP method (above the* gluteus medius *muscle (mm)).*
[3]*Measured at the level of the first rib (first thoracic vertebra).*
[4]*Measured at the level of the last rib or reported as the average of measurements taken along the carcass.*

Table 6.
Summary of collected literature data on body composition and carcass traits in Gascon pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	FA composition of IMF (%)				FA composition of BFT (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[3]	17	—	5.68	—	—	—	—	—	—	—	—	—	—	—	—
[4]	—	6.40	5.92	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	5.70	38	6.4	3.5	—	—	—	—	—	—	—	—	—
	—	—	5.70	41	6.8	4.4	—	—	—	—	—	—	—	—	—
	—	—	5.70	42	6.7	4.5	—	—	—	—	—	—	—	—	—
[6, 12]	8	—	—	—	—	—	3.2	—	—	—	—	46.6	43.5	9.9	—
	16	6.41	5.69	46	10.1	—	—	—	—	—	—	—	—	—	—
	18	6.37	—	—	—	—	—	—	—	—	—	—	—	—	—
[13, 14]	24	—	5.73	—	—	—	3.3	38.1	52.2	9.7	1.1	39.8	50.2	10.0	—
[15]	39	—	5.64	40	6.7	4.2	—	—	—	—	—	42.6	47.6	9.8	—
[16]	8	6.34	5.57	44	9.7	3.5	2.2	—	—	—	—	39.6	54.2	6.2	6.4
	20	6.56	5.68	43	9.3	3.2	2.6	—	—	—	—	40.5	53.4	6.0	5.6
[16, 17]	8	6.64	5.52	48	11.1	4.7	2.7	—	—	—	—	39.5	52.9	7.6	6.1
	18	6.50	5.57	46	10.4	4.2	2.4	—	—	—	—	39.0	54.0	7.0	6.4
	7	6.74	5.55	45	10.0	4.0	2.5	—	—	—	—	39.2	53.7	7.1	5.5
	16	6.76	5.73	42	9.5	3.2	2.0	—	—	—	—	39.9	53.1	6.9	5.8
[18]	12	—	—	—	—	—	2.6	—	—	—	—	—	—	—	—

No. = number, pH 45 = pH measured approximately 45 min post-mortem*; pH 24 = pH measured approximately 24 hours* post-mortem*; IMF = intramuscular fat; FA = fatty acid; BFT = backfat tissue; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; n6/n3 = the proportion between n-6 and n-3 polyunsaturated fatty acids.*
[1]CIE = objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

Table 7.
Summary of collected literature data on meat and fat quality in Gascon pig breed.

especially regarding backfat thickness are also a consequence of the wide range of final live weight of pigs and different feeding regimes and production practices applied in the considered studies.

5.4 Meat and fat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in the *longissimus* muscle that could be compared are presented in **Table 7**. In the studies reporting meat quality of Gascon pigs, pH measured in the *longissimus* muscle at 45 min and 24 hours *post-mortem* varied between 6.34 and 6.76 (n = 9 studies) and 5.55 and 5.92 (n = 14 studies), respectively. These are satisfactory values that indicate lack of major quality defects such as PSE or acid meat. The intramuscular fat content ranged between 2.0 and 3.3% (n = 9 studies). Colour measured in CIE L*, a* and b* colour space denotes a visually red colour and moderate lightness of the meat, which are satisfactory regarding appearance of the meat. In the only available study, SFA, MUFA and PUFA contents of intramuscular fat in the *longissimus* muscle were 38.1, 52.2 and 9.7%, respectively. Fatty acid composition of backfat lipids (n = 9 studies) shows high proportion of MUFA (average values between 47.6 and 54.2%) and SFA (average values between 39 and 46%) and low proportion of PUFA (less than 8% in 6 out of the 9 available studies) as compared to fatty acid profiles of backfat generally found in modern pig breeds [19]. The high proportion of MUFA and low proportion of PUFA of backfat lipids from Gascon pigs can be explained by their high genetic potential for lipid deposition together with their high energy intake during finishing period, leading to high oleic acid production from lipogenesis, the PUFA resulting only from exogenous supplies in pigs [20].

6. Use of breed and main products

The French autochthonous pig breed Gascon is valorised in high-quality fresh pork and pork products, mainly by the CNB but also by independent producers. The local production system associated to the know-how of producers that lead to typicity of pork and pork products has now been recognised at French and European levels through recent obtaining of AOC and PDO official quality labels for Noir de Bigorre fresh pork and dry-cured hams. Indeed, the characteristics of the Gascon pigs that exhibit a low growth potential (low growth rate) and a high carcass fatness, associated with the extensive production system with access to local feeding resources, allow for the development of the intrinsic qualities of muscle and fat tissues that lead to high eating qualities of the products [19, 21]. Mainly, the meat of Gascon pigs exhibits a dark red colour with low lightness, low rate and moderate amplitude of *post-mortem* pH decline, low drip loss and adequate IMF content, as well as white and firm backfat with high monounsaturated fatty and low polyunsaturated fatty acid proportions. These properties are favourable for the pleasant appearance and high tenderness and juiciness of the fresh meat, as well as for the processing of dry-cured products with long ripening duration leading to high tenderness and development of specific flavours.

Dry-cured ham is the main and most "valued" product from Gascon pigs. Other main products are listed in **Table 8**. To still improve the intrinsic qualities (tenderness, flavours) of these hams, processors now intend to increase the hams' ripening duration, from minimum of 20 months required in PDO

Product name	Type of the product	Status of the product	Label/logo
Jambon Noir de Bigorre	Dry-cured ham	AOC (French label) and PDO "Noir de Bigorre"	*AOC, PDO and Noir de Bigorre*
Porc Noir de Bigorre	Carcass and meat	AOC (French label) and PDO "Noir de Bigorre"	*AOC, PDO and Noir de Bigorre*
Pâté	Pâté	No specific status; "from Noir de Bigorre pork"	*Noir de Bigorre*
Boudin noir	Black blood pudding	No specific status; "from Noir de Bigorre pork"	*Noir de Bigorre*
Rillettes	Rillettes	No specific status; "from Noir de Bigorre pork"	*Noir de Bigorre*
Andouille	Andouille	No specific status; "from Noir de Bigorre pork"	*Noir de Bigorre*

Table 8.
Main products from Gascon pig breed.

Figure 5.
From left to right: Logo of noir de Bigorre (for all products produced by the chain), AOC (for AOC/PDO carcass and fresh meat and AOC/PDO dry-cured ham; French label, mandatory before PDO registration) and AOP (for AOC/PDO carcass and fresh meat and AOC/PDO dry-cured ham; French translation for PDO).

specifications to 24 months. The production of longer ripening hams is also considered with products aged 36 months to allow further development of specific and very high eating properties and thereby propose a wider range of high-quality "gourmet" products to consumers (**Figure 5**).

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Chapter 9

Ibérico (Iberian) Pig

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Abstract

The main characteristics of the Iberian breed, an autochthonous pig breed of the Iberian Peninsula, are presented in this chapter along with the results of a literature review on productive traits. Reproductive performance was estimated by sow age at first parturition, litters per sow and year, piglets alive per litter, piglet weight at birth and at weaning, percentage of stillborn per litter, mortality at weaning, lactation length and farrowing interval. For growth performance, average daily gain and daily feed intake during lactation and in different growing phases are provided. Carcass traits were evaluated by age and weight at slaughter, hot carcass weight, carcass yield, backfat thickness measurements, muscle thickness and loin eye area. Meat quality traits of longissimus muscle (pH, objective colour measurements and intramuscular fat) were also assessed. The main part of the studies considered simulated practical production conditions in Iberian pig rearing although others evaluated a defined growing period, sometimes quite far from the usual commercial slaughter weight of this breed. Therefore, some figures should be interpreted with caution. Although a considerable number of studies on Iberian pig were included in the current review, scientific papers on reproductive performance and some meat quality parameters are still rather scarce.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Spain

1. History and current status of the breed (census)

The Iberian pig is an autochthonous porcine breed derived from ancestral domestic pig populations of the Iberian Peninsula. For centuries, it was widely spread all over this territory. Nowadays, it can be found in the Southwest of the Peninsula: West Andalusia, Extremadura and Salamanca province. In the Portuguese Alentejo, this porcine breed, with some minor differences, is known as Porco Alentejano.

Until the middle of the XX century, the Iberian pig was the main porcine breed reared in Spain. In the first decades of the last century, the census of reproductive sows could have surpassed 500,000 animals that widely extended all over the country. Since then, a series of sanitary challenges, changes in social and feeding habits, as well as the transformation of the dehesa territory into field crops, lead to a dramatic decline in the Iberian pig population [1] that did not stop until the middle

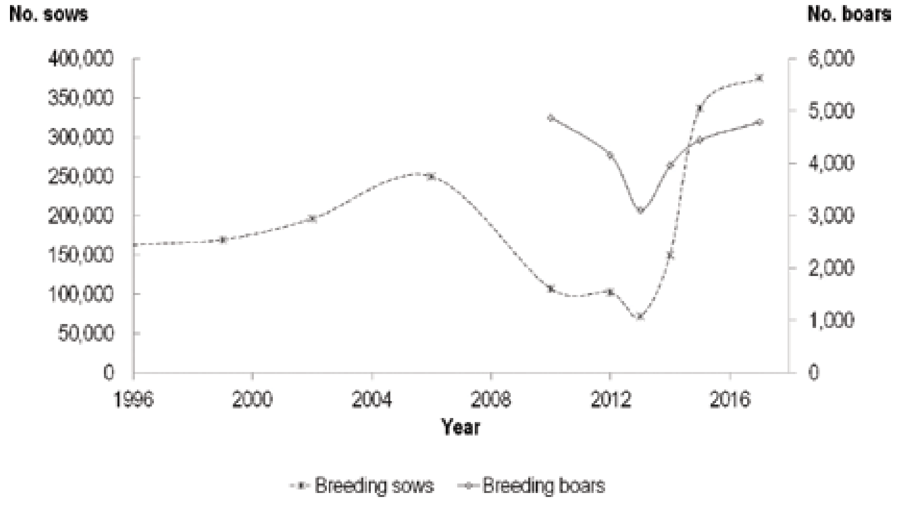

Figure 1.
Census of Iberian pig breed, presenting number of sows (No. sows) and boars (No. boars) per year, starting with the year of heard book establishment.

1980s. The most critical moments of the Iberian pig population crisis took place during the 1960s, in which the breed was at serious risk of extinction.

In the late 1980s, a new period started with the beginning of Iberian pig breeding recovery and the revalorisation of its products. To this recovery contributed not only the increasing demand for traditional food products of high organoleptic quality—a key issue for the definitive recuperation of the Iberian pig population—but also the social awareness for preservation of the genetic heritage and the natural habitat associated to this breed.

There is no official historical census of the Iberian population as the classification was based on the production system (extensive vs. intensive) and not on genetic discrimination. However, taking into account part of these data, along with own data of the Iberian pig breeders association, we can see the approximate evolution of the Iberian pig population during the last years in **Figure 1**. At present, with a reliable system of pig population registration, we know that there are 4370 registered Iberian pig farms, with 375,500 breeding sows and 4780 boars in the latest available status (November 2017). The total number of pigs slaughtered during 2017 were 3,240,000, which represent a 35% increment with respect to 2014 when the sector was suffering the effects of the global economic crisis and a specific crisis due to a production excess that led to a decrease in the census.

2. Exterior phenotypic characteristics

The racial characteristics that identify the Iberian pig are recorded in the racial standard of the genealogical book (order APA/3376/2007). Nevertheless, even today there is a great morphological heterogeneity resulting from the historical genetic isolation of this breed that gave rise to multiple local varieties, many of them already lost or subsumed into the *Retinto* variety, which is the predominant nowadays. The Iberian breed general morphology information is summarised in **Table 1**. In general, it is a medium-sized animal with pigmented skin which colour could vary from intense black to blond or reddish. The hair is weak and rather scarce (in *entrepelado* varieties) or absent (in hairless or

Measurement (average)	Adult male	Adult female
Body weight (kg)	140.5	128.0
Body length[1] (cm)	84.1	84.6
Head length (cm)	32.1	31.1
Ear length (cm)	18.4	18.7
Chest girth (cm)	24.7	22.7
Height at withers (cm)	79.8	77.3
Number of teats	10–12	10–12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Iberian pig breed.

Figure 2.
Iberian sow with piglets.

Figure 3.
Iberian boar.

lampiño varieties). The legs are thin and resistant, and the hooves are dark and uniformly coloured (**Figures 2** and **3**), except for the variety *Torbiscal* which can present depigmented or whitish-striped legs.

3. Geographical location and production system

One of the characteristics of the Iberian pig production is its high diversity, both from the genetic point of view as well as for its feeding and management.

The genuine traditional production system, carried out in the wide *dehesas* found in southwestern Spain, is based on the rearing of pure Iberian pigs, which have extensive or semi-extensive management up to 95–105 kg of body weight, and a finishing period or *montanera* in which pigs graze acorns and pastures up to 155–165 kg body weight and reach between 14 and 18 months of age. However, since several years ago, the majority of fattened pigs are produced under intensive conditions using Iberian × Duroc crossed pigs. These pigs are slaughtered with only 10 months, and their production has extended to geographical areas non-traditionally related to the Iberian pig (Murcia, Catalonia). Between these two extreme situations, several combined systems can be found. From the genetic point of view, pigs can be purebred or 50 or 75% Iberian, always obtained by crossing Iberian pure sows with Duroc boars. From the feeding and management perspective, they can be either reared intensively and fed concentrates—based on cereals and legumes—during its whole life or in mixed outdoor systems in which pigs are fed concentrates plus the natural resources available (mainly pastures). On the other extreme, we found the traditional completely extensive system (*montanera)* in which pigs graze acorns and the pasture available. As an example of the numerical relevance of the different rearing systems, in 2017 the total Iberian pigs produced in *montanera* were 635,000, from which 297,000 where purebred and 338,000 crossed with Duroc. On the other hand, 664,000 were fattened in extensive or semi-extensive systems with no-acorn feeding, most of them cross-breed; finally, 1,941,000 were fattened in intensive systems, all of them cross-breed. These figures point out that only 20% of the pigs are fattened under the traditional *montanera* system and that only 10% of total slaughtered pigs are pure Iberian [2].

The Duroc crossing provides increased precocity, higher lean deposition rates and increased prolificacy and reproductive performance. However, purebred Iberian pigs have particular qualities and distribution of lipids in tissues which are responsible for the characteristic texture, aroma and juiciness of their products. The extensive management allows pigs to reach a higher age at slaughter along with continuous exercise, both contributing to higher meat quality. The traditional production system is highly linked to the valorisation of the *dehesa*, and their rural environment play an essential role in the preservation of this ecosystem.

4. Organisations for breeding, monitoring, and conservation

The Spanish Association of Iberian Pig Breeders (AECERIBER)[1] was born in 1985 in Zafra (Badajoz, Extremadura) during a critical period when the breed was at serious risk of extinction. According to non-official records, during these years the population of Iberian breeding sows could had been as low as 5000. Therefore, this was a moment that required an organisation that would join all traditional farmers to work together in the conservation and expansion of the breed. In 1987, the Spanish

[1] AECERIBER—Spanish Association of Iberian Pig Breeders; C/San Francisco, 51, 1°D, Zafra, Badajoz, Spain, 06300, E-mail address: zafra@aeceriber.es.

Ministry of Agriculture granted AECERIBER the management and development of the genealogical book, since 1992 the genetic selection programme and, more recently, the Conservation programme for several varieties in danger of extinction. Nowadays, more than 2000 breeders in Spain take part in the association.

5. Productive performance

5.1 Reproductive traits

An overview of data registered on reproductive traits is presented in **Table 2**. The recorded age of sows at first parturition is 10.0–16.5 months [7, 12, 22]. On average, sows of Iberian pig breed have 2.2 litters per year [15, 21] with around 7.5 piglets (from 6.0 to 8.3; [3–7, 9–11, 13–16, 18–21]). Mean body weight of piglets at birth varies from 1.1 to 1.4 kg [9, 17–20, 23]. Stillborn percentage of piglets and mortality rates until weaning in the considered studies are satisfactory and range from 1.7 to 20.6 [4–6, 9–11, 13, 14, 16, 19–21] and 2.5 to 22.9% [14–16, 19–21], respectively. Although there are few studies with data available for this period of Iberian pig rearing, the average duration of lactation registered in the collected studies is prolonged in comparison to modern intensive systems (up to 60 days [23], but in average to 39 days [6, 13, 14, 17–21, 23]), which leads to a longer farrowing interval (approximately 173 days [14, 15, 21]) and higher weaning weight (6.9–20.8 kg [9, 17–20, 23]). However, recent analysis shows that the trends in the last years are to reduce the duration of lactation to 25–26 days, close to the lactation periods found in conventional sows [24].

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 3** and **4**. Due to differences among studies concerning the live weight ranges covered and for comparative purposes, we defined the stages for growth performance as lactation (regardless of its length), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages, estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined in this case as overall). The recorded data in **Table 3** shows heterogeneity. A big part of the collected studies simulated practical conditions of the production systems used in Iberian pig rearing so that they can be considered as field studies. On the other hand, a reduced group of the recorded papers aimed at evaluating the actual growth potential of Iberian pigs in a defined growing period. For this reason, the average growth rates were not calculated. The average daily gain in the early stage that corresponds to the lactation period (approximately 257 g/day, range from 168 to 371 g/day [9, 18, 23, 27, 28, 60, 61, 64, 67]) could be considered in the range of those described for modern sows [71, 72], although the average lactation period in the present studies (approximately 39 days; **Table 2**) is considerably greater than in sows of conventional breeds (21–28 days). The collected data show that daily gain is characterized by high heterogeneity in the growing (185–524 g/day, [28, 43, 44, 49, 50, 54, 57, 58, 60, 63]), early (228–566 g/day, [26, 49, 53, 54, 57, 68]), middle (181–800 g/day, [9, 26, 38, 42, 48, 51, 52, 57, 68]), late (387–1018 g/day, [4, 9, 25, 26, 29–31, 33–48, 55, 59, 60, 62, 65, 66, 68]) and overall (181–800 g/day, [9, 25, 26, 29, 32, 33, 38, 42–44, 48, 49, 51–54, 56, 57, 68–70]) fattening stages, which is related to the fact that this review comprises studies of a

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[3]	—	—	8.0	—	—	—	—	—	—
[4]	—	—	7.3	—	4.6	—	—	—	—
[5]	—	—	7.1	—	4.5	—	—	—	—
[6]	—	—	7.7	—	8.1	—	—	56	—
[7]	10.0	—	7.7	—	—	—	—	—	—
[8]	—	—	—	—	—	—	—	—	—
[9]	—	—	8.1	1.3	3.6	—	10.0	—	—
[10]	—	—	7.6	—	4.7	—	—	—	—
[11]	—	—	7.5	—	4.2	—	—	—	—
[12]	16.5	—	—	—	—	—	—	—	—
[13]	—	—	7.8	—	9.9	—	—	56	—
[14]	—	—	8.3	—	15.3	22.9	—	21	177
	—	—	7.7	—	20.6	20.8	—	31	172
	—	—	8.2	—	15.1	22.0	—	41	179
[15]	—	2.2	6.9	—	—	6.2	—	—	166
[16]	—	—	6.3	—	1.7	4.3	—	—	—
[17]	—	—	—	1.4	—	—	7.8	35	—
[18]	—	—	6.0	1.4	—	—	7.1	34	—
[19]	—	—	7.3	1.4	6.5	2.9	6.9	35	—
[20]	—	—	7.6	1.1	6.4	2.5	8.0	35	—
[21]	—	2.1	7.8	—	5.6	10.6	—	27	173

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[22]	10.0	—	—	—	—	—	—	—	—
[23]	—	—	—	1.4	—	—	20.8	60	—

No.—number; mth—month; and d—days.

Table 2.
Summary of collected literature data on reproduction traits in Iberian pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]				ADG birth to slaughter
					Early	Middle	Late	Overall	
[4]	Ad lib	579	—	—	—	—	566	—	—
[9]	Rest	78	—	—	—	445	—	445	—
	Ad lib	78	207	—	—	—	515	—	—
[18]	Ad lib	32	168	—	—	—	—	—	—
[23]	Ad lib	1704	346	—	—	—	—	—	—
[25]	Rest	58	—	—	—	—	—	473	—
	Ad lib	58	—	—	—	—	720	—	—
[26]	Rest	365	—	—	228	—	—	228	—
	Ad lib	365	—	—	—	651	651	651	—
[27]	Ad lib	26,913	267	—	—	—	—	—	—
[28]	Ad lib	2633	320	320	—	—	—	—	—
[29]	Rest	182	—	—	—	—	—	241	—
	Ad lib	182	—	—	—	—	845	—	—
	Rest	231	—	—	—	—	—	250	—
	Ad lib	231	—	—	—	—	595	—	—
	Rest	226	—	—	—	—	—	307	—
	Ad lib	226	—	—	—	—	714	—	—
[30, 31]	Rest	22	—	—	—	—	—	—	277
	Ad lib	22	—	—	—	—	545	—	—
[32]	Ad lib	701	—	—	—	—	—	608	—
[33]	Rest	16	—	—	—	—	—	389	—
	Ad lib	16	—	—	—	—	471	—	—
[34]	Ad lib	43	—	—	—	—	577	—	—
[35]	Ad lib	32	—	—	—	—	559	—	—
[36]	Semi	32	—	—	—	—	387	—	—
[37]	Semi	16	—	—	—	—	396	—	—
[38]	Rest	24	—	—	—	299	—	299	—
	Rest	16	—	—	—	—	694	—	—
	Ad lib	8	—	—	—	—	800	—	—
[39]	Ad lib	16	—	—	—	—	650	—	—
[40, 41]	Ad lib	8	—	—	—	—	532	—	—
	Ad lib	16	—	—	—	—	522	—	—
[42]	Rest	16	—	—	—	181	—	181	—
	Ad lib	16	—	—	—	—	472	—	—
[43, 44]	Semi	78	—	185	—	—	—	—	—
	Semi	60	—	—	—	—	—	500	—
	Semi	60	—	—	—	—	807	—	—
[45]	Ad lib	20	—	—	—	—	880	—	—
	Ad lib	20	—	—	—	—	880	—	—
[46]	Ad lib	151	—	—	—	—	701	—	—
[47]	Ad lib	122	—	—	—	—	755	—	—

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]				ADG birth to slaughter
					Early	Middle	Late	Overall	
[48]	Rest	1159	—	—	—	338	—	338	—
	Ad lib	1159	—	—	—	—	586	—	—
[49]	Rest	48	—	349	349	—	—	349	—
	Ad lib	24	—	506	506	—	—	506	—
[50]	Semi	18	—	524	—	—	—	—	—
[51, 52]	Ad lib	24	—	—	—	800	—	800	—
	Rest	48	—	—	—	576	—	576	—
[53]	Ad lib	20	—	—	566	—	—	566	—
[54]	Rest	12	—	415	415	—	—	415	—
	Ad lib	12	—	499	499	—	—	499	—
	Semi	25	—	485	—	—	—	—	—
[55]	Ad lib	6	—	—	—	—	917	—	—
	Rest	6	—	—	—	—	679	—	—
[56]	—	400	—	—	—	—	—	581	—
[57]	Semi	16	—	501	501	—	—	501	—
	Semi	12	—	—	—	671	—	671	—
[58]	Ad lib	26	—	391	—	—	—	—	—
	Rest	27	—	251	—	—	—	—	—
[59]	Ad lib	161	—	—	—	—	775	—	—
[60]	—	8816	193	—	—	—	—	—	—
	—	8047	—	377	—	—	—	—	—
	—	1666	—	—	—	—	662	—	—
[61]	Ad lib	120	190	—	—	—	—	—	—
[62]	Rest	16	—	—	—	—	423	—	—
[63]	Ad lib	60	—	444	—	—	—	—	—
[64]	Ad lib	38	371	—	—	—	—	—	—
[65]	Ad lib	24	—	—	—	—	1018	—	—
[66]	Ad lib	25	—	—	—	—	893	—	—
	Ad lib	100	—	—	—	—	893	—	—
[67]		14	247	—	—	—	—	—	—
[68]	Ad lib	60	—	—	465	—	—	465	—
	Ad lib	60	—	—	—	622	—	622	—
	Ad lib	60	—	—	—	—	619	—	—
[69]	Ad lib	12	—	—	—	—	—	450	—
[70]		27	—	—	—	—	—	735	—

*No.—number; ADG—average daily gain in g; Ad lib—*ad libitum *feeding regime; Semi—*semi ad libitum *feeding regime; Rest—restrictive feeding regime.*
[1]*ADG in period of lactation regardless of how long it was.*
[2]*ADG in growing period estimated from weaning to approximately 30 kg live body weight.*
[3]*ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 3.
Summary of collected literature data on growth performance in Iberian pig breed.

variety of production systems and, probably more important, feeding levels. In the context of the evaluation of growth performance, it is of interest to point out the extreme values recorded as it can be assumed that the maximum figures obtained for each growing phase correspond to Iberian pig's growth potential determined in *ad libitum* or close to *ad libitum* feeding conditions (i.e. 524 g/day in growing stage [50], 800 g/day in overall fattening stage [51, 52] and 1018 g/day from 128 kg onwards [65]).

Information on feed intake and feed nutritional composition was mentioned only in few of the considered studies, which limits the evaluation of maximum growth potential as this parameter is directly related to pig nutrition and management (**Table 4**). Average daily feed intake increased as pigs increased body weight from approximately 1.4 kg/day (0.80–1.81 kg/day [43, 44, 49, 57, 58]) in the growing stage, to approximately 4.1 kg/day (3.41–4.74 kg/day [55, 68]) in the late fattening stage in *ad libitum*-fed pigs. The maximum value recorded, 5.6 kg/day (determined in individually allocated animals), corresponds to pigs fed *ad libitum* on acorns in the late fattening stage (from approximately 90 to 140 kg body weight [39]) and shows high intake capacity in Iberian pigs. In comparative studies, the higher intake capacity of Iberian pigs compared to conventional pigs has been confirmed in similar experimental conditions and body weight range [73]. In this respect, according to van Lunen and Cole [74], voluntary feed intake has declined in the development of modern high-selected pigs compared to non-selected animals.

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most common carcass traits are presented in **Table 5**. As mentioned before, attention should be given to high heterogeneity of the recorded data, because slaughter body weights in the included studies ranged from 1 to 191 kg. A big part of the studies—some of them including high number of pigs—simulated practical conditions of the production systems used in Iberian pig rearing, whereas a reduced group of papers aimed at evaluating different performance and carcass composition parameters in a defined growing period [28, 49, 53, 58, 63, 64, 75, 86], in some cases quite far from the usual commercial slaughter weight of this breed (140–160 kg). In studies where final body weight was above 100 kg, pigs were slaughtered at approximate age of 407 days [25, 29, 33, 38, 40–44, 46, 64, 65, 68, 82, 85, 86] and reached around 152 kg live body weight [9, 25, 29–46, 48, 51, 52, 55, 56, 62, 64, 65, 69, 76–86]. In agreement with high slaughter weight, dressing yield in these studies was around 81%. The back fat thickness values measured in all considered studies spanned from 35 to 90 mm on the withers (in average 85 mm in studies with final body weight above 100 kg [55, 62, 85]), from 10 to 90 mm at the level of the last rib (in average 58 mm in studies with final LW above 100 kg [25, 29–31, 34, 35, 37–44, 46, 51, 52, 55, 64, 65, 68, 69, 76, 77, 82, 85, 86]) and from 48 to 65 mm when measured above *gluteus medius* muscle (in average 56 mm in studies final body weight above 100 kg [68, 76]). Similarly, muscularity measured as loin eye area span from 13 to 29 cm^2 (in average 23 cm^2 in studies with final LW above 100 kg [30, 31, 34, 35, 65, 76, 82]) and muscle thickness measured at the cranial edge of *gluteus medius* muscle from 11 to 60 mm (in average 40 mm in studies with final body weight above 100 kg [68, 76]). Percentage of lean meat content is not reported in the literature as this is not commonly estimated on Iberian pig carcass composition studies, which are focused mainly in the premium cuts obtained from these animals (hams, shoulders and loins). The variation in back fat and muscle thickness of the values recorded is also a consequence of the wide range of final live weights and different feeding

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI growing[1]	ADFI fattening[2]			
						Early	Middle	Late	Overall
[25]	Rest	—	13	58	—	—	—	—	1.82
	Ad lib	—	—	58	—	—	—	—	3.28
[30, 31]	Rest	12.6	16	22	—	—	—	—	1.62
[33]	Rest	12.5	14	16	—	—	—	—	2.15
[38]	Rest	12.5	14.3	24	—	—	—	1.72	—
	Rest	13.8	13.2	16	—	—	—	—	3.65
	Ad lib	13.8	13.2	8	—	—	—	—	4.00
[39]	Ad lib	—	3.5	16	—	—	—	—	5.60
[40, 41]	Ad lib	13.3	—	8	—	—	—	—	3.38
[42]	Rest	—	16	16	—	—	1.40	—	—
[43, 44]	Semi	12.6	17.8	78	0.91	—	—	—	—
	Semi	11.9	15.8	60	—	—	—	—	2.06
	Semi	13.1	13.5	60	—	—	—	3.24	—
[49]	Rest	13.1	14.4	48	1.34	1.34	—	—	—
	Ad lib	13.1	14.4	24	1.81	1.81	—	—	—
	Semi	—	13.6	18	1.52	—	—	—	—
[51, 52]	Ad lib	12.6	9.5	24	—	—	3.52	—	—
	Rest	12.6	9.5	48	—	—	2.63	—	—
[53]	Ad lib	—	11.6	20	—	1.67	—	—	—
[54]	Rest	—	—	12	—	1.43	—	—	—
	Ad lib	—	—	12	—	1.60	—	—	—
	Semi	—	—	25	—	1.39	—	—	—
[55]	Ad lib	13.0	8.4	6	—	—	—	4.74	—
	Rest	13.0	8.4	6	—	—	—	3.65	—
[57]	Semi	12.0	14.6	16	1.77	1.77	—	—	—
	Semi	12.0	14.6	12	—	—	3.09	—	—
[58]	Ad lib	13.0	14.8	26	0.80	—	—	—	—
	Rest	13.0	14.8	27	0.59	—	—	—	—
[62]	Rest	11.8	5.4	16	—	—	—	3.36	—
[68]	Ad lib	—	—	60	—	2.05	—	—	—
	Ad lib	—	—	60	—	—	3.12	—	—
	Ad lib	—	—	60	—	—	—	3.41	—

*No.—number; ADFI—average daily feed intake in kg/day; Ad lib—*ad libitum *feeding regime; Semi—*semi ad libitum *feeding regime; Rest—restrictive feeding regime; ME—metabolisable energy; and CP—crude protein.*
[1]*ADFI in growing period estimated from weaning to approximately 30 kg live body weight.*
[2]*ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on average daily feed intake (in kg/day) in Iberian pig breed.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
						S[2]	At withers	At last rib		
[9]	78	—	155	125	80.8	—	—	—	—	—
[25]	58	—	—	—	—	—	—	—	31	—
	58	303	136	112	82.2	—	—	62	28	—
[28]	2633	—	—	40	—	—	—	—	11	—
[29]	182	475	160	132	82.3	—	—	76	—	—
	231	481	149	117	78.7	—	—	67	—	—
	226	476	169	140	82.9	—	—	77	—	—
[30, 31]	22	—	152	120	78.8	—	—	64	—	25
[32]	701	—	162	131	80.7	—	—	—	—	—
[33]	8	477	159	126	79.1	—	—	—	—	—
	8	355	145	116	80.5	—	—	—	—	—
[34]	43	—	156	121	77.5	—	—	55	—	29
[35]	32	—	155	125	80.5	—	—	52	—	21
[36]	32	—	144	115	80.2	—	—	—	—	—
[37]	16	—	147	116	79.4	—	—	48	—	—
[38]	16	412	151	120	79.1	—	—	46	—	—
	8	412	159	125	78.3	—	—	49	—	—
[39]	16	—	138	109	78.8	—	—	45	—	—
[40, 41]	8	481	173	140	81.3	—	—	44	—	—
	16	481	171	137	80.3	—	—	46	—	—
[42]	16	281	163	130	79.6	—	—	50	—	—
[43, 44]	60	336	158	121	76.8	—	—	62	—	—
[45]	20	—	159	131	82.2	—	—	—	—	—
	20	—	159	131	82.2	—	—	—	—	—
[46]	—	427	136	—	—	—	—	64	—	—
[48]	1159	—	164	137	83.4	—	—	—	—	—
[49, 75]	48	—	50	37	74.8	—	—	24	—	—
	24	—	50	36	73.3	—	—	24	—	—
[51, 52]	52	—	100	—	78.1	—	—	51	—	—
	26	—	100	—	79.0	—	—	52	—	—
[53]	20	—	51	34	67.4	—	35	23	—	18
[55]	6	—	150	116	77.3	—	90	64	—	—
	6	—	151	117	77.8	—	86	71	—	—
[56]	—	—	151	119	79.1	—	—	—	—	—
[58]	25	85	25	16	66.7	—	—	12.	—	—
	27	106	25	16	68.1	—	—	14.	—	—
[62]	16	—	132	111	84.1	—	77	—	—	—

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
						S[2]	At withers	At last rib		
[63]	42	81	25	—	—	—	—	12	—	—
[64]	18	122	36	28	77.9	—	—	16	—	—
	20	336	158	124	78.2	—	—	63	—	—
[65]	24	484	191	159	82.4	—	—	76	—	29
[68]	60	311	145	117	81.2	65	—	80	—	—
[69]	12	—	118	93	78.6	—	—	48	—	—
[41]	8	481	150	121	80.6	—	—	49	—	—
	8	481	141	113	80.1	—	—	47	—	—
[76]	83	473	156	126	80.5	48	—	54	60	13
[77]	470	340	160	—	—	—	—	90	—	—
[78]	286	256	108	88	81.2	—	—	—	—	—
	270	362	138	112	81.7	—	—	—	—	—
[79]	2553	490	131	—	—	—	—	—	—	—
[80]	319	353	159	127	79.9	—	—	—	—	—
[81]	6166	508	163	130	79.7	—	—	—	—	—
[82]	241	458	158	133	84.0	—	—	67	—	25
[83]	125	—	161	139	86.8	—	—	—	—	—
[84]	22	—	135	116	85.8	—	—	—	—	—
	82	—	150	125	83.5	—	—	—	—	—
	177	—	161	134	83.2	—	—	—	—	—
	19	—	174	146	83.6	—	—	—	—	—
[85]	90	458	150	—	—	—	88	71	—	—
[86]	8	1	1	1	83.1	—	—	—	—	—
	8	58	14	9	61.8	—	—	10	—	—
	8	234	56	34	60.0	—	—	22	—	—
	8	352	80	56	70.4	—	—	36	—	—
	8	395	83	60	72.0	—	—	38	—	—
	8	424	97	74	76.4	—	—	42	—	—
	8	482	153	124	80.9	—	—	71	—	—

No.—number; BW—body weight; and CW—carcass weight.
[1]*M is the muscle thickness measured according to ZP method (at the cranial edge of* gluteus medius *muscle (mm)).*
[2]*S is the back fat thickness measured according to ZP method (above* gluteus medius *muscle (mm)).*

Table 5.
Summary of collected literature data on body composition and carcass traits in Iberian pig breed.

regimes applied in the reported studies. Despite the body weight range considered, these parameters point out the strong tendency of Iberian pigs for depositing high rates of fat and low rates of lean tissue when compared to conventional types of pigs.

5.4 Meat quality

The basic data obtained in this review concerning some of the most common meat and fat quality traits measured in *longissimus* muscle and back fat tissue are presented in **Table 6**. In the studies reporting meat quality, pH measured in *longissimus* muscle at 45 min and 24 hours *postmortem* varied from 6.29 to 6.62 [69, 76, 96] and from 5.61 to 5.75 [69, 76, 88, 89, 93, 96], respectively. Intramuscular fat content was very variable and ranged from 3.0 to 19.7% (6.9% in average) [29–33, 37–39, 42, 62, 65–69, 76, 77, 79–83, 87–92, 94]. Colour measured in CIE L, a, b colour space varied from 34 to 54, 7.5 to 14.8 and 1.7 to 13.6 for L, a* and b*, respectively [68, 69, 76, 88–93, 95, 96]. Total SFA, MUFA and PUFA content of intramuscular fat in *longissimus* muscle, reported for the control groups of animals in the considered studies, were approximately 38, 56 and 7%, with n6–n3 ratio varying from 2 to 20% [30, 31, 33, 35–39, 42, 64, 66, 67, 77, 88–92, 97]. On the other hand, total SFA, MUFA and PUFA content of back fat tissue, reported for control animals in the mentioned studies, were close to 33, 56 and 11%, with n6–n3 ratio varying from 5.6 to 20% [30, 31, 33, 35–39, 41, 42, 62, 68, 69, 77, 91, 97]. Due to wide differences between studies regarding parameters as feeding management, feed composition, final body weight or age and fatness, which are all important factors influencing the fatty acid composition of meat and fat tissue, the results of average fatty acid composition should be interpreted with caution. When comparative studies in which Iberian pigs have been contrasted either with its crosses with Duroc pigs [68] or with pigs from conventional breeds [69, 92], the pigs from Iberian genotype show redder (higher values of a*) and darker (lesser values of L) muscles and higher level of intramuscular fat in *longissimus* muscle than the other pigs types. The red tone is related to greater myoglobin content [91, 92] and is generally associated with higher intramuscular fat levels and more oxidative muscle metabolism.

6. Use of breed and main products

The Iberian pig production is mainly focussed on the elaboration of cured products, with hams, shoulders and loins being those more important, although other charcuterie pieces of lower economic relevance are also produced (chorizo, salchichón, morcón, etc.). More recently, fresh meat either for domestic consumption or for the HORECA sector has gained increasing importance being highly appreciated for its peculiarities in aroma, texture and juiciness, competing in the market with the conventional pig meat and also with specific meat pieces of lamb and beef. Nevertheless, the cured products from the Iberian pig fattened in the traditional *montanera* system are the commercially strategic products for the whole sector since their high-quality standards provide a prestige that, in a way, favours the rest of productions. All the hams, shoulders and loins produced from Iberian pig in Spain are currently under an official regulation [98] that classify the cured products detailed according to their genetic origin (pure or cross-breed and at what percentage) and system of production (intensive, semi-extensive or *montanera*), with the aim of offering the consumer a precise information of product origin which is directly related with their market prices. There are currently four protected designations of origin (DPO) for Iberian cured products (Guijuelo, Dehesa de Extremadura, Jabugo and Los Pedroches) that endorse and protect Iberian hams and shoulders. The most typical and well-known product that represents the breed is the *bellota* cured ham that reaches high prices in the market and acts as a flagship of the increasing export market (EU, Japan and the USA).

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	FA composition of IMF[2] (%)				FA composition of BFT[3] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[29]	182	—	—	—	—	—	5.9	—	—	—	—	—	—	—	—
	231	—	—	—	—	—	5.3	—	—	—	—	—	—	—	—
	226	—	—	—	—	—	6.9	—	—	—	—	—	—	—	—
[30, 31]	22	—	—	—	—	—	6.2	35.5	59.3	5.2	2.1	28.2	60.8	11.0	14.8
[32]	701	—	—	—	—	—	9.5	—	—	—	—	—	—	—	—
[33]	8	—	—	—	—	—	6.0	36.8	57.9	5.3	2.4	27.8	59.8	12.4	6.2
	8	—	—	—	—	—	4.6	36.9	58.1	5.0	2.6	28.3	61.0	10.7	8.0
[35]	8	—	—	—	—	—	—	35.5	59.0	5.5	2.1	29.4	59.1	11.5	11.8
[36]	8	—	—	—	—	—	—	36.9	58.1	5.0	2.6	28.3	61.0	10.7	8.0
[37]	16	—	—	—	—	—	8.5	37.5	56.7	5.8	8.8	33.3	43.6	23.1	6.7
[38]	16	—	—	—	—	—	5.4	38.5	57.4	3.6	5.4	32.3	56.4	11.2	5.7
	8	—	—	—	—	—	5.0	37.5	58.5	4.0	5.6	32.2	56.9	10.9	5.6
[39]	16	—	—	—	—	—	5.2	38.7	57.3	4.0	5.5	30.3	58.9	10.8	5.7
[42]	16	—	—	—	—	—	9.8	37.8	58.1	4.1	—	28.3	59.6	12.2	—
[62]	16	—	—	—	—	—	19.7	—	—	—	—	38.6	54.7	6.8	20.0
[64]	16	—	—	—	—	—	—	39.6	50.0	10.4	10.0	—	—	—	—
	20	—	—	—	—	—	—	38.0	58.4	3.6	10.0	—	—	—	—
[65]	24	—	—	—	—	—	4.6	—	—	—	—	—	—	—	—
[66]	25	—	—	—	—	—	9.7	37.8	58.1	4.0	6.3	—	—	—	—
	100	—	—	—	—	—	8.4	38.8	57.9	3.2	3.3	—	—	—	—

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	FA composition of IMF[2] (%)				FA composition of BFT[3] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[67]	14	—	—	—	—	—	6.1	33.2	47.8	19.0	—	—	—	—	—
[68]	60	—	—	40	11.3	13.6	8.8	—	—	—	—	38.7	52.5	8.7	—
[69]	12	6.49	5.75	54	7.5	—	3.9	—	—	—	—	34.8	51.7	13.5	—
[41]	8	—	—	—	—	—	—	—	—	—	—	28.1	57.7	14.2	—
[76]	83	6.62	5.74	34	13.2	1.7	8.3	—	—	—	—	—	—	—	—
[77]	470	—	—	—	—	—	8.2	39.8	53.2	7.0	—	37.0	51.5	11.5	—
[79]	1489	—	—	—	—	—	9.8	—	—	—	—	—	—	—	—
[80]	319	—	—	—	—	—	7.5	—	—	—	—	—	—	—	—
[81]	3083	—	—	—	—	—	9.5	—	—	—	—	—	—	—	—
[82]	241	—	—	—	—	—	4.8	—	—	—	—	—	—	—	—
[83]	125	—	—	—	—	—	5.2	—	—	—	—	—	—	—	—
[87]	319	—	—	—	—	—	7.5	—	—	—	—	—	—	—	—
[88, 89]	90	—	5.72	43	13.1	6.7	6.4	36.0	57.2	6.8	15.6	—	—	—	—
[90]	24	—	—	47	12.4	7.3	4.6	35.8	55.4	8.7	12.3	—	—	—	—
[91]	10	—	—	46	14.8	4.7	4.8	39.9	48.2	11.9	—	34.7	49.4	15.9	—
[92]	21	—	—	45	10.5	4.3	3.0	40.9	49.1	10.0	13.8	—	—	—	—
[93]	15	—	5.61	34	11.0	3.9	—	—	—	—	—	—	—	—	—
[94]	12	—	—	—	—	—	4.0	—	—	—	—	—	—	—	—
	12	—	—	—	—	—	4.2	—	—	—	—	—	—	—	—
[95]	21	—	—	45	10.5	—	—	—	—	—	—	—	—	—	—

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	FA composition of IMF[2] (%)				FA composition of BFT[3] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[96]	27	6.29	5.61	42	9.6	4.8	—	—	—	—	—	—	—	—	—
[97]	13	—	—	—	—	—	—	39.5	57.4	3.1	20.0	36.6	55.0	8.4	9.9

No.—number; pH 45—pH measured approximately 45 min postmortem*; pH 24—pH measured approximately 24 hours* postmortem*; FA—fatty acid; IMF—intramuscular fat; BFT—back fat tissue; SFA—saturated fatty acids; MUFA—monounsaturated fatty acids; PUFA—polyunsaturated fatty acids; and n6/n3—the proportion between n6 and n3 polyunsaturated fatty acids.*

[1]*CIE—objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

[2]*For fatty acid composition of intramuscular fat tissue in longissimus muscle, only pigs on control diet were considered, and when fatty acid composition was reported separately for neutral and polar lipids, values reported for neutral lipids were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*

[3]*For fatty acid composition of back fat tissue, only pigs on control diet were considered and when fatty acid composition was reported separately for outer and inner layers, values reported for outer layer of back fat tissue were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*

Table 6.
Summary of collected literature data on meat quality traits in Iberian pig breed.

The quality of the Iberian products from the sensorial and organoleptic, technological, dietetic, biosecurity, commercial and healthy point of view, is due to various meat properties that determine their essence. All of them together are responsible for their commercial success and consumer appreciation. Its sensory characteristics, such as appearance, smell, colour and above all the flavour, justify the conservation of this breed and its ecosystem and the maintenance of its ancient forms of production and processing.

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Chapter 10

Krškopoljski prašič (Krškopolje Pig)

Nina Batorek Lukač, Urška Tomažin, Martin Škrlep, Andrej Kastelic, Klavdija Poklukar and Marjeta Čandek-Potokar

Abstract

This chapter presents the history and the current state-of-the-art in the only Slovenian autochthonous pig breed - Krškopolje pig. A review of literature regarding productive traits was carried out. The reproductive performance includes sow age at first parturition and at culling, litters per sow per year, number of live born and percentage of stillborn piglets per litter, piglet birth and weaning weight, mortality at weaning, duration of lactation and length of farrowing interval. Growth performance was evaluated as average daily gain in lactation, post-weaning, and early, mid, or late fattening. Daily feed intake in different stages was also assessed. Review also addresses age and weight at slaughter, and carcass traits: hot carcass weight, carcass yield, lean meat content, backfat and muscle thickness, and loin eye area. Meat quality traits considered were Longissimus muscle pH, objective colour parameters and intra muscular fat content. Additionally, fatty acid composition of intramuscular fat and backfat tissue was considered. Although studies on Krškopolje pig are scarce and the results on productive traits should be interpreted with precaution, due to different production systems and feeding strategies used in considered studies, the current review gives the first overview on this local pig breed in its current phenotype.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Slovenia

1. History and current status of the breed (census)

Slovenia has only one preserved indigenous local pig breed, the Krškopolje pig (in Slovenian, Krškopoljski prašič). The oldest known record about Krškopolje pig dates back to the year 1899 when Rohrman described a widespread pig production in Dolenjska region, especially in the area of Krško polje (Krško is the name of the town and "polje" means field in Slovenian). In the old literature, Krškopolje pig was also named the black-belted, belted or striped pig. The breed became endangered due to official campaign against Krškopolje pig in the 1960s; consequently, the last official records about the breed and fertility data were reported in 1972 before its revival in the early 1990s of the twentieth century when in situ gene bank was implemented [1]. In that time around 40 farms were still raising Krškopolje pigs [2]. Promotion and support for organic farming along with the subsidies for the use of Krškopolje pig

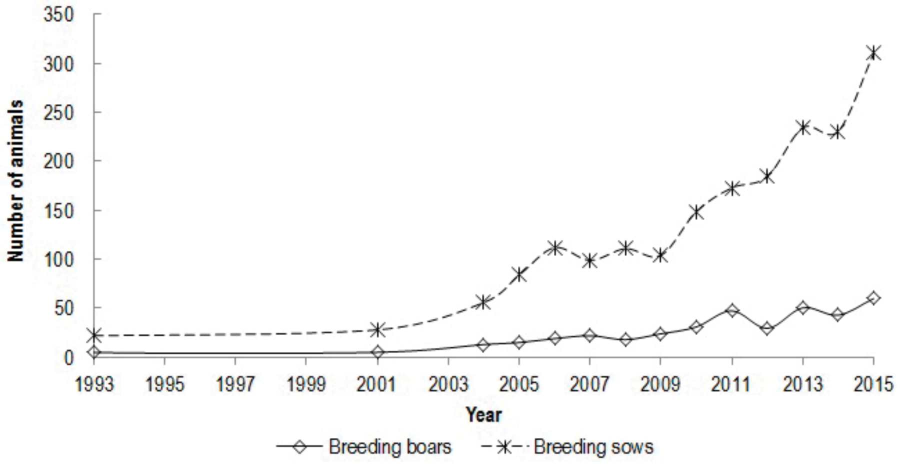

Figure 1.
Census of the Krškopolje pig breed, presenting a number of sows and boars per year, starting with the year of heard book establishment.

increased the interest for the breed. After the year 2003, when individual marking of all newborn piglets was introduced, the interest for breeding the Krškopolje pigs has increased. Census of the Krškopolje pig breed is presented in **Figure 1**. Presently, there are 130 registered farms of the Krškopolje pigs with about 311 breeding sows and 60 boars in the latest available status (August 2015). However, the breeders have on average only one to two sows.

2. Exterior phenotypic characteristics

The Krškopolje pig breed morphology information is summarised in **Table 1**. It is a middle to large sized breed of black coat colour and a characteristic continuous white belt across the shoulders and forelegs (**Figures 2** and **3**). The head is medium sized, with looped ears of medium length. The face should be slightly dished and the nose top white. The body is wide and not too deep, the back is long, wide and straight, the shoulders are strong and medium in width, and the hams are broad,

Measurement (average)	Adult male	Adult female
Body weight (kg)	280	230
Body length[1] (cm)	152	140
Head length (cm)	63	30
Tail length (cm)	45	41
Ear length	Large	Medium
Chest girth (cm)	—	140
Height at withers (cm)	87	83
Number of teat	—	14

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on the Krškopolje pig breed.

Figure 2.
Krškopolje sow with piglets.

Figure 3.
Krškopolje boar.

full and long. The hair is strong, straight and dark over the pigmented parts of the body. Their temperament is calm.

3. Geographical location and production system

The origin of the Krškopolje pig is geographically located in the south-east part of the Dolenjska region, the area of Krško-Brežiško field and the foothills of Gorjanci hills. However, nowadays farms with the Krškopolje pigs are distributed throughout Slovenia (**Figure 4**). The breed is adapted to poor rearing conditions, is robust and efficiently uses the forage; thus, it can be kept outdoors. Traditionally, the Krškopolje pigs were kept in a mixed production system—with indoor housing and access to outdoor area. Indoor housing was usually in pens with the

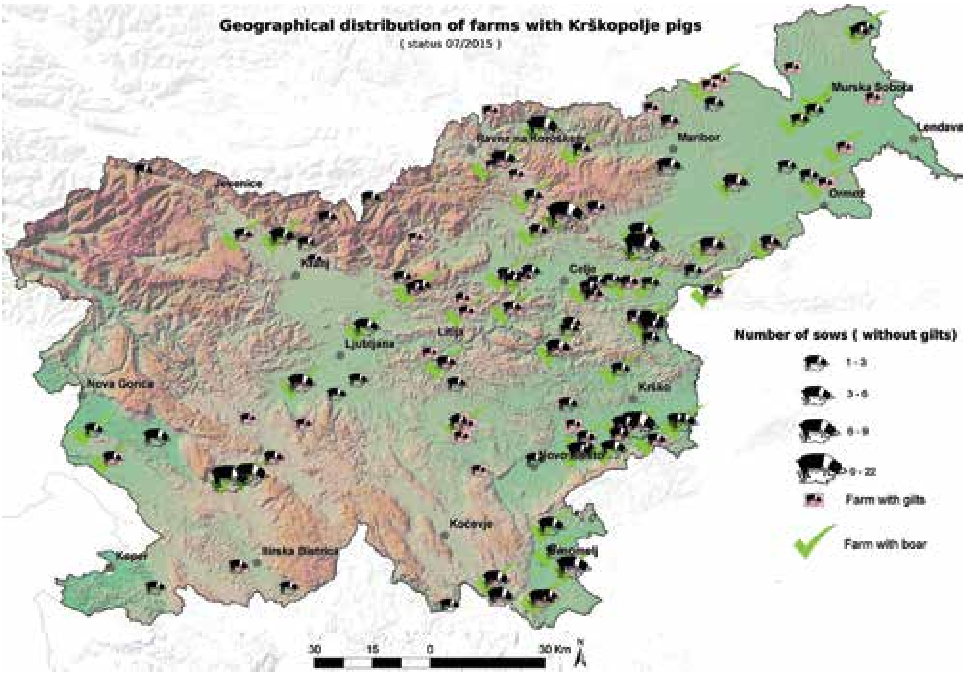

Figure 4.
Geographical distribution of Krškopolje pig breeders with size of their herds, i.e. number of sows.

full floor and straw bedding or deep litter. Water and feed were provided twice per day (morning and late afternoon) in wooden troughs. Pigs were fed with locally available seasonal ingredients that were usually pre-cooked in large kettles. The feed mixture was composed of seasonal vegetable (e.g. carrots, turnips, beets, cabbage and potatoes), cereals (barley, oats, wheat, triticale, buckwheat and millet) and residual food from the household. Sometimes, skimmed milk or whey was added. Additionally, fresh grass or clover in spring and summer and grass or alfalfa hay in winter was provided through the day. Nowadays, animals of the Krškopolje pig breed are being reared in various production systems: from more intensive indoor system with conventional feed mixture to fully outdoor system where pigs are fed with various crops and kept on pasture. They are provided a shelter in case of unfavourable weather conditions and are moved indoor only in strong winter.

4. Organisations for breeding, monitoring and conservation

The Krškopolje pig is listed among the endangered Slovenian breeds of farm animals. The breed is included in the breeding programme for pigs SloHibrid, which is run by the Chamber for Agriculture and Forestry of Slovenia. However, the Association of breeders of Krškopolje pig breed[1] has prepared their own breeding programme, which has recently been approved by the Ministry of Agriculture, Forestry and Food.

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[1] Društvo rejcev Krškopoljskih prašičev = Association of breeders of Krškopolje pig; Cesta prvih borcev 41, 8250 Brežice, Slovenia; web address: http://www.krskopoljski-prasic.si/; e-mail address: info@krskopoljski-prasic.si

5. Productive performance

5.1 Reproductive traits

The basic data obtained on reproductive traits in this review are presented in **Table 2**. The age of sows at the first parturition is around 14 months (12–16 months [3–6, 9, 10, 12])denoting the age at which sows reach a target weight of 100 kg when they are usually mated for the first time is to some extent later than in intensively kept modern breeds. The breed has moderately good fertility. On average sows of the Krškopolje pig breed have 1.8 litters per year [1, 3, 5–10] with between 8.1 and 10.5 piglets [1–6, 8–10, 12] of approximately 1.2 kg live body weight [10]. Stillborn percentage of piglets is very variable and ranges between 5.7 and 21.9% [1–3, 5, 6, 8, 9, 12], in most studies being slightly higher than 7% desired in a normal indoor herd unaffected by specific disease [13]. However, regarding the fact that piglet mortality in loose farrowing systems commonly ranges from 20–33% [14, 15], which is about twofold greater than that normally occurring in confinement farrowing crates [16], mortality at weaning in the considered studies of Krškopolje is satisfactory (8.1 to 26.7% [1–3, 5, 6, 8–10, 12]). Duration of lactation is prolonged in comparison to modern intensive systems (to approximately 44 days [1, 3, 6–8, 11, 12]), which leads to a longer farrowing interval (between 187 and 240 days [1, 3, 6–10, 12]) and consequently a lower number of piglets produced per sow per year (16.9; data not shown). On average sows have 5.6 litters in their lifetime (data not shown [1, 7]), which corresponds to results obtained in modern breeds [17].

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 3** and **4**. Due to big differences between studies concerning the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth–slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used in practice and that only a smaller part of the studies exhibit the breed potential for growth. In the considered studies, daily gain in the early growing stage, which corresponds to lactation period (195–355 g/day [8, 18, 19, 25, 26]), is in the range of values described for leaner breeds. However, it should be taken into account that the lactation period (approximately 44 days; **Table 3**) is considerably greater than in sows of conventional breeds (21–28 days). Average daily gain in the growing stage (between 207 and 385 g/day [8, 18, 19, 25, 26]) is lower than in modern breeds, which denotes lower intensity of rearing. Also, the early, middle, late and overall fattening stages are generally characterised by slower growth and big heterogeneity (355–934, 352–968, 533–1085 and 352–951 g/day in early, middle, late and overall growing stage, respectively), related to the fact that this review comprises studies where different systems and feeding levels were practised. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Krškopolje pigs in ad libitum conditions of feeding (≈951 g/day in overall fattening stage).

Reference	Sow age at the first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling[1] (mth)
[1]	—	1.9	9.1	—	9.7	19.5	—	41	193	39.0
[2]	—	—	8.9	—	8.8	8.1	—	—	—	—
	—	—	8.1	—	21.9	26.7	—	—	—	—
[3]	15.3	1.8	9.4	—	8.8	19.9	—	50	200	—
[4]	14.2	—	9.6	—	—	—	—	—	—	—
[5]	16.2	1.4	9.3	—	8.3	17.5	—	—	—	—
[6]	13.9	2.0	9.3	—	9.6	19.5	—	39	187	—
[7]	—	1.8	—	—	—	—	—	45	205	34.2
[8]	—	1.5	9.1	—	5.7	17.6	—	53	240	—
[9]	12.0	1.8	10.5	—	11.5	17.0	—	—	207	—
[10]	16.0	1.8	9.0	1.2	—	22.2	—	—	203	—
[11]	—	—	—	—	—	—	8.6	38	—	—
[12]	15.5	—	9.3	—	8.5	20.8	—	50	200	—

No. = number, mth = month, d = days.
[1]*Calculated as number of farrowing in lifetime divided with litters per sow per year and multiplied with 12.*

Table 2.
Summary of collected literature data on reproduction traits in the Krškopolje pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]				ADG birth–slaughter
					Early	Middle	Late	Overall	
[2]	—	27	—	—	—	—	—	625	—
[8, 18, 19]	Semi	36	195	385	784	826	629	734	526
[11]	Semi	6	—	—	648	475	580	562	—
	Semi	6	—	—	455	475	—	465	—
[20]	—	20	—	—	463	—	629	558	—
[21–23]	Ad Lib	10	—	—	934	968	1085	951	637
[24]	Semi	17	—	—	—	—	—	—	497
[25, 26]	Rest	10	225	225	—	352	—	352	—
	Semi	40	355	355	355	—	533	355	463
	Rest	23	—	207	—	585	—	585	377

No. = number, ADG = average daily gain in g, Ad Lib = ad libitum feeding regime, Semi = semi ad libitum *feeding regime, Rest = restrictive feeding regime.*
[1]*ADG in a period of lactation regardless of how long it was.*
[2]*ADG in a growing period estimated from weaning to approximately 30 kg live body weight.*
[3]*ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 3.
Summary of collected literature data on average daily gain (in g) in the Krškopolje pig breed.

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI growing[1]	ADFI fattening[2]			
						Early	Middle	Late	Overall
[2]	—	—	—	27	—	2.1	2.1	—	—
[8, 18, 19]	Semi	12.7	14.8	36	1.07	2.53	3.36	3.19	2.99

No. = number, ADFI = average daily feed intake in kg/day, Semi = semi ad libitum *feeding regime, ME = metabolisable energy, CP = crude protein.*
[1]*ADFI in a growing period estimated from weaning to approximately 30 kg live body weight.*
[2]*ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on average daily feed intake (in kg/day) in the Krškopolje pig breed.

In considered studies, the information on feed intake and feed nutritional value were rarely provided, which limits the evaluation of growth potential, because growth is directly related to both energy and nutrient supply. Average daily feed intake increased from 1.1 kg/day in growing stage to max 3.2 kg/day in the late fattening stage when *semi ad libitum* feeding regime was applied [8, 18, 19].

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 5**. In considered studies, pigs were slaughtered at approximately 276 days of age [11, 20, 24, 26, 27, 31], between 88 and 146 kg, i.e. an average 118 kg live weight [2, 11, 20–24, 26–29, 31]. Dressing yield was around 77% [2, 20–23, 26–29, 31] and

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
							S[2]	At withers	At last rib		
[2]	27	—	90	70	77.1	—	—	—	—	—	26
[11]	6	228	120	—	—	—	—	—	40	—	—
	6	220	88	—	—	—	—	—	22	—	—
[20]	20	312	146	—	71.6 [3]	—	—	—	—	—	—
[21–23]	10	—	139	111	79.3	42.2	44	—	—	49	36
[24]	17	245	123	98	—	46.2	—	—	29	—	42
[26, 27]	10	347	—	96	—	47.8	33	45	40	61	—
	40	303	140	109	77.9	39.7	40	67	49	67	—
	23	328	125	95	75.9	44.2	34	48	41	69	—
[28]	9	—	90	71	78.4	—	—	—	35	—	23
[29]	4	—	118	94	79.6	—	—	—	33	—	—
[30]	10	—	—	93	—	47.8	33	—	—	61	—
[31]	24	228	123	98	80.4	42.9	36	53	—	—	36

No. = number, BW = body weight, CW = carcass weight.
[1]M muscle thickness measured according to ZP method (at the cranial edge of gluteus medius muscle (mm)).
[2]S backfat thickness measured according to ZP method (above gluteus medius muscle (mm)).
[3]The skin, feed and head are removed.

Table 5.
Summary of collected literature data on body composition and carcass traits in the Krškopolje pig breed.

lean meat content around 44% (39.7 to 47.8%; SEUROP classification or dissection [21–24, 26–29, 31]). The backfat thickness values measured on the withers spanned from 45 to 67 mm [26, 27, 31], at the level of the last rib from 22 to 49 mm [11, 26–29] and at the level of gluteus medius muscle from 33 to 44 mm [21–23, 26, 27, 30, 31]. Muscularity measured as loin eye area varied from 23 to 42 cm^2 [2, 21–24, 28, 31] and muscle thickness measured at the cranial edge of gluteus medius muscle from 49 to 69 mm [21–23, 26, 27, 30], which indicates lower muscular development in the Krškopolje pig compared to modern breeds. This variation in backfat and muscle thickness is also a consequence of the wide range of the final live weight (88 to 146 kg) of pigs and different feeding regimes applied in considered studies.

5.4 Meat quality

The basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in longissimus muscle that could be compared are presented in **Table 6**. In the few studies reporting meat quality of Krškopolje pigs, pH values measured in longissimus muscle at 45 min and 24 h post-mortem were around 6.08 [24, 30–40] and 5.47 [11, 21–24, 30–40], respectively. Relatively low average value of pH 45 in the considered studies could be an indicator of a higher presence of an RYR1 mutation in the Krškopolje pig breed [24, 41]. pH 24 values in the considered studies are somewhat higher than in modern breeds, which is indicative of lower glycogen stores before slaughter. This corroborates with higher intramuscular fat content (2.0–4.3% [11, 24, 30–40]), both indicative of more oxidative muscle metabolism. In agreement with this, colour measurements

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	FA[2] composition of IMF (%)				FA[2] composition of BFT (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[11]	6	—	5.46	50	6.6	0.9	2.8	—	—	—	—	—	—	—	—
	6	—	5.43	48	8.5	1.0	3.1	—	—	—	—	—	—	—	—
[21–23]	10	—	5.50	56	10.9	7.3	—	—	—	—	—	—	—	—	—
[24, 32]	17	5.84	5.59	54	9.7	4.9	3.0	—	—	—	—	—	—	—	—
[28]	8	—	—	—	—	—	2.7	—	—	—	—	—	—	—	—
[30]	—	—	—	—	—	—	—	33.8	48.6	17.6	14.5	—	—	—	—
[30, 33–40]	10	—	5.49	48	9.5	2.4	2.0	33.8	48.6	17.6	14.3	36.1	50.8	12.7	12.1
	40	6.00	5.42	.	10.7	—	4.3	37.0	55.1	7.9	13.5	40.5	50.6	8.9	18.8
	23	6.00	5.28	.	9.3	—	2.1	34.4	42.4	23.3	10.3	36.7	45.3	18.0	8.2
[31]	24	6.49	5.59	52	7.4	1.6	3.0	41.0	47.5	11.6	15.7	42.2	43.6	14.7	12.9

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem, *pH 24 = pH measured approximately 24 hours* post-mortem, *FA = fatty acid, IMF = intramuscular fat, BFT = backfat tissue, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, n6/n3 = the proportion between n-6 and n-3 polyunsaturated fatty acids.*
[1]*CIE = objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*
[2]*For fatty acid composition, only pigs on control diet were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*

Table 6.
Summary of collected literature data on meat quality in the Krškopolje pig breed.

(Minolta L value; L* = 48 to 52 [11, 21–24, 30–40]) confirm a bit more intensive colour of meat. In the considered studies, SFA, MUFA and PUFA contents were approximately 36, 48 and 16% for intramuscular fat in longissimus muscle [30, 31, 33–40] and approximately 39, 48 and 14% for backfat tissue [30, 31, 33–40]. Due to big differences between studies concerning the feeding regime, feed composition, final body weight and fatness, which are all important factors influencing the fatty acid composition of meat, it is difficult to interpret the results on the fatty acid composition. Nevertheless, it can be concluded that the results obtained from the considered studies indicate a higher proportion of MUFA and SFA in Krškopolje pigs and lower PUFA content in comparison to the modern meaty type of pigs. This can be attributed to higher synthesis of MUFA and SFA [42], caused by higher fat deposition in this breed of pigs, as shown by the results of body composition (**Table 5**).

6. Use of breed and main products

The Krškopolje pig is intended for production of high-quality meat and fat. Pigs are raised in poorer conditions, with less concentrated feeds and with additional fibre feed. The breed is prone to fat deposition, but meat contains relatively high content of intramuscular fat, which makes it tastier. It is suitable for roasted pork or preparation of traditional dried products (e.g. salami, sausages, dry cured hams and pancetta). In the year 2017, an association of breeders of the Krškopolje pig registered a trademark "Meat products from Krškopolje pig" (**Figure 5**), which can be used by registered breeders within the Association of breeders of Krškopolje pig breed for products made exclusively from meat and fat of the Krškopolje pig.

Figure 5.
Logo for trademark "Meat products from Krškopolje pig".

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Chapter 11

Lietuvos Vietinė (Lithuanian Indigenous Wattle) Pig

Violeta Razmaitė, Rūta Šveistienė, Virginija Jatkauskienė, Remigijus Juška, Raimondas Leikus and Nina Batorek-Lukač

Abstract

Lietuvos vietinė pigs were developed in Lithuanian ethnic lands following natural selection and introduction of some imported pigs. Earlier, no purposeful selection was carried out for this old Lithuanian pig breed. Lietuvos vietinė pigs as other local pig breeds are adapted to the specific local environment and could be fed with various locally available feedstuffs. So besides their genetic merit for agro-biodiversity, they represent the basis for sustainable local pork chains. The present chapter aims to present history and current status of Lietuvos vietinė pig breed, its exterior phenotypic characteristics, geographical location, production system and main products from this Lithuanian autochthonous breed of pigs, one of the local pig breeds investigated in the project TREASURE. Moreover, a collection and review of available literature data, available until August 2017, on reproductive and productive traits of Lietuvos vietinė pig breed were carried out. Reproductive and growth performance was estimated in different stages. Lean meat content was measured by ultrasonic equipment Piglog on the side of live pigs at the position of 12 ribs. Measurements of backfat thickness were taken with a ruler on the left side of carcasses at the dorsal line of the mid-back at the last rib and loin area at the 1/2 lumbar vertebra by digital camera EX-Z110 and afterwards were planimetrically measured by means of the "SCAN-STAR K" planimetrical system. Meat quality traits of the longissimus muscle were evaluated by means of pH at 45 min and 24 hours after slaughter.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Lithuania

1. History and current status of the breed (census)

The Lithuanian indigenous wattle (Lithuanian: Lietuvos vietinė) is a domestic pig native to Lithuania and is one of the oldest pig varieties in Europe. Census of Lietuvos vietinė pig breed is presented in **Figure 1**. Presently, there are only two registered farms of Lietuvos vietinė pigs with about 43 breeding sows and 11 boars in the latest available status (December 2017).

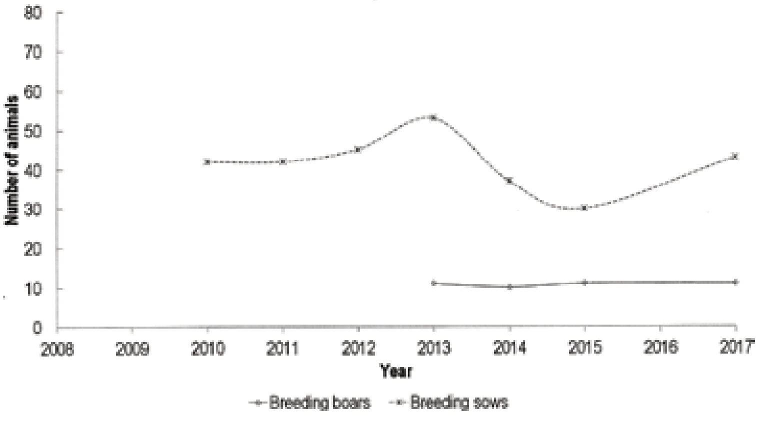

Figure 1.
Census of Lietuvos vietinė pig breed, presenting a number of sows and boars per year, starting with the year of heard book establishment.

2. Exterior phenotypic characteristics

The Lietuvos vietinė pig breed morphology information is summarised in **Table 1**. It is a middle-sized breed with wattles under the neck, and usually large

Measurement (average)	Adult male	Adult female
Body weight (kg)	277.8	215.2
Body length[1] (cm)	166.6	156.7
Head length (cm)	32.9	30.3
Tail length (cm)	39.0	35.9
Ear length (cm)	26.3	25.0
Chest girth (cm)	157.9	143.6
Height at withers (cm)	88.6	78.3
Number of teats	13.1	13.1

[1]*Measured from the back of the head to the starting point of the tail.*

Table 1.
Summary of morphology information on Lietuvos vietinė pig breed.

Figure 2.
Lietuvos vietinė sow with piglets.

Figure 3.
Lietuvos vietinė boar.

black spots on the body, but colour variations include black and white, ginger, black and tricoloured (**Figures 2** and **3**). They have a friendly temperament. Being insensitive to the sun, these pigs are suitable for grazing.

3. Geographical location and production system

Lietuvos vietinė pigs are conserved at the Centre for Farm Animal Genetic Resources in Coordination with Animal Science Institute, Lithuanian University of Health Sciences where the nucleus herd is maintained. Most of Lietuvos vietinė pigs are concentrated in this nucleus herd which is located in the central part of Lithuania, Baisogala, Radviliškis district (in the latitude of 55° 64′N and the longitude of 23° 70′E). Individually recorded representatives of Lietuvos vietinė pigs and their crossbreeds with other breeds are in the farm located in Algimantai, Raseiniai district (in the latitude of 55° 26′N and the longitude of 23° 50′E).

Previously in Lithuania some small farms kept pigs outdoor during warm season. The experiments showed that at 14.3–18.7°C air temperature the weight at 60 days of age outdoor-born piglets was 16.9–32.6% higher than that of indoor-born piglets. In individual and group enclosures with shelters, they consumed, respectively, 18.2–8.7% less feed than indoor piglets of Lietuvos vietinė breed. However, the loss of outdoor piglets until weaning, particularly in group enclosures, was by 8.0–8.5% higher than that of indoor piglets [11]. Nowadays, due to the African swine fever in wild boars and high veterinary standards for biosecurity, all domestic pigs in Lithuania should be kept strictly indoors. Consequently, the numbers of small pig farms and the numbers of local pigs have drastically decreased, because Lietuvos vietinė pigs are mainly intended for grazing. Currently, there is only a possibility for indoor rearing in semi-extensive conditions. Thus, Lietuvos vietinė pigs are kept, not for commercial purposes but for breed preservation and restoration and maintenance of herd stability by preserving biodiversity for future generations.

4. Organisations for breeding, monitoring and conservation

The activities for conservation of Lithuanian breeds were launched in 1994 when a minimal herd of Lietuvos vietinė pigs was formed at the Animal Science Institute, and thus their complete extinction has been prevented. Due to a small number of owners of Lithuanian local pigs, it is not possible to establish a separate association. Thus, Lithuanian Pig Producers Association is responsible for pig breeding.

Researchers of Animal Science Institute of Lithuanian University of Health Sciences prepared the National Programme for the Conservation of Native Farm Animal Genetic Resources adopted by the Ministry of Agriculture of Lithuania in 1996 and 2008. The main purpose of these programmes was a collection, monitoring, investigation and conservation of Lithuanian local breeds in situ and ex situ. To achieve these goals, the National Farm Animal Genetic Resources Coordinating Centre was established at the Animal Science Institute at the end of 2008. Lithuanian Endangered Farm Animal Breeders Association (LEFABA) was established in 2010 (**Table 2**).

Name of organisation	Address	Web address
Lithuanian Pig Producers Association	Verkių 5, LT-08218 Vilnius, Lithuania	http://www.kiaules.lt
Lithuanian Endangered Farm Animal Breeders Association	R. Žebenkos 12, LT-82317 Baisogala, Radviliškis Distr., Lithuania	https://luga.lt/
National Farm Animal Genetic Resources Coordinating Centre	R. Žebenkos 12, LT-82317 Baisogala, Radviliškis Distr., Lithuania	https://gic.lsmuni.lt/

Table 2.
Contact details of breeding organisation for Lietuvos vietinė pig breed.

5. Productive performance

5.1 Reproductive traits

The basic data obtained on reproductive traits in this review are presented in **Table 3**. Sows of Lietuvos vietinė pig breed have 7.2–9.7 piglets [1–3] of approximately 1.3 kg live body weight [1–4]. Stillborn percentage of piglets is in between 7.4 and 16.1% [1, 3], whereas piglet mortality rate until weaning in the considered studies varied between 14.6 and 31.1% [2, 3]. Duration of lactation is prolonged in comparison to modern intensive systems (to approximately 59 days [1, 3, 4]), which leads to a higher piglet weaning weight (around 14 kg [1, 3, 4]).

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation

Reference	Piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)
[1]	9.7	1.31	7.35	—	14.68	56
[2]	8.8	1.21	—	31.1	—	—
[3]	7.42	1.5	16.1	14.6	13.9	60
[4]	—	1.24	—	—	13.77	60

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on traits of reproduction in the Lietuvos vietinė pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]			ADG birth–slaughter
					Early	Middle	Overall	
[4]	—	—	—	—	—	—	698	511
[5]	—	—	—	—	—	—	—	472
	—	—	—	—	—	—	—	504
[6]	—	25	—	—	—	—	—	403
[7]	Ad Lib	14	224	452	690	646	667	483
	Rest	14	238	381	653	530	567	435

No. = number, ADG = average daily gain in g, Ad Lib = ad libitum feeding regime, Rest = restrictive feeding regime.
[1]ADG in a period of lactation regardless of how long it was.
[2]ADG in a growing period estimated from weaning to approximately 30 kg live body weight.
[3]ADG in a period of fattening is reported for early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in the Lietuvos vietinė pig breed.

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]		
					Early	Middle	Overall
[4]	—	—	—	—	—	—	2.53
[7]	Ad Lib	12.4	16	14	2.04	2.8	2.51
	Rest	12.4	16	14	2.02	2.14	2.1

No. = number, ADFI = average daily feed intake in kg/day, Ad Lib = ad libitum feeding regime, Rest = restrictive feeding regime, ME = metabolisable energy, CP = crude protein.
[1]ADFI in a period of fattening is reported for early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 5.
Summary of collected literature data on the average daily feed intake (in kg/day) in the Lietuvos vietinė pig breed.

(regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight), early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth–slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. In the considered studies, daily gain in lactation period was approximately 230 g/day [7]. The average daily gain was 417 g/day in growing stage; 672, 588 and 644 g/day in early, middle and overall fattening stage [4, 7]; and around 470 g/day from birth to slaughter [4–7], which indicates slower growth rate and lesser intensity of rearing in the Lietuvos vietinė pig breed. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Lietuvos vietinė pigs in ad libitum conditions of feeding (≈698 g/day in overall fattening stage [4]).

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. Average daily feed intake increased from 2.0 kg/day in early to 2.5 kg/day in middle fattening stage [7], whereas in the overall fattening stage, the average daily feed intake was 2.4 kg/day [4, 7].

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of the Lietuvos vietinė breed were slaughtered at approximately 200 days of age [4–6] and between 57 and 108 kg live weight [4–9]. Dressing yield was around 74% [6–9] and lean meat content varied from 42 to 52% [5, 8, 9]. The backfat thickness measured on the withers was approximately 49 mm [6, 9], at the level of the last rib 29 mm [4–7, 9] and above gluteus medius muscle 28 mm [6]. Muscularity measured as loin eye area averaged 29 cm^2 [4, 6, 7], and longissimus muscle thickness measured on live animals was approximately 38 mm [5].

5.4 Meat quality

The basic data obtained in this review with some of the most commonly encountered meat quality traits measured in the longissimus muscle that could be found are presented in **Table 7**. In the studies reporting meat quality of Lietuvos vietinė pigs, pH measured in *the* longissimus muscle at 45 min and 24 h post-mortem were 6.3 [7] and 5.4 [7, 9], respectively. The intramuscular fat content varied from 1.7 to 3.5% [7, 9], and colour measured in CIE L*, a* and b* colour space

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
							S[2]	At withers	At last rib		
[4]	—	194	100	—	—	—	—	—	27	—	31
[5]	—	199	93	—	—	49.5	—	—	21	40	—
	—	190	95	—	—	44.0	—	—	26	37	—
[6]	22	220	91	62	68.2	—	28	45	27	—	26
[7]	4	—	108	83	76.6	—	—	—	37	—	29
	4	—	99	75	75.9	—	—	—	34	—	29
[8]	8	—	57	41	72.3	51.7	—	—	—	—	—
	8	—	69	51	73.0	46.2	—	—	—	—	—
	8	—	76	56	73.8	47.3	—	—	—	—	—
	8	—	101	78	77.3	42.2	—	—	—	—	—
[9]	8	—	101	78	77.3	50.7	—	53	34	—	—

No. = number, BW = body weight, CW = carcass weight.
[1]M muscle thickness measured by ultrasonic equipment Piglog 105 (7 cm from the midline by ultrasonic equipment Piglog 105 (7 cm from the midline between 10 and 11 ribs (mm) on live pigs).
[2]S backfat thickness measured at the thinnest lumbar point according to ZP method (mm).

Table 6.
Summary of collected literature data on body composition and carcass traits in the Lietuvos vietinė pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)
				L*	a*	b*	
[7]	—	6.30	5.44	54	14.9	7.3	1.7
	—	6.33	5.50	56	14.6	7.8	2.5
[9]	8	—	5.12	—	—	—	3.5
[10]	13	—	—	—	—	—	—

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem, pH 24 = pH measured approximately 24 hours post-mortem, IMF = intramuscular fat.
[1]CIE = objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour, a* greater value indicates a redder colour and b* greater value indicates a more yellow colour.*

Table 7.
Summary of collected literature data on meat quality in the Lietuvos vietinė pig breed.

was approximately 55, 15 and 7.6 for L*, a* and b*, respectively [7]. The longissimus muscle from Lietuvos vietinė pigs has lower contents of cholesterol (39.6 mg/100 g [7]) than those of lean conventional hybrids (44.24 mg/100 g).

6. Use of breed and main products

Due to the high fatness of Lietuvos vietinė pigs, implemented SEUROP grading system for carcass evaluation in abattoirs and import of cheap surplus meaty cuts of carcasses, Lietuvos vietinė pigs are not competitive on the market. Thus, their number is not increasing. Most of Lietuvos vietinė pigs are slaughtered and processed in the conventional pig production chain. Due to veterinarian restrictions related to the African swine fever, people refuse to keep growing pigs up to bacon condition for self-supply, although this was a common practice in the past among the people of the countryside. Most of the Lietuvos vietinė pigs from nucleus herd are used in the common pig production chain, whereas only the small part of pigs is being used for the production of home-made products. The traditional Lithuanian pork products produced are smoked backfat, including salt-cured backfat in the southeastern part of Lithuania, smoked hams and bellies, loins and different fresh and smoked dry sausages. The amount of unused carcass parts from Lietuvos vietinė pigs is small because Lithuanian cuisine knows different dishes not only from lean and fat pork but also from the offal, like meat jelly, blood pudding, liver pate and others.

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Chapter 12

Lietuvos Baltosios Senojo Tipo (Lithuanian White) Pig

Violeta Razmaitė, Rūta Šveistienė, Virginija Jatkauskienė, Raimondas Leikus, Remigijus Juška and Nina Batorek-Lukač

Abstract

Lietuvos Baltosios senojo tipo pigs are remaining purebred pigs of local Lithuanian pig breed (Lietuvos Baltosios) adapted to the specific local environment and locally available feedstuffs. Although previously Lietuvos Baltosios was the main dam pig breed in Lithuania, regarding scientific substantiation, their performances and products are, as in the case of Lietuvos Baltosios remains (senojo tipo-old type) pigs, practically untapped. Thus, the present chapter aims to present history and current status of Lietuvos Baltosios senojo tipo pig breed, its exterior phenotypic characteristics, geographical location, production system and main products from this Lithuanian breed of pigs, one of the local pig breeds investigated in the project TREASURE. Moreover, a collection and review of available literature data, available until August 2017, on reproductive and productive traits of Lietuvos Baltosios senojo tipo pig breed were carried out. Reproductive and growth performance, and feed intake in different stages was estimated. Lean meat content was measured by ultrasonic equipment Piglog on the side of live pigs at the position of 12 ribs. Measurements of backfat thickness were taken with a ruler on the left side of carcasses at dorsal line of the mid-back at the last rib and loin area at the 1/2 lumbar vertebra by digital camera EX-Z110 and, afterwards, were planimetrically measured by means of the "SCAN-STAR K" planimetrical system. Meat quality traits of the longissimus muscle were evaluated using pH at 45 min and 24 h after slaughter, objective colour (CIE L*, a*, b*) and intramuscular fat content.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Lithuania

1. History and the current status of the breed (census)

The Lithuanian White old genotype (Lietuvos Baltosios senojo tipo) is a domestic pig native to Lithuania. This breed was developed by the process of improving old Lietuvos vietinės pigs with Large White, Middle White, Edelsweine, Berkshire and local Danish pigs. Until the twenty-first century, Lietuvos Baltosios pig breed was one of the main pig breeds used as dam breed in commercial crossing combinations. Since 2003, all purebred boars in breeding farms were castrated, and this caused a fast decline in pig numbers of original Lietuvos Baltosios breed and conservation of the old genotype of the Lithuanian White pig breed. Census of Lietuvos Baltosios senojo tipo pig breed is presented in **Figure 1**. Presently,

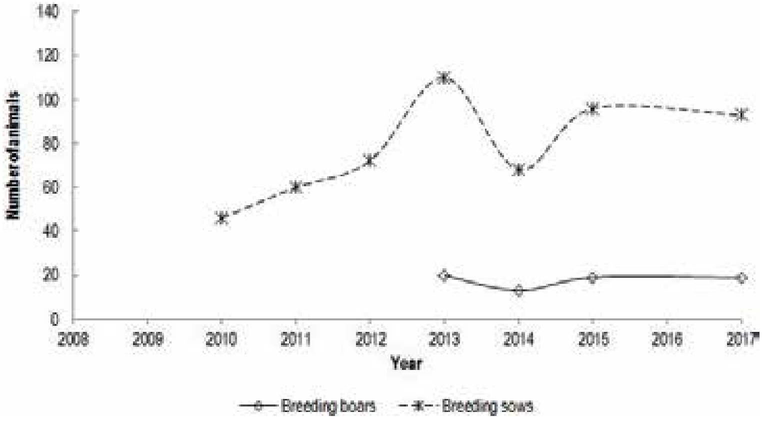

Figure 1.
Census of Lietuvos Baltosios senojo tipo pig breed, presenting number of sows and boars per year, starting with the year of heard-book establishment.

there are three registered farms of Lietuvos Baltosios senojo tipo pigs with about 93 breeding sows and 19 boars in the latest available status (December 2017).

2. Exterior phenotypic characteristics

The Lietuvos Baltosios senojo tipo pig breed morphology information is summarised in **Table 1**. It is a middle-sized, unicoloured white breed of pigs (**Figures 2** and **3**). The breed is well adapted to the local conditions. The animals are known for their strong constitution but low stress susceptibility.

3. Geographical location and production system

Lietuvos Baltosios pigs are conserved at the Centre for Farm Animal Genetic Resources, Coordination of Animal Science Institute, Lithuanian University of Health Sciences, where the nucleus herd with full genealogical structure is maintained. Most of the Lietuvos Baltosios pigs are concentrated in this nucleus

Measurement (average)	Adult male	Adult female
Body weight (kg)	299	212
Body length[1] (cm)	170.4	159.7
Head length (cm)	32.4	30.6
Tail length (cm)	44.1	39.2
Ear length	20.9	21.3
Chest girth (cm)	158.8	136.7
Height at withers (cm)	92.1	80.0
Number of teats	14	14

[1]*Measured from the back of the head to the starting point of the tail.*

Table 1.
Summary of morphology information on Lietuvos Baltosios senojo tipo pig breed.

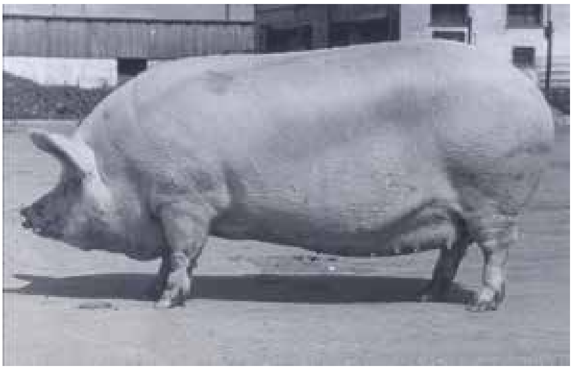

Figure 2.
Lietuvos Baltosios senojo tipo sow.

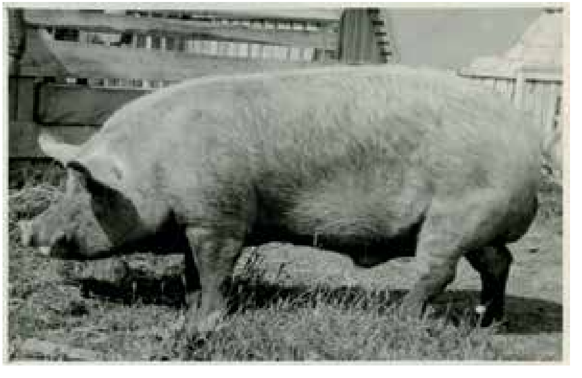

Figure 3.
Lietuvos Baltosios senojo tipo boar.

herd, which is located in Baisogala, Radviliškis district, in the central part of Lithuania (in the latitude of 55° 64′N and the longitude of 23° 70′E). Other recorded representatives of Lietuvos Baltosios pigs and their crosses with other breeds are in two farms located in Algimantai, Raseiniai district (in the latitude of 55° 26′N and in the longitude of 23° 50′E), and in Ažuolų Būda, Kazlų Rūda district (in the latitude of 54° 42′N and in the longitude of 23° 31′E). Previously in Lithuania, outdoor keeping or free access of outdoor enclosures during warm season for breeding pigs was recommended. The experiments showed that at average 13.7°C air temperature daily gain of outdoor pigs was 143 g higher and their daily feed intake (kg/day) was 3.5% lower than analogous indoor pigs [8]. However, nowadays due to the African swine fever in wild boars and high veterinary standards for biosecurity, all domestic pigs in Lithuania should be kept strictly indoors. Consequently, only conventional indoor pig rearing is possible, although Lietuvos Baltosios pigs are adapted to local conditions and suitable for ecological production.

4. Organisations for breeding, monitoring and conservation

The activities for conservation of Lietuvos Baltosios senojo tipo pig breed were launched in 1999 when a minimal herd of Lietuvos Baltosios pigs was formed at the

Institute of Animal Science, and thus their complete extinction has been prevented. Due to a small number of owners of Lithuanian pig breeds, it is not possible to establish a separate association. Lithuanian Pig Producers Association is responsible for organisation of pig breeding. Also, there is a joint company AB Kiaulių veislininkystė which is responsible for control of pig productivity, control of fattening and slaughter, carcass evaluation and data recording. Researches of Animal Science Institute of Lithuanian University of Health Sciences prepared the "National programme for the conservation of native farm animal genetic resources". The last version of consevation programme was adopted by the Ministry of Agriculture of Lithuania in 2008. The main purpose of this programme is collection, monitoring, investigation and conservation of Lithuanian national breeds in situ and ex situ. To achieve these goals, the National Farm Animal Genetic Resources Coordinating Centre was established at the Institute of Animal Science at the end of 2008. Lithuanian Endangered Farm Animal Breeders Association (LEFABA) was established at 2010 (**Table 2**).

Name of organisation	Address	Web address
Lithuanian Pig Producers Association	Verkių 5, LT-08218 Vilnius, Lithuania	http://www.kiaules.lt
Lithuanian Endangered Farm Animal Breeders Association	R. Žebenkos 12, LT-82317 Baisogala, Radviliškis distr., Lithuania	https://luga.lt/
National Farm Animal Genetic Resources Coordinating Centre	R. Žebenkos 12, LT-82317 Baisogala, Radviliškis distr., Lithuania	https://gic.lsmuni.lt/

Table 2.
Contact details of breeding organisation for Lietuvos Baltosios senojo tipo pig breed.

5. Productive performance

5.1 Reproductive traits

The basic data obtained on reproductive traits in this review are presented in **Table 3**. The age of sows of Lietuvos Baltosios senojo tipo pig breed at the first parturition is 14 [3]. They have 9.6–10.4 piglets per litter [1, 3, 4] of approximately 1.3 kg live body weight [2, 3, 5]. Stillborn percentage of piglets is in between 7 and 8% [1, 4], whereas piglet mortality rate until weaning in the considered studies was 10.8 and 19.7% [3, 4]. Duration of lactation is prolonged in comparison to modern intensive systems (to 58 days on average [2, 4]), which also leads to a higher piglet weaning weight (app. 12 kg [2, 4]).

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth-slaughter, which is often calculated from the data given on live weight and age of pigs). It

Reference	Sow age at first parturition (mth)	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)
[1]	–	10.4	–	8.1	–	–	–
[2]	–	–	1.3	–	–	12.0	60
[3]	14.0	9.6	1.3	–	19.7	–	–
[4]	–	10.2	–	7.1	10.8	11.9	56
[5]	–	–	1.3	–	–	–	–

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on reproduction traits in Lietuvos Baltosios senojo tipo pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG fattening[2]			ADG birth-slaughter
				Early	Middle	Overall	
[5]	–	–	–	–	–	683	–
[6]	–	–	–	–	–	–	500
	–	–	–	–	–	–	525
[7]	Ad Lib	28	275	846	746	777	541
	Rest	28	275	864	632	709	508

No. = number, ADG = average daily gain in g, Ad Lib = ad libitum feeding regime, Rest = restrictive feeding regime.

[1]*ADG in a period of lactation regardless of how long it was.*
[2]*ADG in a period of fattening is reported for early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on growth performance in Lietuvos Baltosios senojo tipo pig breed.

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]		
					Early	Middle	Overall
[7]	Ad Lib	12	16	28	2.22	2.94	2.65
	Rest	12	16	28	2.2	2.45	2.35

No. = number, ADFI = average daily feed intake in kg/day, ME = metabolisable energy, CP = crude protein, Ad Lib = ad libitum feeding regime, Rest = restrictive feeding regime.
[1]*ADFI in a period of fattening is reported for early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg body weight, respectively. Sometimes, the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).*

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Lietuvos Baltosios senojo tipo pig breed.

should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. In the considered studies, daily gain in lactation was 275 g/day [7], whereas average daily gain in early, middle and overall fattening stages was around 855, 689 and 723 g/day [5, 7] and 513 g/day from birth to slaughter [6, 7]. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Lietuvos Baltosios senojo tipo pigs in ad libitum conditions of feeding (≈777 g/day in overall fattening stage [7]).

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. Average daily feed intake increased from 2.2 kg/day in early fattening stage to 2.7 kg/day in the middle fattening stage [7].

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of Lietuvos Baltosios senojo tipo breed were slaughtered at approximately 186 days of age [6], an average 100 kg live weight [6, 7]. Dressing yield was around 76% [7] and lean meat content approximately 50% [6]. The backfat thickness measured at the level of the last rib ranged from 17 to 31 mm [6, 7]. Muscularity measured as loin eye area averaged 28 cm^2 [6], and muscle thickness measured at the cranial edge of the gluteus medius muscle was 39 mm [7].

5.4 Meat quality

The basic data obtained in this review with some of the most commonly encountered meat quality traits measured in the longissimus muscle that could be found are presented in **Table 7**. In the only available study reporting meat quality of Lietuvos Baltosios senojo tipo pigs [7], pH measured in the longissimus muscle at 45 min and 24 h post-mortem were in average 6.20 and 5.45, respectively. The

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness[1] (mm)	M[2] (mm)	Loin eye area (cm^2)
[5]	–	–	–	90	–	–	–	–	–
[6]	–	188	93	–	–	52.8	17	40	–
	–	184	96	–	–	46.9	23	38	–
[7]	19	–	106	80	75.4	–	31	–	23
	19	–	103	78	76.0	–	27	–	32

No. = number, BW = body weight, CW = carcass weight.

[1]Backfat thickness measured at the thinnest lumbar point according to ZP method (mm).
[2]M muscle thickness measured by ultrasonic equipment Piglog 105 (7 cm from the midline by ultrasonic equipment Piglog 105 (7 cm from the midline between 10 and 11 ribs (mm) on live pigs)).

Table 6.
Summary of collected literature data on body composition and carcass traits in Lietuvos Baltosios senojo tipo pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)
				L*	a*	b*	
[7]	12	6.15	5.41	55	15.5	7.4	2.2
	12	6.25	5.48	53	15.6	6.8	2.0

No. = number, pH 45 = pH measured approximately 45 min post-mortem, pH 24 = pH measured approximately 24 h post-mortem, IMF = intramuscular fat.
[1]CIE, objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

Table 7.
Summary of collected literature data on meat quality in Lietuvos Baltosios senojo tipo pig breed.

intramuscular fat content was around 2.1%, and colour measured in CIE L*, a* and b* colour space was 54, 15 and 7.1 for L*, a* and b*, respectively. Additionally, the longissimus muscle from Lietuvos Baltosios pigs has been shown to have lower contents of cholesterol (36.4 mg/100 g [7]) than lean conventional hybrids (44.24 mg/100 g).

6. Use of breed and main products

In the past Lietuvos Baltosios pigs were used as a main dam breed in commercial crossing combinations; however, currently the use of pigs from such a small population is limited. Their share of the total slaughtered pigs is lower than 0.2%. Most of the Lietuvos Baltosios pigs are used in the common pig production chain. Due to veterinarian restrictions related to the African swine fever, people refuse to keep growing pigs up to bacon condition for self-supply, although this was a common practice in the past among the people of the countryside. As a bacon-type breed, Lietuvos Baltosios are more popular pigs than fatty Lietuvos vietinės pigs. In addition to the pigs used in common pork chain, a part of pigs are used for production of home-made products. The traditional Lithuanian pork products produced are smoked backfat, smoked hams and bellies, loins and different fresh and smoked dry sausages. There is a small amount of unused carcass parts in pig production, because Lithuanian cuisine knows different dishes not only from lean and fat pork but also from the offal, like meat jelly, blood pudding, liver pate and others.

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Chapter 13

Mangalitsa (Swallow-Belly Mangalitsa) Pig

Čedomir Radović, Radomir Savić, Milica Petrović, Marija Gogić, Miloš Lukić, Dragan Radojković and Nina Batorek-Lukač

Abstract

Autochthonous pig breed is adapted to the specific local environment, fed with various locally available feedstuffs and well adapted to extensive conditions of housing. Their genes represent safety in the production of food in future times, in which the greater importance will be attributed to the resistance and adaptability of the breed. In terms of scientific substantiation, their performances and products are, as in the case of Mangalitsa pig, practically untapped. Thus, the aim of the present chapter is to present history and current status of Mangalitsa pig breed, its exterior phenotypic characteristics, geographical distribution, production management and main products from this Serbian autochthonous breed of pigs, one of the local pig breeds investigated in the project TREASURE. Moreover, a collection and review of available literature data, available until August 2017, on reproductive and productive traits of Mangalitsa pig breed were carried out. Mangalitsa is a late and extremely fatty pig breed with low fertility, long suckling period and a very weak-slow growth. Although studies on Mangalitsa pig are scarce, the current review gives the first insight into this local pig breed.

Keywords: autochthonous breeds, traditional European breed, TREASURE, productive traits, phenotype, Serbia

1. History and current status of the breed (census)

Mangalitsa is an autochthonous fatty type pig breed, created from the old Serbian Šumadinka breed. During the nineteenth century, pigs were the main export product of Serbia, especially in the northern part of the country (today's Autonomous Province of Vojvodina) and in the region of Šumadija (central part of Serbia). In Šumadija, pigs were mostly fattened in the forests where they were searching for oak and beech acorn and other forest feed resources. The majority of animals were exported to the former Austro-Hungarian monarchy. In that time, the pig farming was based on local indigenous breeds with the dominant breeds Šiška and Šumadinka. Šiška and Šumadinka were the most primitive breed of pigs, created by domestication of wild pigs *Sus scrofa ferus* [1]. Šiška once had high importance, in the relatively recent past (eighteenth century), not only in Serbia but also in Croatia, Slovenia, Hungary, Romania and Bulgaria. In the nineteenth century, a new breed Šumadinka was created by domestication of wild pigs (*Sus scrofa ferus*) and reared in slightly

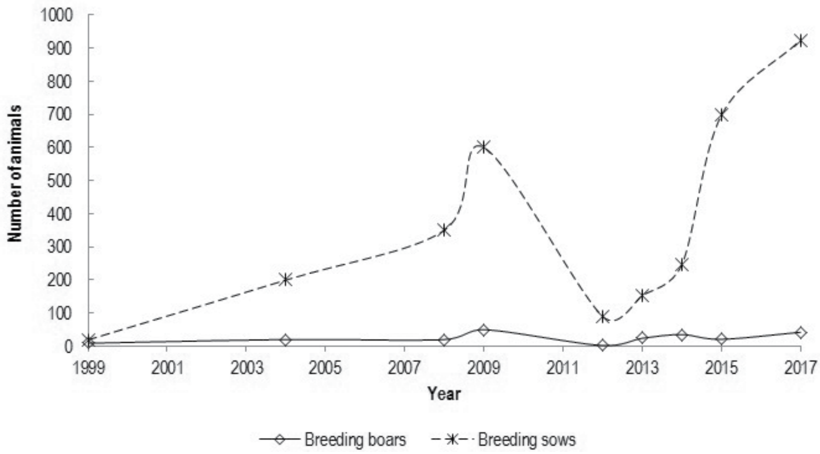

Figure 1.
Chronological population dynamics of Mangalitsa pig breed, presenting the number of sows and boars per year, starting with the year of herd book establishment.

better conditions. Both of these breeds are lost in their original form. However, Šumadinka can be considered as an important ancestor of Mangalitsa. In the Republic of Serbia, there are three Mangalitsa breed types: **swallow-belly strain** (Srem black Mangalitsa or Buđanovci pig developed in the area of Srem near Ruma, a village of Buđanovci [2]), **white strain** (blonde or Hungarian strain, created when in 1833 Prince Miloš Obrenović gave two boars and 10 sows of Šumadinka breed to the Hungarian nobleman Palatine Joseph on the farm Kisjeno where better rearing conditions, accommodation and food source were provided, which lead to the creation of more productive pig breed of white Mangalitsa) and **red strain** (mainly represented on the territory of Hungary and Romania and, in our country, present only in traces).

Apart from Serbia, the Mangalitsa is present in Austria, the Czech Republic, Germany, Romania, Hungary, Slovakia and Switzerland. Chronological population dynamics of Mangalitsa pig breed is presented in **Figure 1**. In 2016, only on the territory of Central Serbia, 321 sows and 32 boars were registered (in the records of the Main Breeding Organization). At the end of 2017, on the territory of R. Serbia, there were about 67 registered farms with 925 sows, 605 gilts and 42 boars registered in the records of the Main Breeding Organization, of which more than 95% are **swallow-belly strain**.

2. Exterior characteristics

The main morphological characteristics of the Mangalitsa breed are summarized in **Table 1**. It is a medium-size breed, known for its thick, wooly coat similar to that of a sheep. The three Mangalica breed types are blonde, swallow-belly and red Mangalitsa. **Swallow-belly strain** (**Figures 2** and **3**), which is one of the most numerous in Serbia, is late maturing type, resistant and well adapted to extensive rearing and housing conditions. It requires only a simple shelter from rain and snow. The head is relatively small, with large ears that hang in front over the eyes and face. The earlobe is set high and elastic to the touch. The ear length is 2/3 of the length of the head. The chest and short torso/body are broad and deep and extend to just below the elbow. The back and loin are straight or slightly curved from the side view. The back part of the body and thighs are well developed, wide and muscular. The abdomen is long and cylindrical with the mammary complex consisting of four to six pairs of teats [1]. Limbs are long, wide and muscular. The skin is pigmented, dark or brown in colour, with dense, bright and curly bristles that are shorter in swallow-belly strain. The colour of bristles can be from grey-yellow to reddish (ginger). The eyelids, eyebrows, muzzle, nipples of the mammary complexes, hooves, tail tip and natural openings on the body are always black. Brinzej [3] states that there are two varieties of this type, of which one from the western breeding region is called "Buđanovac" variety named after the village Buđanovci. This variety has a greater part of the body pigmented (entire head, body and the sides of the body and the legs from the outer-lateral side to the claws). The second variety—"Otok" and "Lasa" named after the village of Otok in the western part of the Srem region—with the legs pigmented only to the hock joint and the lower part of the papilla is white. The Otok variety has regularly strongly developed bristles, which the "Buđanovac" variety lacks or is less developed. At birth, piglets have characteristic stripes, which disappear in 10 days in white strain piglets and in 3–4 months in swallow-belly strain.

Measurement (average)	Adult male	Adult female
Body weight (kg)	78	73
Body length[1] (cm)*	95	92
Head length (cm)	32	33
Chest girth (cm)	140	150
Height at withers (cm)	78	78
Number of teats	—	8–12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of the main morphological characteristics of the Mangalitsa breed.

Figure 2.
Mangalitsa sow with piglets.

Figure 3.
Mangalitsa boar.

3. Geographical location and production system

Mangalitsa pigs are reared in the wider area of the Republic of Serbia, mostly along major waterways. Farms are located in the municipalities of Subotica, Sremska Mitrovica, Bačka Palanka, Vršac, Pančevo, Ub, Obrenovac, Ljig, Valjevo, Novi Sad, Kuzmin, Šid, Surčin and Kovilj (Krčedinska ada). Some Mangalica pigs can also be found on Stara Planina mountain (Municipality of Dimitrovgrad) and around Čačak and Kraljevo.

These pigs are usually reared in free-range conditions, outdoor, extensive or in semi-intensive production systems. Rearing of pigs implies a free holding in limited areas in pastures, woods or orchards. In extensive system, pigs are kept around the household, which depends on the number of animals and size of the owner's property, and in the winter period, animals are housed in cheap, wooden pig stables. Feeding them is primarily based on pasture and forest products (oaks, wild fruits). Additional daily meal represents an extremely small amount of grains per head, primarily corn. In extensive system sows very frequently farrow in the forest, which significantly complicates the control of productivity and recording. In semi-intensive conditions, sows are farrowed in objects, which allows for better control. In the growing and fattening phase, pigs are mostly outdoor.

4. Organizations for breeding, monitoring and conservation

Organization for breeding is regulated by the Law on Livestock [4]. The Institute of Animal Husbandry and University of Novi Sad, Faculty of Agriculture, are the authorized main breeding organization for selection and animal recording of breeding livestock in Serbia.

Information on population status in the last 20 years is collected by the organizations shown in **Table 2**. The law of incentives in agriculture and rural development defines the maximum amounts of incentives per head for breeding gilts, boars and sows of Mangalitsa, Moravka and Resavka [5]. Protection includes in situ *and* ex situ preservation. The number of breeders of indigenous breeds of pigs is increasing in the last year. Ex situ preservation is regulated by the rule book on incentives for the conservation of animal genetic resources in the gene bank [6].

Name of organization	Address	Web address
Institute for Animal Husbandry	Autoput 16, 11080 Zemun-Belgrade	http://istocar.bg.ac.rs/en/
University of Novi Sad, Faculty of Agriculture	Trg Dositeja Obradovića 8, 21,000 Novi Sad	https://www.uns.ac.rs/index.php/en/faculties/ffaculties/faculty-agriculture
Ministry of Agriculture, Forestry and Water Management	Nemanjina 22–26, 11000 Belgrade	http://www.minpolj.gov.rs/?lang=lat

Table 2.
Contact details of breeding organization for Mangalitsa pig breed.

5. Productive performance

5.1 Reproductive traits

The basic data obtained on reproductive traits in this review are presented in **Table 3**. The age of Mangalitsa pig breed sows at the first parturition is approximately 17.3 months [8, 12, 17, 18]. They have 1.2–2.0 litters per year [8, 10–13, 17] with around five piglets [7, 8, 12, 16, 18] of 1.1–1.6 kg live body weight [9, 12, 14, 16, 17]. Stillborn percentage of piglets ranges from only 2.2 to 7.5% [7, 8, 16], whereas piglet mortality rate until weaning in the considered studies varies from 2.0 to 11.1% [7, 8, 10, 12, 16]. Duration of lactation is prolonged in comparison to modern intensive systems to 50 days on average (ranging from 37 to 60 days [7–9, 11, 14–16, 18]), which leads to a longer farrowing interval (around 216 days on average [8, 10–13]) and higher weaning weight (from 8.1 to 15.1 kg [9, 13–16]).

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth–slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies actually aimed at evaluating the breed potential for growth. In the considered studies, the daily gain in the early growing stage that corresponds to lactation period was approximately 136 g/day [9, 12, 14–16]. The average daily gain in growing stage was 310 g/day [16]; 430, 519 and 405 g/day in early, middle and late fattening stage [12]; 434 g/day in overall fattening stage [12, 15, 16, 18, 20–22]; and 307 g/day [15, 16, 21] from birth to slaughter. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Mangalitsa pigs in ad libitum conditions of feeding (≈830 g/day in overall fattening stage [20]).

Reference	Sow age at the first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Still born per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[7]	—	—	4.9	—	7.5	2.0	—	50.0	—
[8]	17.0	1.2	4.7	—	4.6	5.3	—	47.1	302
[9]	—	—	—	1.1	—	—	8.1	56.0	—
[10]	—	1.8	—	—	—	11.1	—	—	202
[11]	—	1.8	—	—	—	—	—	52.6	206
[12]	16.7	1.8	4.6	1.1	—	11.1	—	—	206
[13]	—	1.7	—	—	—	—	10.0	—	215
	—	1.8	—	—	—	—	10.2	—	203
	—	1.7	—	—	—	—	15.1	—	215
	—	2.0	—	—	—	—	—	—	183
[14]	—	—	—	1.2	—	—	9.7	60.0	—
[15]	—	—	—	—	—	—	7.5	50.0	—
[16]	—	—	6.8	1.6	2.2	10.9	7.1	37.0	—
[17]	16.9	1.2	—	1.3	—	—	—	—	—
[18]	18.5	—	4.6	—	—	—	—	50.0	—

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on reproduction traits in Mangalitsa pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]				ADG birth to slaughter
					Early	Middle	Late	Overall	
[9]	—	31	119	—	—	—	—	—	—
	—	31	125	—	—	—	—	—	—
[12]	—	35	—	—	430	—	—	430	—
	Ad lib	35	—	—	—	519	405	468	—
[14]	—	148	140	—	—	—	—	—	—
[15]	Rest	15	130	—	—	—	—	257	242
[16]	Rest	53	120	266	—	—	—	333	297
	Ad lib	71	180	353	—	—	—	422	375
[18]	Ad lib	12	—	—	—	—	—	480	—
[19]	—	—	—	—	—	—	—	—	—
[20]	—	32	—	—	—	—	—	830	—
[21]	—	16	—	—	—	—	—	414	315
[22]	Rest	12	—	—	—	—	—	268	—

No. = number, ADG = average daily gain in g, Ad lib = ad libitum feeding regime, Rest = restrictive feeding regime.
[1]ADG in a period of lactation regardless of how long it was.
[2]ADG in a growing period estimated from weaning to approximately 30 kg live body weight.
[3]ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in Mangalitsa pig breed.

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]			
					Early	Middle	Late	Overall
[12]	—	12	15	35	1.95	—	—	—
	Ad lib	13	13	35	—	2.85	3.19	2.54

No. = number, ADFI = average daily feed intake in kg/day, Ad lib = ad libitum feeding regime, ME = metabolisable energy, CP = crude protein.
[1]ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Mangalitsa pig breed.

In the considered studies, the information on feed intake and feed nutritional value were given only in one study [12], which limits the evaluation of growth potential. The average daily feed intake increased from 2.0 kg/day in the early fattening stage to 3.2 kg/day in the late fattening stage.

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In the considered studies, pigs of the Mangalitsa breed were slaughtered at approximately

114 kg live weight [12, 15, 20–28]. Dressing yield ranged from 73 to 80% [12, 24–28] and lean meat content 28 to 37% (SEUROP classification or dissection [19, 22–25]). The backfat thickness values measured at the level of the last rib span from 42 to 81 mm [12, 20–25], at the position of withers from 59 to 102 mm [12, 20–24] and at the level of *gluteus medius* muscle from 48 to 79 mm (n = 8). Muscularity measured as loin eye area was 24 cm^2 [22, 23] and as muscle thickness measured from the vertebral canal to the cranial edge of *gluteus medius* muscle around 60 mm [12, 22].

5.4 Meat quality

The basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *longissimus* muscle that could be found are presented in **Table 7**. In the studies reporting meat quality of Mangalitsa pigs, pH measured in *longissimus* muscle at 45 minutes and 24 hours *post-mortem* was around 6.1 [12, 22, 25–27, 29] and 5.6 [12, 15, 22, 26, 27, 29, 30], respectively. The intramuscular fat content is very high in reported studies and ranges from 2.9 to 18.2% [15, 19, 21, 24–31]. The colour measured in CIE L, a, b colour space was approximately 45, 11.4 and 4.2 for L, a* and b* [12, 15, 22, 30], indicating relatively dark colour of Mangalitsa. In the considered studies, SFA, MUFA and PUFA contents of intramuscular fat in the *longissimus* muscle were in around 35, 56 and 7%, respectively, with high n6 to n3 ratio (9.2–37.3 [21, 22, 26, 27, 32]).

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
							S[2]	At withers	At last rib		
[12]	35	—	116	—	78.3	—	55	72	54	58	—
[15]	15	604	147	—	—	—	53	—	—	—	—
[19]	—	—	—	80	—	28.8	—	—	—	—	—
[20]	32	—	158	—	—	—	79	102	81	—	—
[22]	12	—	133	—	—	33.0	48	68	51	62	24
[23]	13	—	125	—	—	32.3	60	72	52	—	24
[24]	10	—	101	74	73.0	27.8	52	62	44	—	—
[25]	13	—	104	82	79.3	34.5	—	64	44	—	—
	10	—	104	82	79.3	37.1	—	59	42	—	—
[26]	12	—	102	80	77.4	—	55	—	—	—	—
	10	—	98	77	73.9	—	52	—	—	—	—
[27]	24	—	101	77	77.7	—	—	—	—	—	—
[28]	16	—	76	61	80.1	—	—	—	—	—	—

No. = number, BW = body weight; CW = carcass weight.
[1]M muscle thickness measured according to ZP method (at the cranial edge of gluteus medius muscle (mm)).
[2]S backfat thickness measured according to ZP method (above gluteus medius muscle (mm)).

Table 6.
Summary of collected literature data on body composition and carcass traits in Mangalitsa pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)	Fatty acid composition[2] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n-6/n-3
[12]	35	5.95	5.77	56	10.3	5.1	—	—	—	—	—
[15]	15	—	5.46	46	12.8	5.2	8.4	—	—	—	—
[19]	—	—	—	—	—	—	8.1	—	—	—	—
[21]	16	—	—	—	—	—	5.1	39.5	56.4	4.1	—
[22]	12	6.11	5.50	40	11.8	3.7	—	33.3	50.3	11.6	17.9
[24]	10	—	—	—	—	—	13.2	—	—	—	—
[25]	—	6.04	—	—	—	—	8.1	—	—	—	—
	—	6.32	—	—	—	—	5.5	—	—	—	—
[26]	12	6.12	5.80	—	—	—	18.2	33.9	57.2	5.9	37.3
	10	5.89	5.41	—	—	—	12.1	35.5	55.5	6.5	9.2
[27]	24	6.01	5.68	—	—	—	15.2	34.6	56.6	6.1	14.1
[28]	16	—	—	—	—	—	9.8	—	—	—	—
[29]	—	6.42	5.56	—	—	—	2.9	—	—	—	—
[30]	7	—	5.47	38	10.9	2.9	6.4	—	—	—	—
[31]	—	—	—	—	—	—	8.0	—	—	—	—
[32]	22	—	—	—	—	—	—	35.6	56.6	6.9	25.1

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem, *pH 24 = pH measured approximately 24 hours* post-mortem, *IMF = intramuscular fat, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids.*
[1]*CIE = objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*
[2]*For fatty acid composition, only pigs on control diet were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*

Table 7.
Summary of collected literature data on meat quality in Mangalitsa pig breed.

6. Use of breed and main products

Mangalitsa is a late maturing pig breed, selected for fat production. It has low fertility, long suckling period and a very weak-slow growth. But on the other hand, Mangalitsa is very resistant and well adapted to extensive conditions of housing, where the needs are only for a simple shelter from rain and snow. With such features, its cost-effectiveness is in low investment in housing facilities with large areas for pasturing and acorn nutrition, preferably if an organic breeding system is possible. Considering the low production performance (low daily gain and meatiness), crossbreeding with the Moravka, Resavka, Duroc, Hampshire or Berkshire breed could contribute to an improvement of growth and carcass traits, with the shorter fattening period and higher percentage of meat content in the carcass. The study of Radović et al. [22] showed not significantly better growth rate between Mangalitsa and Mangalitsa × Moravka crossbreeds (average daily gain, 267.9 vs. 336.9 g) and similarly not significant content of meat in carcass sides (33.2 vs. 33.9%). The animals not chosen for the nucleus herd could be crossed with Duroc, Hampshire or Berkshire which would contribute to more economical production of meat and the production of traditional high-value products (ham, sremski kulen and Sremska sausages) and their marketing as highly valuable organic products or products protected by a geographical indication. Dry-fermented sausages are meat products with a very long tradition of production, and today there are numerous national variants of these products. The most popular types of traditional fermented sausages in Serbia are kulen [37] and Sremska sausage. Kulen, a traditional fermented dry sausage, is a well-known and very popular meat product in the north of Serbia (Srem, Bačka) and Croatia (Slavonia, Baranja). For all variants of basically the same product, high-quality meat from mature pigs with a relatively low water content, intensive red colour and firm consistency is used as raw material. The meat used is primarily from the leg, shoulder and possibly some parts of the neck; a small amount of firm backfat tissue is also used (muscle and adipose tissue; 75:25 [33]). Smoking and maturation of sausages were carried out in the winter period (December to February).

Sremska sausage is a Serbian dry-fermented sausage traditionally produced in the north-western part of Serbia (Srem region), where it was produced in village households. It was made of grounded (about 8 mm) pig meat and backfat and mixed with salt and spices. The mixture was filled into pig's small intestines, smoked and dried for 14–21 days depending on ambient conditions [34]. Sremska sausage is of pronounced red colour, tender texture and slightly hot taste, with a fermented meat odour and a mild note of spices and smoke [35, 36]. The meat and adipose tissue as well as meat products of Mangalitsa are much appreciated by the Serbian consumers; the scientific efforts were not only limited to preserve the breed as such but also to better exploit its potential for human consumption.

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Chapter 14

Mora Romagnola Pig

Riccardo Bozzi, Maurizio Gallo, Claudia Geraci, Luca Fontanesi and Nina Batorek-Lukač

Abstract

Mora Romagnola breed, one of the Italian local pig breeds, owes its name to its colour, dark brown tending to black. Currently 31 farms are registered in the herdbook started in 2001 with about 270 breeding females and 67 boars. During the 1990s, only 18 animals were left, all concentrated in one single farm. The breed was investigated within the H2020 project TREASURE, and a collection and review of available literature data on reproductive and productive traits of Mora Romagnola pig breed were carried out. The average age of sows at first parturition was 22 months, whereas age at culling was 58 months. On average, Mora Romagnola pig breed has 8.0 piglets per parity with 1.4 parities per year. Slaughter weight was on average 163 kg with a dressing yield of 80%. Few information is available for meat quality traits. Although studies on Mora Romagnola pig are scarce, the current review gives the first insight into this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Italy

1. History and current status of the breed (census)

The Mora Romagnola is a breed of pig from Emilia-Romagna, in northern Italy [1]. The breeding of pigs in Romagna has very ancient origins, and trace of its presence dates back to the Lombard period. The Mora Romagnola was bred in the province of Forlì and Ravenna, and different types were distinguished according to the breeding areas and different shades of colour [2]. The name 'Mora' was codified in 1942 and is due to its colour, dark brown tending to black. The Romagna region belonged to different states in the past, and this is probably the reason of the different varieties of the breed, very distinct until the early twentieth century [2]. Usually the name of the varieties reflects the place of origin (forlivese, faentina, bolognese) or the characteristics of the mantle (brunette, blackberry, castagnina). In these last years, a morphotype with a blackish coat, with tints of the lighter abdomen and with the characteristic 'Sparta line', became diffused, and it was probably derived from repeated crossing of Mora and Chianina and Cappuccia (two other local pig breeds now extinct) [2]. The Mora Romagnola is one of the Italian pig breeds interested by the crossing with the Large White forming the so-called 'Fumato' very popular for the heavy weights reached. During the 1990s, the breed was very close to extinction, and only the activation of the registry, in 2001, allowed to set up the technical basis for initiatives to enhance the breed through a gradual and progressive recovery. Presently, there are 31 registered farms of Mora Romagnola pigs with about 270 breeding sows and 67 boars in the latest available status (August 2015; [3]). Census of Mora Romagnola pig breed is presented in **Figure 1**.

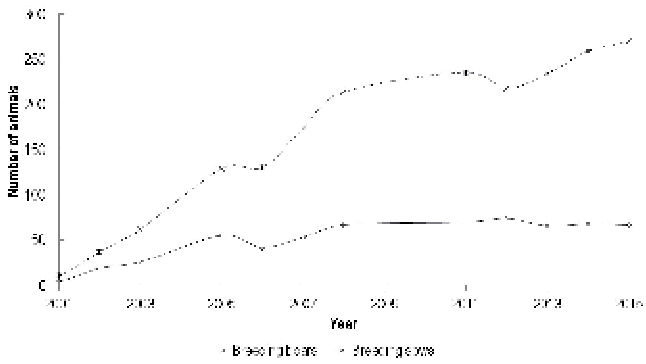

Figure 1.
Census of Mora Romagnola pig breed, presenting number of sows and boars per year, starting with the year of herdbook establishment.

2. Exterior phenotypic characteristics

The Mora Romagnola pig breed morphology information is summarised in **Table 1**. It is a medium-sized breed with a dark-coloured coat (**Figures 2** and **3**). The breed type is robust and rustic, with thin but solid skeleton. The skin is pigmented (black or dark grey) on the back and in the external areas of the limbs and rosy in the abdomen and in the inner sides of the forearm and thighs. Bristles are particularly robust in correspondence with the 'Sparta line' on the back (this is a peculiar characteristic of the breed). The breed presents head of medium development, concave profile, long and thin snout; medium-sized ears directed forward; eyes with characteristic almond shape with black pigmented sclera.

Measurement (average)	Adult male	Adult female
Body weight (kg)	160–200	160–200
Body length[1] (cm)	120	120
Ear length	Medium	Medium
Height at withers (cm)	80–90	80–90
Number of teats (average)	12.8	12.8

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Mora Romagnola pig breed.

Figure 2.
Mora Romagnola sow.

Figure 3.
Mora Romagnola pigs on pasture.

3. Geographical location and production system

In the early 1990s, only 18 animals were left concentrated in a single farm with high levels of inbreeding. Subsequently, WWF Italy in collaboration with the University of Torino decided to implement a recovery plan for the Mora Romagnola breed, and later the ANAS established the registry of Italian native breeds to protect them. Today there are dozens of farms registered in the register of Mora Romagnola, mainly found in the provinces of Ravenna (Faenza, Brisighella, Bagnacavallo), Forlì, Bologna and Modena but also in the rest of Emilia-Romagna (Reggio Emilia, Parma). There are also few farms in other areas of Italy (Torino, Arezzo, Benevento). Animals are usually intensive raised in confined spaces by small farmers even if outdoor farming is also present. Animals are usually kept continuously confined with limited control of climate conditions but with basic heat protections.

4. Organisations for breeding, monitoring and conservation

The Italian Swine Breeders Association (ANAS) is responsible for monitoring the breed. Activity is focussed towards the maintenance of genetic variability, promoting economic exploitation. The farmers have been associated since 2005 with the COPAF, which was established as a consortium for the protection of the Mora Romagnola. COPAF also presented to the Ministry of Agriculture, Forestry and Fisheries (MIPAAF) the PDO application for the Mora Romagnola pig breed, but the process is still ongoing (**Table 2**).

Name of organisation	Address	Web address
Associazione Nazionale Allevatori Suini (ANAS)	Via Lazzaro Spallanzani 4, 00161 Rome, Italy	www.anas.it
Consorzio di tutela e valorizzazione della razza suina 'Mora Romagnola' (COPAF)	Via Masironi, 7 Brisighella (RA), Italy	

Table 2.
Contact details of breeding organisation for Mora Romagnola pig breed.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. The age of sows at first parturition is between 19 and 25 months [1, 8], whereas age at culling is 58 months [3]. On average sows of Mora Romagnola pig breed have 1.4 litters per year (from 0.8 to 1.3; [1, 4, 10, 11]) with around 8 piglets [3, 4, 6, 10, 11] of approximately 0.9 kg live body weight [1, 6, 8, 9]. Stillborn percentage of piglets is low (3–3.8% [3, 6]), whereas piglet mortality rate until weaning in the considered studies ranges from 4.4 to 20.8% [3, 4, 6]. The farrowing interval is prolonged in comparison to modern intensive systems (from 209 to 435 days; [1, 4, 10, 11]).

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. In the considered studies, the information on daily gain was rarely provided. Due to big differences between studies with regard to the live weight range covered, we defined the periods for growth performance as early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth-slaughter, which is calculated from the data given on live weight and age of pigs). It should also be noted that the collected studies simulated practical conditions of the production systems used not aiming to evaluate breed potential for growth. Fortina et al. [12] showed that daily gain in the early, middle and late fattening stage was 517, 501, 560 and 488 g/day, whereas according to Bonanzinga et al. [11], pigs of Mora Romagnola gain only 331 g per day considering the period from birth to slaughter. The maximal growth rate observed for Mora Romagnola pigs was 600 g/day in overall fattening stage [1].

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Farrowing interval (d)	Sow age at culling (mth)
[1]	25	0.8	—	0.6	—	—	435	—
[3]	—	—	7.7	—	3.8	20.6	—	58
[4]	—	1.3	8.7	—	—	4.4	281	—
[5]	—	—	—	—	—	—	—	—
[6]	—	—	6.9	0.7	3.0	20.8	—	—
[7]	—	—	—	—	—	—	—	—
[8]	19	—	—	1.1	—	—	—	—
[9]	—	—	—	1.3	—	—	—	—
[10]	—	1.8	8.3	—	—	—	209	—
[11]	—	1.8	8.3	—	—	—	209	—

No. = number; mth = month; d = days.

Table 3.
Summary of collected literature data on reproduction traits in Mora Romagnola pig breed.

Reference	Feeding	No. of animals	ADG fattening[1]				ADG birth-slaughter
			Early	Middle	Late	Overall	
[1]	—	—	—	—	—	600	—
[11]	—	—	—	—	—	—	331
[12]	Semi	11	517	501	560	—	—

No. = number; ADG = average daily gain in g; semi = semi ad libitum feeding regime.
[1]ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in Mora Romagnola pig breed.

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. In the only available study by Fortina et al. [12], average daily feed intake reported for the overall fattening period (body weight from 42 to 193 kg) was 2.1 kg/day (declared as semi ad libitum feeding with complete feed mixture containing 13.8 MJ/metabolisable energy and 17% crude protein).

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 5**. Pigs of Mora Romagnola breed were slaughtered at approximately 514 days of age [12] and at an average live weight of 163 kg [11–14]. Dressing yield was around 80% [1, 12, 14] and lean meat content 39.2% ([12]; SEUROP classification), which corresponds to high slaughter weight. An average backfat thickness measured on the withers was 68 mm [12–14], 52 mm at the position of the last rib [12, 13] and 54 mm measured above the gluteus medius muscle [12–14]. Other data providing measurements of muscularity were not found in considered studies.

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in the longissimus muscle that could

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		
							S[1]	At withers	At last rib
[1]	—	—	—	240	80.0	—	—	—	—
[11]	—	—	160	—	—	—	—	—	—
[12]	11	514	193	155	80.4	39.2	62	76	57
[13]	4	—	152	—	—	—	45	64	47
[14]	50	—	146	119	81.2	—	55	64	—

No. = number; BW = body weight; CW = carcass weight.
[1]S backfat thickness measured according to ZP method (above the gluteus medius muscle (mm)).

Table 5.
Summary of collected literature data on body composition and carcass traits in Mora Romagnola pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)	Fatty acid composition[2] (%)		
				L*	a*	b*		SFA	MUFA	PUFA
1 [12]	11	6.57	6.15	42	8.7	2.2	6.1	41.31	47.63	11.04
2 [13]	4	—	5.79	43	—	—	7.5	—	—	—

No. = number; pH 45 = pH measured approximately 45 minutes post-mortem; pH 24 = pH measured approximately 24 hours post-mortem; IMF = intramuscular fat; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.
[1]CIE, objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*
[2]For fatty acid composition, only pigs on control diet were considered. Control diets differed among studies, to see diet composition address to the corresponding source.

Table 6.
Summary of collected literature data on meat quality in Mora Romagnola pig breed.

be found are presented in **Table 6**. In the studies reporting meat quality of Mora Romagnola pigs, pH measured in the *longissimus* muscle at 45 min and 24 h *post-mortem* was 6.57 [12] and 5.97 [12, 13], respectively. High intramuscular fat content was observed (in average 6.8%; [12, 13]) and relatively dark colour (43 for CIE L, [12, 13]). In the only available study, SFA, MUFA and PUFA content of intramuscular fat in the *longissimus* muscle were 41.3, 47.6 and 11.0%, respectively.

6. The use of breed and main products

The Mora Romagnola breed is a good grazer, adaptable to difficult geographical conditions. Reproduction takes place outdoors in all periods of the year, as the Mora resists well even at low temperatures. The breeding is a closed cycle; in fact, the arable crops provide cereals and legumes necessary for feeding the animals. Strengths of the breed are the hardiness, the good resistance to diseases and the already cited excellent grazing ability (in several months of the year, it provides itself with food in the sparse woods). Weaknesses are poor prolificity, mediocre feeder and late fattening. Animals are very voracious and precocious, with a good meat quality: excellent for cured meats with firm fat and good shelf life. The slaughter of pigs takes place all year round for the production of fresh meat but preferably in the period from autumn to spring for the preparation of cured meats. The breed produces sapid, soft but compact meat, rather fatty: these are the characteristics that distinguish Mora. Excellent results have been achieved by using it for the production of high-quality salami such as 'culatello', 'cotechino', or cured shoulder.

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Chapter 15

Moravka Pig

Radomir Savić, Čedomir Radović, Milica Petrović, Marija Gogić, Dragan Radojković and Nina Batorek-Lukač

Abstract

Indigenous breeds of pigs are adapted to the specific areas in which they were created. In terms of scientific substantiation, their production potential and the products obtained from them are, as in the case of Moravka pig, practically untapped. The main objective of the present chapter is to present history and current status of this breed, breeding area, its performance, production systems and main products from this local breed of pigs. Reproductive traits were estimated by means of sow age at first farrowing, litter size, weaning weight, duration of lactation and length of the farrowing interval. Growth performance was estimated by means of average daily gain and average daily feed intake in the early, middle, late and overall fattening stage. Carcass performance was evaluated by means of slaughter weight, hot carcass weight, carcass yield, lean meat content, loin eye area, the back fat thickness at the level of the last rib and withers and the back fat and muscle thickness above the *gluteus medius* muscle. Meat quality traits of the *longissimus* muscle were evaluated by means of pH at 45 min and 24 h after slaughter, objective colour (CIE L*, a* b*), intramuscular fat content and fatty acid content of intramuscular fat.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Serbia

1. History and current status of the breed (census)

Šiška, a primitive breed of pigs created by domestication of wild pigs [1], was of great importance in the eighteenth century for the development of pig farming in the territory of Serbia, Croatia, Slovenia, Hungary, Romania, and Bulgaria. In the nineteenth century, in better conditions of rearing, from Šiška the Šumadinka breed of pig was created. Unfortunately, both breeds had disappeared permanently today. However, Moravka a breed of combined production traits was created as a result of unsystematic crossings of Šumadinka and Berkshire [2]. In order to create herds of pigs for pure breeding, and partly to improve the production characteristics of domestic breed Šumadinka, at the end of nineteenth and beginning of twentieth century, the breeds Berkshire and Yorkshire have been imported [2]. This is why Moravka is also known by the name "Moravka Black English". In 1909 there was a proposal that Black English pigs called "Moravka" should be bred in a pure breed with better care, nutrition and selection, but also crossing with Yorkshire was proposed, with the selection control of cross pigs. However, there is no relevant information whether this crossing was done. In addition to Moravka, at the same time, Resavka breed ("Colourful Moravka") was created in a similar way but in smaller numbers. The only difference is the colour, since Resavka has unequal fields

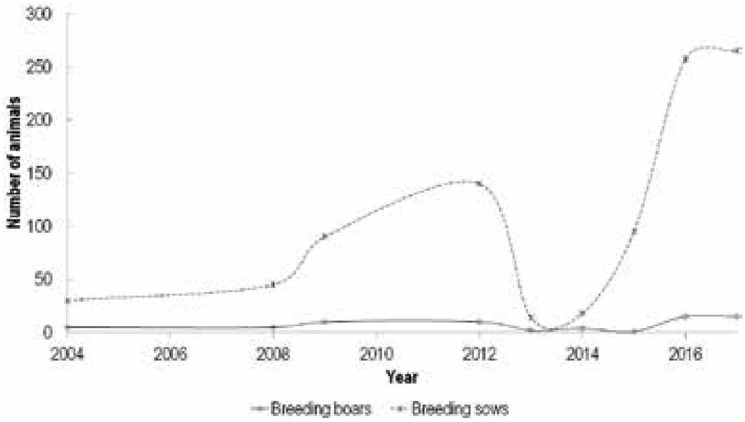

Figure 1.
Chronological distribution of Moravka pig breed, presenting number of sows and boars per year, starting with the year of herdbook establishment.

of black and white-yellowish colour of the hair and skin. Chronological distribution of Moravka pig breed is presented in **Figure 1**. Presently, in Serbia there are only 25 registered farms with 265 breeding sows and 15 boars of Moravka pig breed in the latest available status (February 2018; [3]).

2. Exterior characteristics

Information about the morphological characteristics of Moravka pig is summarized in **Table 1**. The Moravka pig has relatively thin, pigmented black skin and thick but rare ("naked Moravka") black hair, which is smooth and straight [4]. The longer hairs are located on the ridge, neck, and upper parts and thinner on the lower parts of the body. When removing hair from the skin with hot water, the pigmented epidermis is removed, after which the skin that is completely white remains [2]. The neck is of medium length and is often narrow. The body is quite long and often narrow, and the back line is slightly convex or straight. The extremities are medium long, thin, gentle, and poorly covered with muscle tissue (**Figures 2** and **3**). When the animals are reared in the intensive conditions, they have well-defined exterior widths. The mammary complex consists of four to six pairs of teats.

Measurement (average)	Adult male	Adult female
Body weight (kg)	98.0	93.7
Body length[1] (cm)	84.6	82.6
Head length (cm)	–	27.1
Ear length	–	21.7
Chest girth (cm)	112.2	107.2
Height at withers (cm)	63.4	62.4
Number of teats	–	8–12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphological characteristics of Moravka pig breed.

Figure 2.
Moravka sows with piglets.

Figure 3.
Moravka boar.

3. Geographical location and production system

Moravka pig breed was first developed in extensive management conditions in the Morava Valley of central Serbia. In the present times, Moravka pigs are reared in municipalities of Despotovac, Ub, Ljig, Mionica, Mladenovac, Topola, Prokuplje, and Kuršumlija. These pigs are usually reared in free-range conditions and outdoor extensive or semi-intensive systems. Rearing of pigs implies a free holding in the limited areas in pastures, woods, or orchards. In extensive system, pigs are kept around the house, which depends on the number of animals and size of the owner's household, and in the winter period, animals are housed in cheap, wooden pig stables [4]. Feeding is primarily based on pasture and forest products (oaks, wild fruits). Additional daily meal represents an extremely small amount of grains per head, primarily corn. In extensive system sows very frequently farrow in the forest, which significantly complicates the control of productivity and record keeping. In semi-intensive conditions, sows farrow in objects, which enable better control. In the growing and fattening phase, pigs are mostly in the open section. They are rarely intensely fattened; however if so they achieve a satisfactory growth rate.

4. Organization for breeding, monitoring and conservation

Information on population status in the last 20 years is collected by the organizations listed in **Table 2**. The law of incentives in agriculture and rural

Name of organization	Address	Web address
University of Belgrade Faculty of Agriculture	Nemanjina 6, Beograd 11,080, Serbia	http://www.agrif.bg.ac.rs/
Institute for Animal Husbandry	Autoput 16, 11,080 Zemun-Belgrade, Serbia	http://istocar.bg.ac.rs/en/
Ministry of Agriculture, Forestry, and Water Management	Nemanjina 22–26, 11,000 Belgrade, Serbia	http://www.minpolj.gov.rs/?lang=lat

Table 2.
Contact details of breeding organization for Moravka pig breed.

development [5] defines the maximum amounts of incentives per head for breeding gilts, boars, and sows of Mangalitsa, Moravka, and Resavka [6]. However, the data on size of population are unreliable, and the greatest number of animals of Moravka wasn't included in the conservation program [4]; thus a sufficient number of representative animals should be selected in order to form herd in the breeding region. Based on the observations in the last 60 years of the existence of this breed, Savić et al. [7] concluded that the lower phenotypic value of some traits in the present is probably due to the decline of population, which indicates the need to increase the population, to continuously control productivity, to improve the system of raring, and to implement the systematic selection. The Moravka breed have the status "critically endangered"; when this reference was published, ex situ protection of endangered species did not exist in Serbia. But in 2017, ex situ preservation of animal genetic resources started accordingly with the rulebook on incentives for the conservation of animal genetic resources in the gene bank [5].

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. The age of sows at first parturition is approximately 11.6 months [3, 4, 9]. Sows of Moravka pig breed have 1.5 litters per year [3]. Average piglet birth weight is 1.3 kg [2–4, 8, 9]. Stillborn percentage of piglets and mortality rate until weaning are not reported within considered studies. Duration of lactation is prolonged in comparison to modern intensive systems to 60 days [2, 4, 8, 9], which leads to a longer farrowing interval (243 days; [3]) and higher weaning weight (10 kg, [2, 4, 8]).

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as growing stage (from weaning to approximately 30 kg live body weight) and early, middle, and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg, and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth–slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only

Reference	Sow age at first parturition (mth)	Litters per sow per year	Piglet live weight (kg)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[2]	–	–	1.2	10.0	60	–
[3]	12.4	1.5	1.3	–	–	243
[4]	–	–	–	–	–	–
	11.0	–	–	–	60	–
	–	–	1.2	10.0	60	–
[8]	–	–	1.3	10.4	60	–
[9]	11.5	–	1.2	–	–	–

No. number, mth month, d days.

Table 3.
Summary of collected literature data on reproduction traits of Moravka pig breed.

Reference	Feeding	No. of animals	ADG growing[1]	ADG fattening[2]				ADG birth–slaughter
				Early	Middle	Late	Overall	
[1]	Rest	12	–	–	–	–	369	–
[2]	–	25	–	–	–	–	660	–
	–	25	–	–	490	–	490	–
	–	50	192	–	–	–	–	–
[4]	Rest	–	–	–	–	–	385	266
[9]	–	10	–	477	552	478	510	–
[10]	–	20	–	–	–	–	600	–
	–	24	–	–	–	–	660	–
[11]	–	15	–	–	–	–	388	303

No., number; ADG, average daily gain in g; Rest, restrictive feeding regime.
[1]ADG in growing period estimated from weaning to approximately 30 kg live body weight.
[2]ADG in a period of fattening is reported for early, middle, and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg, and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance of Moravka pig breed.

a smaller part of the studies actually aimed at evaluating the breed growth potential. In the considered studies, an average daily gain in growing stage was extremely low (192 g/day; [2]) and increased to 477, 521, and 478 g/day in early, middle, and late fattening stages [2, 9]. The average daily gain in the overall fattening stage was 508 g/day [1, 2, 4, 9–11] and only 285 g/day in the period from birth to slaughter [4, 11]. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Moravka pigs in *ad libitum* conditions of feeding (≈660 g/day in overall fattening stage). The maximal growth rate with completed feed mixture observed for Moravka was 607 g in the period corresponding to average body weight of 79 and 89 kg (data not shown, [12]).

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. Average daily feed

Reference	Feeding	CP content of feed (%)	No. of animals	ADFI fattening[1]			
				Early	Middle	Late	Overall
[2]	–	–	25	–	2.99	2.99	–
	–	–	25	–	2.45	–	–
[4]	Rest	–	–	–	–	–	1.44
[9]	–	15	10	1.83	–	–	–
	–	13	10	–	3.12	2.76	2.65
[10]	–	–	20	–	3.16	3.16	–
	–	–	24	–	3.16	3.16	–

No., number; ADFI, average daily feed intake in kg/day; Rest, restrictive feeding regime; CP, crude protein.
[1]ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg, and above 100 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Moravka pig breed.

intake increased from 1.8 kg/day [9] in the early fattening stage to 3.0 kg/day in the late fattening stage [2, 10], whereas pigs consumed 1.4–2.6 kg/day considering overall fattening period [4, 9].

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of the Moravka breed were slaughtered at an approximately 133 kg live weight [1, 2, 9, 10, 13–15]. Dressing yield was between 76 and 83% [2, 9, 10, 14] and lean meat content between 32 and 39% ([1, 13, 14]; SEUROP classification or dissection). The backfat thickness values measured at the level of the last rib ranged from 35 to 84 mm [1, 2, 9, 10, 13, 14], at the position of withers from 59 to 94 mm, and at the level of the *gluteus medius* muscle from 42 to 83 mm [1, 2, 9, 10, 13, 14]. Muscularity measured as loin eye area averaged 27 cm^2 [1, 13] and as muscle thickness above the *gluteus medius* 63 mm [1, 9].

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in the *longissimus* muscle that could be found are presented in **Table 7**. In the studies reporting meat quality of Moravka pigs, the traits considered were pH measured in the *longissimus* muscle at 45 min and 24 h *post-mortem* that were 6.0–6.5 and 5.7–5.9 [1, 9], respectively. The intramuscular fat content was 6.7% [11, 14], and colour measured in CIE L*, a*, b* colour space was around 52, 10.2, and 5.3 for L*, a*, and b* [1, 9]. In available studies SFA, MUFA, and PUFA content of intramuscular fat in the *longissimus* muscle were approximately 42, 54, and 4% [11, 15], respectively. The research of Savić et al. [15] showed that castrated males exhibited higher content of saturated fatty acids C14:0 and C18:0 than females. Increase of slaughter weight was accompanied with decrease of linoleic acid, decrease of total content of polyunsaturated acids, increase of palmitoleic acid, increase in total content of monounsaturated fatty acids, increase of C17:0, and decreased of P/S ratio.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
							S[2]	At withers	At last rib		
[1]	12	–	135	–	–	35.2	48	67	44	61	29
[2]	6	–	145	110	75.5	–	75	90	84	–	–
	50	–	150	117	78.2	–	83	94	82	–	–
[9]	10	–	131	–	80.7	–	63	84	61	64	–
[10]	19	–	132	101	76.9	–	69	91	77	–	–
[13]	16	–	125	–	–	39.0	42	59	35	–	25
[14]	10	–	101	84	83.1	32.1	51	63	43	–	–
[15]	21	339	113	–	–	–	–	–	–	–	–

No., number; BW, body weight; CW, carcass weight.
[1]M muscle thickness measured according to ZP method [at the cranial edge of the gluteus medius muscle (mm)].
[2]S backfat thickness measured according to ZP method [above the gluteus medius muscle (mm)].

Table 6.
Summary of collected literature data on body composition and carcass traits in Moravka pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)	Fatty acid composition[2] (%)		
				L*	a*	b*		SFA	MUFA	PUFA
[1]	12	6.53	5.65	49	12.0	5.9	–	–	–	–
[9]	10	5.95	5.87	55	8.3	4.6	–	–	–	–
[11]	15	–	–	–	–	–	6.7	41.6	53.8	4.1
[14]	10	–	–	–	–	–	6.7	–	–	–
[15]	21	–	–	–	–	–	–	41.8	54.0	4.1

No., number; pH 45, pH measured approximately 45 min post-mortem; pH 24, pH measured approximately 24 h post-mortem; IMF, intramuscular fat; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

[1]*CIE, objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

[2]*For fatty acid composition, only pigs on control diet were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*

Table 7.
Summary of collected literature data on meat quality of Moravka pig breed.

6. The use of breed and main products

The potential of the Moravka breed is untapped. The territory of Serbia has high potential of rearing autochthonous breeds, given the natural resources it possesses. The autochthonous Moravka breed is well adapted to this area, so it is one of the breeds that are suitable for outdoor rearing, in an ecological or organic, low-input production system. The study of Radović et al. [1] showed not significant better growth rate between Moravka and Moravka x Duroc (average daily gain, 368.9 vs. 503.0 g) but higher content of meat in carcass sides (35.2 vs. 43.6%). The animals not included in the nucleus herd could be crossed with Duroc, which would contribute to more economical production of meat. From this crossbreed, with combined production capabilities, we could obtain quality raw materials for the production of various products (ham, dried bacon, sausages). Today, on individual farms, these products are made according to traditional recipes and have added value, and the price of such products is significantly higher than those of conventional products. According to the results of Parunović et al. [16], it is possible to produce some meat products (kulen and sremska dry fermented sausages), with the appropriate combination of meat and fat from local pig breeds, with a respectable chemical content, with a favourable and reasonably healthful fatty acid composition, and with sensory qualities acceptable for consumers. This result should contribute to encouraging the sustainable breeding of the Moravka pigs which can significantly contribute to regional rural development.

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Chapter 16

Negre Mallorquí (Majorcan Black) Pig

Joan Tibau, Neus Torrentó, Raquel Quintanilla Aguado, Joel González, Maria Angels Oliver, Marta Gil, Jaume Jaume and Nina Batorek-Lukač

Abstract

Negre Mallorquí pig is a native breed from Mallorca, characterized by its high rusticity and adaptation to the Mediterranean climatic conditions. The present chapter presents the history and current status of this breed, its phenotypic characteristics, the particularities of its production system and main products from this Mediterranean native pig breed. Data come from the scarce literature about Porc Negre Mallorquí breed, adding non-published data obtained during the TREASURE project. Reproductive performance was estimated by means of sow age at first parturition, litters per sow per year, piglets alive per litter, piglets birth and weaning weights, percentage of stillborn per litter, death rate percentage from birth to weaning, duration of lactation and farrowing interval. Growth performance was estimated by means of average daily gain and daily feed intake in several production periods. Carcass traits were evaluated by means of age and weight at slaughter, hot carcass weight, carcass yield and back fat thickness in several points. Meat quality traits were evaluated by means of pH at 45 min and 24 h after slaughter, objective colour, intramuscular fat content and fatty acid composition of intramuscular fat and back fat. The current chapter defines a first review about this local pig breed.

Keywords: untapped European breed, TREASURE, productive traits, phenotype, Spain

1. History and current status of the breed (census)

The Porc Negre Mallorquí, Cerdo Negro Mallorquín in Spanish and Majorcan Black Pig (MBP) in English, is a native breed from Mallorca, characterized by its high rusticity and adaptation to the Mediterranean climatic conditions [1]. The MBP is the only native pig breed in state of conservation in the Balearic Islands, declared as in danger of extinction. It is uncertain to assure the origin of this breed but the existence of pig livestock and pork consumption in Mallorca dates from the period of the first settlers, approximately 3500 BC [2]. The MBP reared nowadays is the sum of the genetic origins and the equilibrium between selection pressure by different civilisations, and the natural adaptation of the breed in the territory [3]. Very few studies exist about MBP genomics, but Clop et al. [4] found that this breed lacks for Asian haplotypes and halothane sensitivity gene,

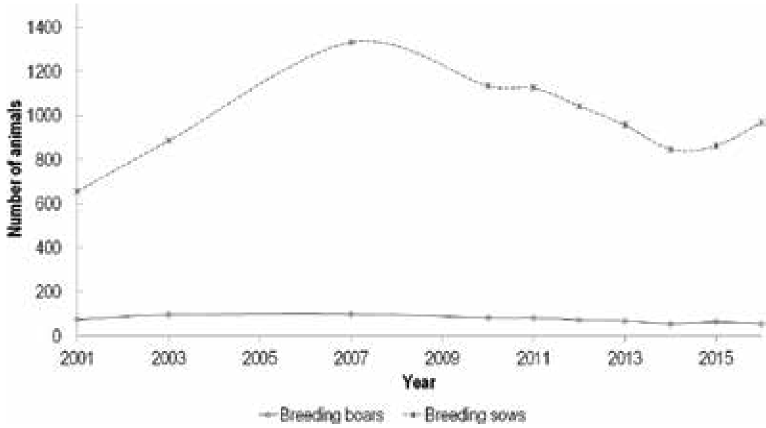

Figure 1.
Census of Porc Negre Mallorquí pig breed, presenting number of sows and boars per year, starting with the year of herd book establishment.

indicating a long-lasting geographical and genetic isolation. This breed had a great importance in the economy as well as in the Majorcan lifestyle until the middle twentieth century [3], contributing to the cultural heritage of the Island. Several circumstances promoted the reduction of pig numbers, such as the effect of diseases, and, more recently, the introduction of leaner pig breeds, the migration from farms to cities because of the tourism growth and the reduced generational renewal. Nevertheless, the MBP lived on as a source of protein and fat, because of its adaptation to the local environment and its ability to exploit the scarce natural resources of the Island [5].

Nowadays, the MBP Producers Association promotes its production and controls the herd book. Census of Negre Mallorquí pig breed is presented in **Figure 1**. Presently, there are 59 registered farms of Negre Mallorquí pigs with about 969 breeding sows and 54 boars in the latest available status (August, 2016 [6]).

The main meat product obtained from these pigs is the "sobrassada de Porc Negre Mallorquí", a specialty fat-rich cured sausage granted with a PGI certification. Another appreciated product is Mallorcan suckling pig "Porcella", the three-month purebred MBP piglet eaten mainly roasted for Christmas. It is estimated that around 2000 piglets are sold yearly as "porcella" [7], which is approximately 15% of piglets produced per year. The revenues obtained from "porcella" are a key factor for the durability of the reproductive farms, and therefore, the breed itself, contributing to its sustainability. It is especially worth mention the particularities of this production system regarding its main product, the "sobrassada", since almost the whole carcass is used to elaborate them, by mincing the ham, shoulder, loin, belly and back fat.

2. Exterior phenotypic characteristics

The MBP breed morphology information is summarized in **Table 1**. It is a rustic, medium-sized breed with high percentage of fat tissue (as in other Mediterranean pig breeds: Iberian, Nero Siciliano and Nero Casertano). This breed presents black or grey skin colour, and tassels in the neck (seen on **Figure 2**), pendulous ears and a concave nose profile (**Figures 2** and **3**).

Measurement (average)	Adult male	Adult female
Body weight (kg)	115	120
Tail length (cm)	40	40
Ear length	Large	Large
Height at withers (cm)	70	69
Number of l functional teats	9	9

Table 1.
Summary of morphology information on Negre Mallorquí pig breed.

Figure 2.
Negre Mallorquí sow with piglets.

Figure 3.
Negre Mallorquí boar.

3. Geographical location and production system

The farms rearing MBP (n = 61; **Figure 4**) are located all over Mallorca Island. Although the traditional production areas are near the sea because of specific vegetation, more than 60% of animals are located in the southeast of the island, corresponding with the zone of major production of cereals, and most of them have complementary farming and agricultural activities. The farms are classified according to their functioning as: (a) farrowing units (49.4%) focused in producing reproductive sows and selling piglets as "porcellas" or to the fattening units; (b)

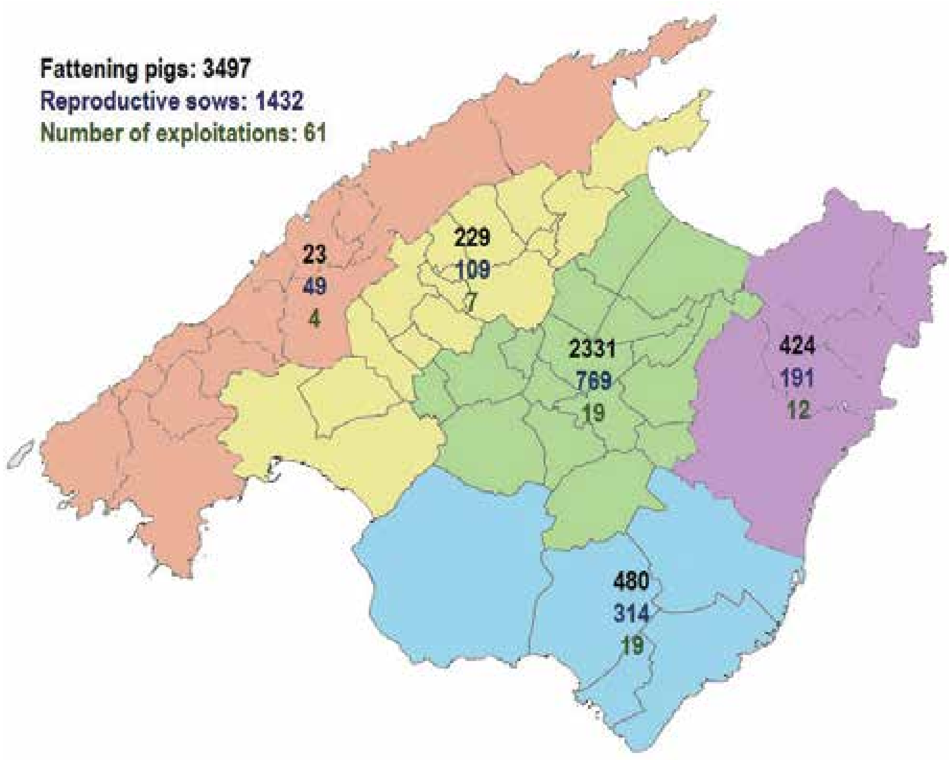

Figure 4.
*Distribution of MBP production farms by municipalities (excluding farms that have been exclusively engaged in fattening). * The maximum number of farms in one municipality is 12 (Manacor).*

fattening units (13.9%) focused in rearing piglets until slaughter weight; (c) mixed units (36.7) which produce piglets some sold as "porcella" and some fattened until slaughter at heavy weights (150 kg body weight and average 12 months of age). A characteristic of MBP farrowing farms is seasonality of production, piglets farrowed in October to November are consumed as "porcella" during Christmas time (with a live weight lower than 10 kg), whereas piglets farrowed in May are either consumed as "porcella" from June to July or fattened for 12–18 month to produce "sobrassada". The MBP is always managed in an extensive way, characterised by low-level breeding and feeding conditions [5]. Feeding regime is traditionally based on pasture (**Figure 2**), cereals (barley), legume seeds, figs, almonds, acorns and several Mediterranean shrubs. Aside of natural feeding resources, sows are fed with commercial diets during lactation and pregnancy and growing pigs are supplemented with barley and green peas. Growth figures are related to the natural resources availability (land quality and rain) and the supplementation in the previous weeks before slaughtering.

4. Organisations for breeding, monitoring and conservation

Recovery and promotion of the breed started thanks to the interest of a group of local producers and meat processors to obtain "sobrassada" (a dried and fermented sausage, highly seasoned with paprika, pepper and salt) maintaining the characteristics of the pure breed production system. In 1994, MBP products obtained the recognition of "Protected Geographical Indication" (P.G.I.) for the "sobrassada", and in 1997, the Producers Association of Majorcan Black Pig (ARPNMS) started

Name of organisation	Address	Web address
The Majorcan Black Pig Breeders Association	Agua 4, 07510 Sineu (Palma de Mallorca), Spain	/
Serveis de Millora Agrària i Pesquera (SEMILLA), Government of the Balearic Islands	Eusebi Estada, 145. 07009 (Palma de Malorca), Spain	http://www.caib.es/sites/semilla/ca/gerencia-77038/?campa=yes
IRTA—Animal Breeding & Genetics	Torre Marimon, 08140 Caldes de Montbui (Barcelona), Spain	http://www.irta.cat/en/grup/animal-breeding-genetics/

Table 2.
Contact details of breeding organisation for Porc Negre Mallorquí pig breed.

the herd book of the breed with close to 400 reproductive sows. Semilla, a service of the Balearic Government, gives technical support to preserve and promote the breed. Individual identification of animals is mandatory, and pedigree information is used to limit the incidence of inbreeding (**Table 2**). During years, only the morphological traits were the criteria to select the best boars. At present, there is a specific conservation programme to reduce inbreeding based on continuous exchange of genetic material across herds, with a replacement rate around 33%. In addition, auction sales and reproducer exhibitions are celebrated to promote genetic exchanges across farms.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. The management of reproduction is very simple. In extensive production system, females and males there are kept together, except during the lactation period; thus, there is no controlled mating, and paternity of young piglets is uncertain, especially as free piglet adoption is not uncommon between sows [1, 5]. The reported age of sows at first parturition is 12 months [9]. On average, sows of MBP breed have 2.0 litters per year [1, 8, 9] with 6.8–7.5 piglets [1, 5, 9] of average 0.9 kg live body weight [9]. Stillborn percentage of piglets is 5.1% [1], whereas piglet mortality rate until weaning in the considered studies was 20.0% [1, 9], which is expected for an extensive production system. The farrowing interval is 180 days [9], whereas duration of lactation is over 4 weeks (46 days; [8]), and in some cases, especially in winter, young piglets (close to 8 kg live weight) are removed from the litter and consumed as “porcellas” [1].

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately

References	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[1]	.	2.0	7.5	.	5.1	20.0	.	.	.
[8]	.	2.0	.	.	.	.	11.4	64	.
[9]	12	2.0	7.0	0.9	.	20.0	.	.	180
[5]	.	.	6.8	.	.	.	.	.	.

mth = month, d = days.

Table 3.
Summary of collected literature data on traits of reproduction in Negre Mallorquí pig breed.

References	Feeding	No. of animals	ADG lactation[1]	ADG growing[2]	ADG fattening[3]			ADG birth-slaughter[4]
					Early	Late	Overall	
[1]	Rest		.	405	613	.	.	.
[8]	Rest	1022	.	.	.	.	410	.
		250	200	.	.	.	.	.
[10]	Rest	66	.	.	.	.	.	377
[11]	.	18	.	.	.	.	.	371
	.	39	.	.	.	.	.	360
[12]	.	.	.	.	.	543	.	.
	.	.	.	.	.	471	.	.

No. = number; ADG = average daily gain in g; Rest = restrictive feeding regime.
[1]ADG in a period of lactation regardless of how long it was.
[2]ADG in the growing period estimated from weaning to approximately 30 kg live body weight.
[3]ADG in the fattening period is reported for early and late fattening stages estimated between approximately 30 and 60 kg live body weight and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).
[4]Calculated from the data given on live weight and age of pigs.

Table 4.
Summary of collected literature data on growth performance in Negre Mallorquí pig breed.

References	Feeding	No. of animals	ADFI fattening[1]	
			Late	Overall
[8]	Rest	1022	.	2.95
[12]	.	.	2.76	.
	.	.	2.55	.

No. = number, ADFI = average daily feed intake in kg/day; Rest = restrictive feeding regime.
[1]ADFI in a period of fattening is reported for late fattening stage estimated above 100 kg live body weight and as the overall daily feed intake for the whole studied period (from approximately 30 kg body weight until slaughter).

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Negre Mallorquí pig breed.

30 kg live body weight), early fattening stage (estimated between approximately 30 and 60 kg live body weight) and late fattening stage which corresponds to finishing period in MBP breed (estimated above 100 kg live body weight). Sometimes, the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth-slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that the collected studies simulated practical conditions of the extensive production systems used not aiming at evaluation of the breed potential for growth. Traditional growing period is longer than 12 months and the minimum live weight accepted to produce “sobrassada” is 120 kg [1]. Males to be slaughtered are castrated at a young age [1]. Daily gain in the period of lactation was 200 g/day [8] and increased to 405 g/day in growing [1], 613 g/day in the early fattening stage [1] and 507 g/day in the late fattening stage, which corresponds to the finishing period [12]. In overall, a fattening stage gain of 410 g/day was observed [8], whereas the average daily gain in the period from birth to slaughter was 369 g/day [10, 11] within the considered studies of MBP breed observed in the extensive system of production.

In considered studies, the information on feed intake and feed nutritional value was scarce. Production of MBP is extensive and is characterized by the use of endogenous resources in their diet: grass, Mediterranean shrubs, legumes, seeds, figs, almonds and acorns. In sows, natural feeding resources are supplemented during lactation and pregnancy with commercial diets, and in growing pigs with barley and peas. Cereals are usually subjected to a grinding treatment to be transformed into flour. Jaume et al. reported that the average daily feed intake of finishing MBP (105–152 kg body weight, feed mixture of 80% barley and 20% peas) was 2.8 kg/day [12], whereas in the overall fattening period, an average 3.0 kg/day of granulated grains was distributed to MBP according to the results of Tibau [8]).

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of Negre Mallorquí breed were slaughtered at approximately 374 days of age [8, 10, 11], at an average 136 kg live body weight (100–158 kg; [8, 10, 11, 13, 17]) and reached an average carcass weight of 106 kg [8, 10, 11, 13–17] and a dressing yield of 77% [8, 10, 11, 13, 17]. The carcasses presented an average of 84.2 cm (data not shown; [10, 11, 17]). The fat thicknesses varied from 42 to 75 mm over *Gluteus medius* [8, 10, 11, 14, 15], 62 to 90 mm at the position of the first rib [8, 10, 11, 14], and 42 to 74 mm at the position of last rib [8, 10, 11, 13–16], indicating large quantity of back fat tissue produced. Within the considered studies, muscle depth measured at the cranial edge of *Gluteus medius* muscle ranged from 42 to 75 mm (59 mm in average; [10, 11, 13, 15, 17], whereas other measurements evaluating muscularity were not found, due to the fact that carcasses are not split in common

References	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness[1] (mm)			M[2] (mm)
						S	First rib	Last rib	
[8]	66	366	158	117	80.4	66	89	72	.
[10]	66	427	158	117	80.4	66	89	72	66
[11]	18	275	100	73	72.4	42	62	42	42
	39	427	152	115	80.1	67	90	74	67
[13]	18	.	100	73	72.6	.	.	42	42
	10	.	152	122	80.2	.	.	69	61
[14]	39	.	152	115	80.1	67	90	74	.
	18	.	100	73	72.4	42	62	42	.
[15]	32	.	.	104	.	65	.	56	75
	34	.	.	128	.	75	.	50	65
[16]	67	.	.	115	.	.	.	.	.
[17]	69	.	153	124	74.9	.	.	.	54

No. = number, BW = body weight; CW = carcass weight.
[1]Back fat thickness (mm) measured according to ZP method (above Gluteus medius muscle (S)), at the position of first (first rib) and last rib (last rib).
[2]M muscle thickness measured according to ZP method (at the cranial edge of Gluteus medius muscle (mm)).

Table 6.
Summary of collected literature data on body composition and carcass traits in Negre Mallorquí pig breed.

DOI: http://dx.doi.org/10.5772/intechopen.84434

References	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	IMF fatty acid composition[2] (%)			BFT fatty acid composition[3] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	SFA	MUFA	PUFA	n6/n3
[8]	66	6.19	5.87	44	9.8	1.4	8.9	38.8	50.4	10.8	38.2	58.1	3.7	.
[10]	66	6.19	5.87	44	9.8	1.4	8.9	.	.	.	.	.	.	.
[11]	18	.	5.39	52	10.8	2.4	7.0	.	.	.	.	.	.	.
	39	.	5.78	44	10.2	1.8	9.1	.	.	.	.	.	.	.
[13]	18	5.68	5.39	52	.	.	7.0	.	.	.	37.7	51.8	10.5	10.30
	10	5.88	5.97	43	.	.	9.0	.	.	.	39.3	49.7	11	8.80
[14]	39	.	5.78	44	10.2	1.8	9.1	.	.	.	.	.	.	.
	18	.	5.39	52	10.8	2.4	7.0	.	.	.	.	.	.	.
[15]	32	6.41	.	44	10.7	2.2	7.8	.	.	.	.	.	.	.
	34	6.33	.	44	10.9	2.1	9.7	.	.	.	.	.	.	.
[16]	67	6.37	.	44	.	.	.	.	.	.	.	.	.	.
[17]	69	6.27	5.60	44	11.2	1.2	6.0	.	.	.	41.0	51.3	6.9	15.2

No. = number, pH 45 = pH measured approximately 45 min post-mortem; pH 24 = pH measured approximately 24 h post-mortem; IMF = intramuscular fat; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.
[1]CIE = objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*
[2]For fatty acid composition of intramuscular fat tissue in Longissimus muscle, only pigs on control diet were considered, and when fatty acid composition was reported separately for neutral and polar lipids, values reported for neutral lipids were considered. Control diets differed among studies, to see diet composition address to the corresponding source.
[3]For fatty acid composition of back fat tissue, only pigs on control diet were considered, and when fatty acid composition was reported separately for outer and inner layers, values reported for outer layer of back fat tissue were considered. Control diets differed among studies, to see diet composition address to the corresponding source.

Table 7.
Summary of collected literature data on meat quality in Negre Mallorquí pig breed.

slaughterhouse practices. For measurements of fat thickness, fat tissue is cut from the skin following the midline for about 15 cm, allowing the measurement with a ruler.

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *Longissimus* muscle that could be compared are presented in **Table** 7. In the studies reporting meat quality of MBP, pH measured in *Longissimus* muscle at 45 min and 24 h *post-mortem* were around 6.17 [8, 10, 13, 15–17] and 5.67 [8, 10, 11, 13, 14, 17], respectively. The electrical conductivity in this muscle was 6.78 mS (data not shown; [17]). The average pH 45 min post-mortem at *Semimembranosus* was 6.42 (data not shown; [16, 17]), but no data are available at 24 h because the whole ham is warm deboned and minced for "sobrassada" production. Intramuscular fat content in *Longissimus* muscle reported within the considered studies was high and ranged from 6.0 to 9.7% (8.1% on average; [8, 10, 11, 13–15, 17]). Colour measured in CIE Lab colour space and using the Japanese Colour Scale indicates reddish pink colour of the meat (L^* = 46 [8, 10, 11, 14, 15, 17] and score = 3.4; data not shown; [10]). Drip loss in a *Longissimus* duplicate sample showed an average value of 1.65% (data not shown; [16, 17]). Instrumental texture was evaluated within the TREASURE project [17], being the unique data available, and the mean value for shear force was 3.49 kg. Regarding the fatty acid profile, an average value obtained for SFA, MUFA, and PUFA content of intramuscular fat in *Longissimus* muscle, reported for the control group of animals in the only available study, were 38.8, 50.4 and 10.8%, respectively [8], whereas SFA, MUFA, and PUFA content of back fat tissue were 39.1, 52.7 and 8.0% respectively [8, 13, 17].

6. Use of breed and main products

The main MBP product is spicy meat paste sausage made with paprika known as the "Sobrassada de Mallorca de Porc Negre". It is spreadable dry-cured sausage made only with meat (30–60%) and fat (40–70%) of purebred animals grounded and seasoned with paprika (mix of different varieties of *Capsicum annuum*, 4–7%), salt (1.8–2.8%), spices or natural aromas (pepper, spicy paprika, rosemary, thyme, and oregano). This meat mass is grinded to 3–5 mm in diameter stuffed into natural gut and left in natural or industrial dryer chambers (temperature 8–15°C, humidity 60–85%) [18]. The duration of drying depends on sausage size. The product is qualified as Protected Geographical Indication since 1994. The "Sobrassada de Mallorca" protected geographical indication covers two types of "sobrassada": "Majorcan Sobrassada" made from selected pork meats and "Black pig Majorcan Sobrassada": made exclusively from Majorcan black pig meat and stuffed into natural casings. In this case, pigs are reared and fed on the island of Mallorca in accordance with traditional practices. There are several varieties of Majorcan "sobrassada", the most common one is "Rizada", which weighs around 800 g and the curing process lasts from 6 to 12 weeks. In addition, the consumption of MBP "porcella" is very important from a gastronomic, cultural and sustainability perspective. "Porcella" tender meat is prepared mainly during Christmas, when local Majorcans eat "porcella rostida", cooked with herbs and wine to create a juicy festive dish. Thus, producer's sale piglets in winter, depending on the demands and present or expected feeding seasonal possibilities (the stock of barley and green peas, the intensity of vegetation due to weather condition), increasing the efficiency and flexibility of the production system and improving the sustainability. Mallorca's "porcella" is distinguished by the "porcella mallorquina" label, which indicates that the animal has been born, raised and slaughtered on the island. Flare fat is traditionally used in "ensaimadas", a typical sweet cake. Some alternative products have been developed to increase the presence of MBP products in the market, as fresh meat, especially the loin, or as processed products, such as a loin carpaccio or ready-to-eat ribs, and cured or cooked shoulder and ham.

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Chapter 17

Casertana Pig

Riccardo Bozzi, Maurizio Gallo, Claudia Geraci, Luca Fontanesi and Nina Batorek-Lukač

Abstract

The present chapter aims to present the history, current status and information of Casertana pig breed investigated in the project TREASURE. As for most of the other Italian local pig breed conservation program started in 2001 and in 2015, 20 farms of Casertana pigs with about 545 breeding sows and 20 boars were registered. The average age of sows at the first parturition is 16 months, whereas age at culling is 59 months. On average Casertana pigs have 1.2 litters per year with 7.6 piglets. The farrowing interval (305 days on average) is prolonged compared to modern pig breeds. The fattening phase of Casertana pigs is generally characterised by slower growth, and the animals were slaughtered at around 375 days of age, with an average live weight of 154 kg and a dressing yield of 81%. The breed is characterised by a high level of backfat thickness. The breed is traditionally raised with the semi-extensive system, and the most recognised trait of the Casertana pig is the 'marbling' of the meat. This current review provides a comprehensive insight into the information for this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Italy

1. History and current status of the breed (census)

The Casertana pig is a breed of domestic pig from Campania, in Southern Italy [1]. The census of Casertana pig breed is presented in **Figure 1**. Presently there are 20 registered farms of Casertana pigs with about 545 breeding sows and 20 boars in the latest available status (August 2015 [2]). The presence of hairless pigs in Campania with a short and broad head, resembling the Asian pigs, is already documented in Roman times. Casertana breed originated from the repeated crossing of these pigs with those of Central European origin [3]. Already at the end of the eighteenth century, the Casertana pig was raised in one of the most populated areas of the Bourbon Kingdom, where it was appreciated for its great ability to produce fat. In the nineteenth century, the Casertana pig was present in the province of Caserta, its area of origin. Starting from its area of origin, the breed spreads in the provinces of Naples, Benevento, Avellino, Salerno and Potenza, and during the early decade of the twentieth century was one of the largest populations of the country [3]. After World War II, the consistency contracted drastically, and only the start of the conservation programme in 2001 facilitated the opening and development of numerous small breeding nuclei [3–5].

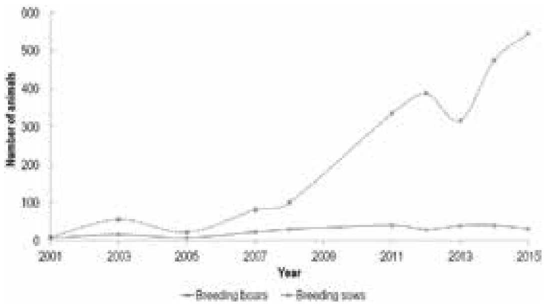

Figure 1.
Census of Casertana pig breed, presenting a number of sows and boars per year, starting with the year of herdbook establishment.

2. Exterior phenotypic characteristics

The Casertana pig is a medium-sized breed with two unusual physical traits: it is virtually hairless, which gives rise to its alternative name Pelatella, 'hairless one', and it has two wattles or cylindrical appendages hanging from the lower part of the throat. Animals present light but solid skeleton with pigmented skin (black or slate grey) and sparse and thin bristles, sometimes grouped especially on the neck, on the head and at the end of the tail. The head is of medium development and truncated conical shape, with a rectilinear or slightly concave profile and long and thin snout. Ears are of medium-sized close together and bending forward (**Figures 2** and **3**). The Casertana pig breed morphology information is summarised in **Table 1**.

3. Geographical location and production system

Casertana breed is raised in different Italian regions: Campania, Molise, Lazio and Umbria [3]. The traditional breeding technique foresees a wide use of grazing in beech, chestnut or oak woods, with poor feed integration and with large spaces where the Casertana pig can freely graze [5]. Currently, most of the animals are fattened according to modern breeding techniques, with the use of protein nuclei and integrated feed even if breeding with extensive and semi-extensive management is still present, usually in the oaks. When animals are intensively raised, they are kept continuously confined with basic heat protections available even if the environment is not completely climate controlled.

Figure 2.
Casertana sow with piglets.

Figure 3.
Casertana boar.

Measurement (average)	Adult male	Adult female
Body weight (kg)	140–260	140–260
Body length[1] (cm)	116	112
Head length (cm)	30–40	25–35
Ear length	Medium	Medium
Chest girth (cm)	150	138
Height at withers (cm)	90–94	82–88
Number of teats (average)	12	12

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Casertana pig breed.

4. Organisations for breeding, monitoring and conservation

The Italian Pig Breeders Association (ANAS) is the organisation responsible for monitoring the breed, to which it is delegated for the conservation strategies of the breed, which is not interested in a selection scheme. Activities carried out by ANAS

Name of organisation	Address	Web or e-mail address
Associazione Nazionale Allevatori Suini (ANAS)	Via Lazzaro Spallanzani 4, 00161 Rome, Italy	www.anas.it
Consorzio del Casertana	Via Provinciale, 44 82,030 Faicchio (BN), Italy	info@consorzionerocasertano.it

Table 2.
Contact details of breeding organisation for Casertana pig breed.

are mainly directed towards the maintenance of genetic variability while promoting economic exploitation. Recently, as for other local Italian breeds, a consortium of Casertana breeders has been set up in the area of origin aimed to promote and enhance the production of this breed (**Table 2**).

5. Productive performance

5.1 Reproductive traits

The basic data on reproductive traits obtained in this review are presented in **Table 3**. According to the herdbook data, the age of sows at the first parturition is 24.5 months, whereas the age at culling is 46.7 months [2]. Sows of Casertana pig breed have 1.1–1.3 litters per year [1, 6] with 6.0–9.2 piglets [2, 6–9] of approximately 1.0 kg live body weight [1, 2, 8, 10, 11] and 4.2 kg weaning weight [11]. Stillborn percentage of piglets is low (around 2.7% [2, 8]), whereas piglet mortality rate until weaning is considerably higher (around 20.4% [2, 8, 12]). The duration of the farrowing interval (approximately 305 days [1, 6]) is prolonged compared to modern pig breeds.

5.2 Growth performance

The basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall) or even from birth to slaughter (defined as birth to slaughter, which is often calculated from the data given on live weight and age of pigs). It should also be noted that a big part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies aimed at evaluating the breed potential for growth. In the considered studies, the early, middle, late and overall fattening stage is generally characterised by slower growth (477, 464, 446 and 453 g/day, respectively), whereas no data were available for growth performance in lactation and growing period.

In the considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. In the only available study by Fortina et al. [15], the average daily feed intake reported for the overall fattening period (body weight from 33 to 200 kg) was 2.1 kg/day (declared as semi ad libitum feeding with complete feed mixture containing 13.8 MJ/metabolisable energy and 17% crude protein).

Reference	Sow age at the first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Farrowing interval (d)	Sow age at culling (mth)
[1]	12	1.1	—	0.83	—	—	—	330	72
[2]	24.5	—	6.7	0.75	1.5	13.2	—	—	46.7
[7]	—	—	9.1	—	—	—	—	—	—
[8]	—	—	7.1	0.76	3.9	30.0	—	—	—
[13]	—	—	—	—	—	—	—	—	—
[9]	11.2	—	6.0	—	—	—	—	—	—
[6]	—	1.3	9.2	—	—	18.1	—	281	—
[10]	—	—	—	1.21	—	—	—	—	—
[14]	—	—	—	—	—	—	—	—	—
[11]	—	—	—	1.23	—	—	4.2	—	—

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on reproduction traits in Casertana pig breed.

Reference	Feeding	No. of animals	ADG fattening[1]				ADG birth to slaughter
			Early	Middle	Late	Overall	
[1]	—	—	—	—	—	500	—
[7]	Semi	21	467	491	361	450	—
[15]	Semi	6	487	437	530	415	403
[16]	Semi	12	—	—	—	468	—
[17]	—	15	—	—	—	430	—

No. = number, ADG = average daily gain in g, Semi = semi *ad libitum feeding regime.*
[1]*ADG in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on growth performance in Casertana pig breed.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		
							S[1]	At withers	At the last rib
[1]	—	—	175	140	80.0	—	—	—	—
[7]	21	367	151	123	81.4	—	—	—	45
[15]	6	494	200	165	82.3	42.1	60	75	48
[16]	12	315	140	115	81.8	—	—	—	46
[17]	15	323	140	119	80.2	—	—	—	52
[18]	50	—	120	93	82.9	—	59	71	41

No. = number, BW = body weight, CW = carcass weight.
[1]*S backfat thickness measured according to ZP method (above* gluteus medius *muscle (mm)).*

Table 5.
Summary of collected literature data on body composition and carcass traits in Casertana pig breed.

5.3 Body composition and carcass traits

The basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 5**. In the considered studies, pigs of Casertana breed were slaughtered at approximately 375 days of age [7, 15–17] and between 120 and 200 kg live weight (154 kg in average [1, 7, 15–18]). Dressing yield was around 81% [1, 7, 15–18]. The average backfat thickness values measured at withers were 73 mm [15, 18], at the level of the last rib 46 mm [7, 15–18] and above the *gluteus medius* muscle 60 mm [15, 18]. Muscularity measured as lean meat content was 42.1% ([15]; SEUROP classification), whereas data providing other measurements of muscularity (i.e. loin eye area or muscle thickness measured at the cranial edge of *gluteus medius* muscle) were not available in the considered studies.

5.4 Meat and fat quality

The basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *longissimus* muscle that

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF content (%)	Fatty acid composition[2] (%)		
				L*	a*	b*		SFA	MUFA	PUFA
[15]	6	6.38	5.96	43	9.4	2.6	4.7	40.0	48.2	11.8
[16]	14	—	—	—	—	—	2.0	45.9	41.0	13.9
[17]	15	6.17	5.51	40	6.8	2.1	—	—	—	—
[12]	30	—	—	45	11.3	8.3	—	—	—	—

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem*, pH 24 = pH measured approximately 24 hours* post-mortem*, IMF = intramuscular fat, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids.*
[1]CIE = objective colour defined by the Commission Internationale de l'Eclairage; L greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*
[2]For fatty acid composition, only pigs on control diet were considered. Control diets differed among studies, to see diet composition address to the corresponding source.

Table 6.
Summary of collected literature data on meat and fat quality in Casertana pig breed.

could be found are presented in **Table 6**. In the studies reporting meat quality of Casertana pigs, pH measured in *longissimus* muscle at 45 min and 24 h *post-mortem* was around 6.23 and 5.7 [15, 17], respectively. The intramuscular fat content was 2.0 and 4.7% [15, 16] and colour measured in CIE L, a, and b colour space was 42, 9.1 and 4.3 for L*, a* and b*, respectively [12, 15, 17]. In the considered studies, SFA, MUFA and PUFA content of intramuscular fat in *longissimus* muscle was around 43, 45 and 13%, respectively. Due to big differences between studies about the feeding regime, feed composition, final body weight/age and fatness, which are all important factors influencing the fatty acid composition of meat, the results of the fatty acid composition should be interpreted with caution.

6. Use of breed and main products

Casertana breed has a good fattening attitude, and the fat tends to spread widely throughout the meat making it soft and tasty. Traditionally raised with the semi-extensive system, mainly fed with acorns, chestnuts, walnuts and wild fruits, it is slaughtered between 16 and 24 months, obtaining meat of good quality with tenderness as a special attribute. The most prized characteristic of the Casertana pig is the 'marbling' of the meat, i.e. the presence of abundant intramuscular connective tissue (noble fat), which gives flavour and softness to the meat. Meat is used both for cured products and fresh consumption. The main typical products are hams, ribs and above all different types of salami (capocollo, pancetta, and soppressata).

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Chapter 18

Nero Siciliano Pig

Riccardo Bozzi, Maurizio Gallo, Claudia Geraci, Luca Fontanesi and Nina Batorek-Lukač

Abstract

Origins of Nero Siciliano pig date to Carthaginian domination and its rearing, after a setback during the Arab period, was rather diffused throughout Sicily. Breed rearing is nowadays limited from the farmed area to the wooded hills of north-eastern Sicily. The latest available status (2015) reported 87 registered farms with about 1100 breeding sows and 124 boars enrolled in the herdbook started in 2001, as well as the conservation programme. Coat colour is mainly black but white face and wattles are accepted. Nero Siciliano pigs have on average 7.6 piglets of 1.4 kg live body weight and the average daily gain during fattening period was on average 346 g/day for the overall fattening stage. Slaughter age of Nero Siciliano breed was on average 390 days, at an average live weight of 95 kg. Average intramuscular fat content was 4.6% and as regards fatty acid composition, average values obtained for SFA, MUFA and PUFA were 37.5, 54.2 and 8.3% in *longissimus* muscle and 39.0, 49.4 and 11.7% in back fat tissue, respectively. This review gives an exhaustive review of the information available for this local Italian breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Italy

1. History and current status of the breed (census)

The Nero Siciliano is a breed of domestic pig from the Mediterranean island of Sicily, in southern Italy [1]. The breeding of this pig has ancient origins: fossil remains and written documents testify the presence of these animals since the period of Greek and Carthaginian domination (VII-VI century). The pig breeding suffered a setback in the ninth century under Arab domination, while it recovered with the Norman conquest. Numerous breeds and pig populations deriving from the Neapolitan black-haired breed have helped to form this breed that nowadays presents well-defined characteristics [2]. From the early twentieth century, the Nero Siciliano was usually raised in small groups of 10–15 animals and the crossing with other improved breeds was rather diffused. It was not rare at that time to observe white spotted or totally white animals [2]. The breeding of this pig population was widespread on the island until the middle of the twentieth century, and the Nero Siciliano assumed different names in the various geographical areas of breeding [2]. The subsequent socio-economic changes limited the farmed area to the wooded hills of north-eastern Sicily (Madonie and Nèbrodi). Presently, there are 87

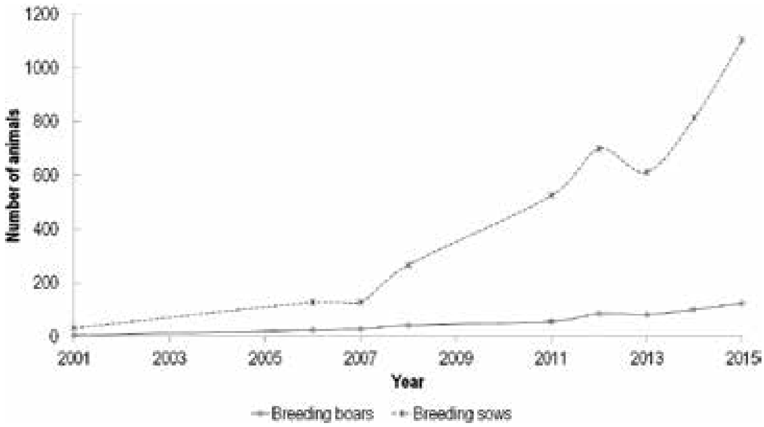

Figure 1.
Census of Nero Siciliano pig breed, presenting number of sows and boars per year, starting with the year of herdbook establishment.

registered farms of Nero Siciliano pigs with about 1103 breeding sows and 124 boars in the latest available status (August 2015, [3]). Census of Nero Siciliano pig breed is presented in **Figure 1**.

2. Exterior phenotypic characteristics

The Nero Siciliano pig breed morphology information is summarised in **Table 1**. It is a medium-size breed with mainly black coat colour (**Figure 2**), robust with strong skeleton and black skin and bristles. Some subjects may have a partially or totally white face ('facciolo' pig). Head of remarkable development and long, straight profile, narrow and inclined snout; small ears obliquely directed at the top with tips brought horizontally forward. The presence of wattles is tolerated, even if not typical of the breed. Elongated neck and poorly developed trunk, compressed in the thoracic region.

Measurement (average)	Adult male	Adult female
Body weight (kg)	150	130
Body length[1] (cm)	102	87
Ear length	Small	Small
Chest girth (cm)	127	115
Height at withers (cm)	60–65	60–65
Number of teat (average)	11.4	11.4

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Nero Siciliano pig breed.

3. Geographical location and production system

Nero Siciliano is raised mainly in the province of Messina, particularly in the Monti Nebrodi. The particular orography of this area, characterised by narrow and parallel valleys that end on the coast, favours the natural segregation of the

Figure 2.
Nero Siciliano sow with piglets.

animals, with consequent conservation of an interesting genetic variability. Since 2001, the conservation programme involves a group of companies that adopt the traditional extensive breeding techniques which usually foreseen to let the pigs in forest, if present, during all the year. Depending on climatic conditions the period in the forest could be limited to autumn-winter or spring-summer seasons. The pig breeding has always been present in the farms of the region with the function of recovery and reuse of waste and for their ability to produce supplementary income. It is bred with a fully extensive system by reproducing itself in the bush without any particular precaution using the resources made available by the pastures and the forest. A study of Aronica et al. [4] showed that almost all the farmers (88%) are only responsible of the breeding, whereas other professionals are in charge of processing and selling products.

4. Organisations for breeding, monitoring and conservation

The Italian Pig Breeders Association (ANAS) is the organisation responsible for monitoring the breed, which is not interested by a selection scheme and the exclusion of the animals from the herdbook is based only on morphological characteristics. Indeed, the activity is aimed at the conservation of the breed with particular regard to the maintenance of genetic variability. In 2003, a private association was

Name of organisation	Address	Web and e-mail address
Associazione Nazionale Allevatori Suini (ANAS)	Via Lazzaro Spallanzani 4, 00161 Rome, Italy	www.anas.it
Consorzio di tutela 'Suino Nero dei Nebrodi'	C/da Forte, 10–98069 Sinagra (ME), Italy	consorzionerosicilia@tiscali.it

Table 2.
Contact details of breeding organisations for Nero Siciliano pig breed.

established (Consorzio di Tutela Suino Nero dei Nebrodi) promoted by the Regional Breeders Association of Sicily in the province of Messina, within the Natural Park of Nebrodi. The activity of the Consortium is aimed at the protection and diffusion of the Nero Siciliano pig through the recognition of PDO that allows the enhancement of its meat and derived products (**Table 2**).

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. According to survey performed within TREASURE project, the age of sows at first parturition is 30 months [9], whereas age at culling is 47 months [1]. The only information reporting these traits does not allow making highly reliable inferences but, nevertheless, the relatively low age at culling could be due to the presence both of sows culled after the first event and of sows at the end of their productive life. It is actually quite frequent that the farmer tests the females keeping only some of them for reproductive career. Sows of Nero Siciliano pig breed have 1.1 litters per year [5] with 6.2–9.0 piglets [3, 5, 7, 11] of approximately 1.4 kg live body weight [7, 9, 10]. Stillborn percentage of piglets (0.4 and 4.8%; [3, 7]) and piglet mortality rate until weaning (1.3 and 8.9%; [3, 7]) are relatively low in the considered studies. As in most of extensive systems of rearing, farrowing interval is prolonged, in comparison to modern intensive systems to 332 days [5].

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as early and middle fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg live body weight, respectively. No studies on late fattening period were found even if, sometimes, the source provided the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that most of the

References	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Farrowing interval (d)	Sow age at culling (mth)
[3]	–	–	7.8	–	0.4	8.9	–	47
[5]	–	1.1	7.3	–	–	–	332	–
[6]	–	–	–	–	–	–	–	–
[7]	–	–	6.2	1.4	4.9	1.3	–	–
[8]	–	–	–	–	–	–	–	–
[9]	30	–	–	1.5	–	–	–	–
[10]	–	–	–	1.5	–	–	–	–
[11]	–	–	9.0		–	–	–	–

No. = number, mth = month, BW = body weight, d = days.

Table 3.
Summary of collected literature data on traits of reproduction in Nero Siciliano pig breed.

References	Feeding	No. of animals	ADG fattening[1]			ADG birth-slaughter
			Early	Middle	Overall	
[1]	–	–	–	–	600	–
[10]	–	31	–	–	253	–
	–	9	–	–	191	–
[11, 12]	–	–	–	–	–	211
[13]	–	12	–	465	465	–
	–	12	–	346	346	–
	Rest	10	–	–	358	–
	Rest	10	–	–	393	–
[14]	Rest	20	–	264	264	–
	Rest	20	–	162	162	–
[15, 16]	Rest	15	328	–	328	–
	Rest	15	360	–	360	–
[17]	Rest	10	–	–	431	–
	Ad Lib	10	–	–	540	–
[18, 19]	–	37	241	333	287	–
	Rest	41	–	–	208	–

No. = number; ADG = average daily gain in g; Ad Lib = ad libitum feeding regime; Rest = restrictive feeding regime.
[1]ADG in a period of fattening is reported for early and middle fattening stages estimated between approximately 30–60 kg and 60–100 kg, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on growth performance in Nero Siciliano pig breed.

collected studies simulated practical conditions of the production systems used. Only the study of Liotta et al. [17] actually aimed at evaluating the breed potential for growth in *ad libitum* conditions of feeding, showing that maximal growth rate of Nero Siciliano pigs is 540 g/day in overall fattening stage (observed from 42 to 93 kg live weight; [17]). In the considered studies, data for average daily gain in lactation and growing period were not found, whereas reported average daily gains in early, middle and overall fattening stage were low and variable (241–360,

References	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]	
					Middle	Overall
[14]	Rest	12.8	15.19	20	1.5	–
	Rest	10.3	10.27	20	2.2	–
[15]	Rest	13.1	15.91	10	–	1.72
	Ad Lib	13.1	15.91	10	–	2.93

No. = number, ADFI = average daily feed intake in kg/day, Ad Lib = ad libitum feeding regime, Rest = restrictive feeding regime; ME = metabolisable energy, CP = crude protein.
[1]ADFI in a period of fattening is reported for early fattening stage estimated between approximately 30 and 60 kg. Sometimes, the source provided only the overall daily feed intake for the whole fattening period (in that case defined as overall).

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Nero Siciliano pig breed.

162–465 and 162–600 g/day in early, middle and overall fattening stage, respectively). Also, average daily gain in the period from birth to slaughter (at 18 months of age) observed for Nero Siciliano pig in QUBIC project was much lower compared to modern breeds of pigs (211 g/day; [11, 12]).

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. Average daily feed intake reported was 1.5–2.2 kg/day in middle fattening stage and 1.7–2.9 kg/day in overall fattening stage [14, 15]. Observing the average feed intakes registered in the different fattening periods and considering the low slaughter weights achieved, it could be argued that the feed transformation efficiency is quite low.

5.3 Body composition and carcass traits

Basic data obtained in this review for some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, the age at slaughter for Nero Siciliano breed ranges from 169 to 730 days of age [10, 15–20], with live weight ranges from 62 to 121 kg [10, 13–20]. These results actually indicating three different orientations of the farmers: one system with older animals and quite high slaughter weights, a second one producing small carcasses with middle age animals (approximately 1 year of age) and a last one devoted to produce light carcasses (60 kg). Dressing yield in considered studies was around 80% [1, 10, 13–20] and lean meat content varied from 39.7 to 59.0% ([13,

References	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Back fat thickness (mm)		
							S[1]	At withers	At last rib
[1]	–	–	–	105	80.0	–	–	–	–
[10]	31	380	96	78	81.1	–	–	–	–
	9	452	86	71	82.9	–	–	–	–
[13]	12	–	121	98	81.0	–	–	–	42
	12	–	110	88	80.5	–	–	–	34
	10	–	97	77	79.4	58.2	–	–	42
	10	–	102	82	80.8	59.0	–	–	49
[14]	20	–	110	89	80.6	–	40	–	34
	20	–	100	81	81.2	–	30	–	28
[15, 16]	15	169	62	45	72.9	48.7	–	–	17
	15	169	67	54	79.9	49.9	–	–	23
[17]	10	339	83	64	76.8	42.3	35	–	32
	10	339	93	74	79.1	39.7	49	–	39
[18, 19]	37	448	102	83	82.5	–	45	–	37
	41	487	88	82	81.9	–	39	–	33
[20]	15	730	107	89	82.9	–	46	52	47

No. = number, BW = body weight; CW = carcass weight.
[1]S back fat thickness measured according to ZP method [above Gluteus medius muscle (mm)].

Table 6.
Summary of collected literature data on body composition and carcass traits in Nero Siciliano pig breed.

References	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	IMF fatty acid composition[2] (%)				BFT fatty acid composition[3] (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[10]	31	6.07	5.51	52	–	–	–	–	–	–	–	–	–	–	–
	9	–	–	49	–	–	–	–	–	–	–	–	–	–	–
[13]	12	6.12		49	10.6	10.1	3.7	39.66	48.9	11.44	3.4	–	–	–	–
	12	6.28		46	10.1	11.4	3.0	34.04	59.93	6.03	13.0	–	–	–	–
	10	6.38		–	–	–	10.0	–	–	–	–	–	–	–	–
	10	6.14		–	–	–	5.7	–	–	–	–	–	–	–	–
[14]	20	6.28	5.65	46	11.0	12.4	5.6	35.7	58.9	5.44	37.8	–	–	–	–
	20	6.38	5.64	47	11.4	13.4	4.6	35.6	58.6	5.79	33.1	–	–	–	–
[15, 16]	15	6.37	5.65	61	–	–	2.7	38.6	49.3	12.1	7.5	40.9	49.1	10.0	9.7
	15	6.34	5.56	61	.	.	3.1	41.4	49.5	9.1	10.8	41.0	47.6	11.4	13.8
[18, 19]	37	6.29	–	47	15.3	4.9	3.3	–	–	–	–	38.3	47.4	14.5	18.3
	41	6.18	–	50	14.7	5.8	4.3	–	–	–	–	35.8	53.3	10.9	10.7
[20]	15	6.06	5.45	51	15.7	4.6	–	–	–	–	–	–	–	–	–

No. = number, pH 45 = pH measured approximately 45 min post-mortem; pH 24 = pH measured approximately 24 h post-mortem; IMF = intramuscular fat; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

[1]*CIE = objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.*

[2]*For fatty acid composition of intramuscular fat tissue in longissimus muscle, only pigs on control diet were considered, and when fatty acid composition was reported separately for neutral and polar lipids, values reported for neutral lipids were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*
[3]*For fatty acid composition of back fat tissue, only pigs on control diet were considered and when fatty acid composition was reported separately for outer and inner layers, values reported for outer layer of back fat tissue were considered. Control diets differed among studies, to see diet composition address to the corresponding source.*

Table 7.
Summary of collected literature data on meat quality in Nero Siciliano pig breed.

15–17]; SEUROP classification). The back fat thickness value measured on the withers was 52 mm [20], from 17 to 49 mm at the level of last rib [13–20] and from 30 to 49 mm above *gluteus medius* muscle [14, 17–20]. No data providing measurements of muscularity were found in considered studies.

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *longissimus* muscle that could be compared are presented in **Table 7**. In the studies reporting meat quality of Nero Siciliano pigs, pH measured in *longissimus* muscle at 45 min and 24 h *post-mortem* was on average 6.24 [10, 13–16, 18–20] and 5.58 [10, 14–16, 20], respectively. Intramuscular fat content in the considered studies ranged from 2.7 to 10.0% [13–16, 18, 19], increasing with slaughter weight. Colour measured in CIE L, a, b colour space was very variable (46–61, 10.1–15.7 and 4.6–13.4 for L, a* and b*, respectively). SFA, MUFA and PUFA content of intramuscular fat in *longissimus* muscle were approximately 37.5, 54.2 and 8.3% [13–16], whereas SFA, MUFA and PUFA content of back fat tissue in the considered studies were around 39.0, 49.4 and 11.7% [15, 16, 18, 19], respectively.

6. Use of breed and main products

The Nero Siciliano breed is raised with a full extensive system. Animals are raised in wide areas of Nebrodi Natural Park (woods of beech and oak trees) limited by fences, exploiting the natural pastures used for grazing: food integration is provided only during the gestation period. In few cases, close to the slaughter weight, the animals are captured and submitted to a finishing phase with a diet based on cereals. Breeders have very small companies and, in most cases, they are also transformers. Their products are intended for family consumption or subject to small local exchanges as well as to local and national markets. The meat of Nero Siciliano is extremely sapid, ruby red coloured, suitable for typical products such as the salami of 'S.Angelo', the Troinese sausage, the Nebrodi bacon and the Nicosia ham. The Sant'Angelo salami obtained the PGI since 2008 even if Nero Siciliano could be employed in this production only with cross-bred animals.

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Chapter 19

Sarda Pig

Riccardo Bozzi, Maurizio Gallo, Claudia Geraci, Luca Fontanesi and Nina Batorek-Lukač

Abstract

Sarda pig breed (a.k.a. Suino Sardo) is a local breed from Sardinia Island (Italy) with its ancestors dating back to the Nuragic period. It is the most recent breed interested by a conservation programme among the six Italian autochthonous pig breeds investigated by the H2020 project TREASURE and could be considered untapped in terms of information on its performances and products. Thirteen farms were registered at the last census (2015) including sixty-one breeding sows and twenty boars. It is a small size breed with black, grey, tawny or spotted coat colour. On average, age at parturition is 15.7 months, with 1.6 litters per year and 7.8 piglets per parity. Average piglet mortality is rather high in the considered studies (16.1%). The average daily gain for Sarda pig within the considered studies was 423 g/day. On average, daily feed intake in the overall fattening stage was 2.3 kg/day. Sarda pigs were slaughtered at approximately 686 days of age, at an average live weight of 193 kg. Sporadic information is available for meat quality traits. Although studies on Sarda pig are scarce, the current review gives the first insight into this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Italy

1. History and current status of the breed (census)

The Sarda or Suino Sardo is a breed of domestic pig from the Mediterranean island of Sardinia (Italy). Evidences of the present pig population in Sardinia date back to 2nd millennium BC [1]. Nuragic sites have returned large quantities of bones and some bronze representations of domestic pigs. Historical and bibliographic research and field surveys have shown that pig breeding in Sardinia has ancient origins documented by numerous prehistoric and historical traces [2]. During the Roman domination, due to the tributes that Sardinia was forced to pour and to the presence of large areas of oaks in the island, there was an increase in pig breeding. Medieval period reported various written records on pig breeding. For instance, the “Codice Rurale di Mariano IV” reported the fees for who leave the pigs on the vineyards as well as the rule that forbid to introduce pigs in the pastures during the fall and winter periods. Sarda pigs and wild boars have been sympatric for centuries in the region, and it has recently been showed that Sarda pig breed belongs to *Sus scrofa meridionalis* subspecies [3, 4]. Since 2006, the breed conservation program based on several small breeding nuclei is active. Presently, there are 13 registered farms of Sarda pigs with about 61 breeding sows and 20 boars in the latest available status [5]. Census of Sarda pig breed is presented in **Figure 1**.

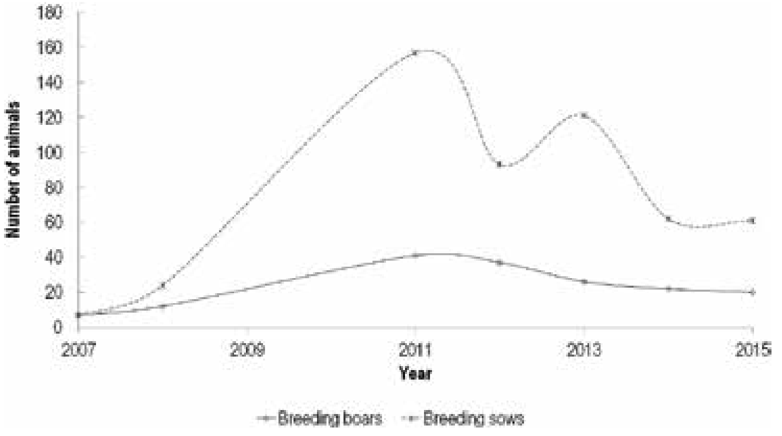

Figure 1.
Census of Sarda pig breed, presenting number of sows and boars per year, starting with the year of heard book establishment.

2. Exterior phenotypic characteristics

The Sarda is a small size breed with black, grey, tawny or spotted coat colour (**Figures 2** and **3**). The bristles are numerous, long and rough, and on the dorsal line, they make up a mane. A lumbar tuft is possible. The head is of medium development, cone-shaped with a straight profile, small ears kept high up or leaning on the side. Wattles are sometimes present. Long tail with bristles sometimes forms a characteristic "horse" tail. Even if the breed presents large phenotypic variability, some morphological traits are considered indicators of crossbreeding and are thus cause of exclusion from the registry: absence of bristles, totally depigmented skin, straight ears, concave profile, striated cloak or agouti, presence of white band, even partial, on the chest. Sows of Sarda breed have on average 12.7 teats.

Figure 2.
Sarda sow with piglets (photo credit LAORE Sardegna).

3. Geographical location and production system

Sarda pigs are raised mainly in the provinces of Ogliastra and Nuoro but are also present in those of Medio Campidano and Sassari and in the Sarrabus-Gerrei subarea. These are the classical areas of pig breeding in Sardinia as already reported by Cetti [6]. The local pig is bred in the wild or semi-wild without any type of

Figure 3.
Sarda boar (photo credit S. Porcu).

control or fences with frequent exchanges between wild boars and domestic pigs. This is one of the reasons of the difficult eradication of the African swine fever (ASF) disease as reported by Jurado et al. [7]. Animals often graze on public lands, with minimal recourse to shelters consisting of hollow trunks or shelters (in wood and/or stone). Animals are fed mainly on the natural resources of the oak and chestnut woods where they graze freely; the integration is minimal and commonly consists of cereals (flour or grain) or legumes, offered during periods of food shortage. With this production system, the animals remain in the herd during more than 1 year and they are slaughtered quite old. It is thus common to simultaneously have young pigs, middle aged pigs, and old animals (up to 3 years of age and more than 100 kg). Furthermore, seasonality of the events (births and slaughters) is a common management practice in Sarda breed. Animals are accustomed by the farmers to respond to their voice calls at pre-established points, where they receive the daily amount of food, directly offered on the ground [8].

4. Organisations for breeding, monitoring and conservation

The Italian Pig Breeders Association (ANAS) is the organisation responsible for monitoring the breed, and the activity is aimed at the conservation of the breed with particular regard to the maintenance of genetic variability. The regional body of Sardegna contributes to the initiatives aimed to preserve and valorize the breed posing special attention to ASF disease. A Consortium (Consorzio Produttori Suini di Razza Sarda) has also been established in 2010 (**Table 1**). Sarda breed has been officially recognized by the Italian Ministry of Agriculture in 2006.

Name of organisation	Address	Web or e-mail address
Associazione Nazionale Allevatori Suini (ANAS)	Via Lazzaro Spallanzani 4, 00161 Rome, Italy	www.anas.it
Consorzio Produttori Suino di Razza Sarda	Località Genn'Antine, 08049 Villagrande Strisaili (NU), Italy	c.s.r.s@tiscali.it

Table 1.
Contact details of breeding organisations for Sarda pig breed.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 2**. According to data registered in ANAS database [5], the age of sows at first parturition is 25.3 months, whereas the age at culling is 60 months. Sows of Sarda pig breed have 1.2–2.0 litters per year [9, 10] with 5.6–9.4 piglets [5, 9, 11] of only 0.3 kg live body weight [10]. Stillborn percentage of piglets and piglet mortality rate until weaning reported within collected studies are quite high (12.1–16.1 and 11.1–20.0%, respectively; [5, 9, 11]). Duration of lactation is prolonged in comparison to modern intensive systems (to 37 days; [11]), which leads to a longer farrowing interval (180–304 days; [9, 10]) and higher piglet weaning weight (7.7; [11]). Extended lactation in such production system serves also as protection against predators as well as to increase the learning process period in such unfavourable areas.

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 3** and **4**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that the major part of the collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies actually aimed at evaluating the breed potential for growth. In the considered studies, data on the average daily gain in lactation were not found, whereas reported average daily gains in growing, early, middle and late fattening stage were on average 342, 352, 494, and 525 g/day ([11, 15, 16], respectively), but it has to be pointed out that the obtained results within each stage were very different and thus the averages reported have to be considered cautiously. The average daily gain in the period from birth to slaughter reported for Sarda pig within the considered studies averages 423 g/day [10, 11], which is lower compared to modern breeds of pigs. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Sarda pigs in *ad libitum* conditions of feeding (≈910 g/day in late fattening stage and 657 g/day in overall fattening stage).

In considered studies, the information on feed intake and feed nutritional value were limited, which also limits the evaluation of growth potential. Average daily feed intake increased from approximately 1.1 kg/day [11] in growing stage to 3.6 kg/day [11] in late fattening stage (declared as *ad libitum* feeding), whereas average daily feed intake in the overall fattening stage was 1.7–2.7 kg/day [11]. In the context of the evaluation of feed intake, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the maximal feed intake of Sarda pigs in *ad libitum* conditions of feeding. Porcu [17] reports that Sarda pigs consumed 6.3 kg/day in late fattening stage when feed was offered on *ad libitum* basis (estimated between 98 and 294 kg body weight), whereas in overall fattening stage, maximal feed intake reported was 2.7 kg/day (estimated until 100 kg body weight; [11]).

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling (mth)
[5]	25.3		5.6	-	16.1	16.5	-	-	-	60
[9]	-	1.2	8.3	-	-	11.8	-	-	304	-
[12]	-	-	-	-	-	-	-	-	-	-
[11]	-	-	9.4	-	12.1	20.0	7.7	37	-	-
[13]	12.3	-	-	-	-	-	-	-	-	-
[14]	-	-	-	-	-	-	-	-	-	-
[10]	9.5	2.0	-	0.3	-	-	-	-	180	-

No. = number, mth = month and d = days.

Table 2.
Summary of collected literature data on reproduction traits in Sarda pig breed.

Reference	Feeding	No. of animals	ADG growing[a]	ADG fattening[b]			
				Early	Middle	Late	Overall
[11]	Ad Lib	24	368	368	-	-	368
	Ad Lib	24	-	-	414	-	392
	Ad Lib	24	416	-	-	-	-
	Ad Lib	24		-	-	-	522
	Ad Lib	24	-	-	-	341	422
	Ad Lib	24	153	-	-	-	-
	Ad Lib	24	-	312	-	-	312
	Ad Lib	24	-	-	466	-	326
	Ad Lib	24	377	377	-	-	377
	Ad Lib	24	-	-	603	454	450
	Ad Lib	-	397	-	-	-	-
	Ad Lib	-	-	-	-	-	657
	Ad Lib	-	-	-	-	622	529
[10]	-	-	-	-	-	-	300
[15–17]	Ad Lib	4	-	-	-	910	-
	Rest	4	-	-	-	351	-
	Rest	4	-	-	-	469	-

No. = number, ADG = average daily gain in g, Ad Lib = ad libitum *feeding regime, and Rest = restrictive feeding regime.*
[a]*ADG in growing period estimated from weaning to approximately 30 kg live body weight.*
[b]*ADG in a period of fattening is reported for early, middle, and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg, and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall growth rate for the whole studied period (in that case defined as overall).*

Table 3.
Summary of collected literature data on the average daily gain (in g) in Sarda pig breed.

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 5**. In considered studies, pigs of Sarda breed were slaughtered at approximately 686 days of age [15, 16, 18], at an average 193 kg live weight (106–294 kg; [15, 16, 18]) and reached dressing yield around 77% [10, 18]. The back fat thickness value measured at the withers varied from 30 to 85 mm [15, 16, 18], at the position of the last rib 28 mm [18] and at the level of last rib 41 mm [18]. No data providing measurements of muscularity were found in considered studies.

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *longissimus* muscle that could be found are presented in **Table 6**. The pH of meat for Sarda pig breed has been measured only

Reference	Feeding	CP content of feed (%)	No. of animals	ADFI growing[a]	ADFI fattening[b]			
					Early	Middle	Late	Overall
[11]	Ad Lib	17.0	24	1.6	1.6	-	-	-
	Ad Lib	12.0	24	-	-	2.9	2.9	2.3
	Ad Lib	18.6	24	1.0	-	-	-	-
	Ad Lib	16.8	24	-	-	-	-	2.7
	Ad Lib	17.3	24	-	-	-	2.8	2.4
	Ad Lib	19.0	24	0.6	-	-	-	-
	Ad Lib	16.0	24	-	1.5	-	-	-
	Ad Lib	15.0	24	-	-	2.8	-	1.7
	Ad Lib	13.5	24	1.4	1.4	-	-	-
	Ad Lib	12.0	24	-	-	2.5	2.8	2.1
	Ad Lib	18.6	-	0.9	-	-	-	-
	Ad Lib	16.8	-	-	-	-	-	2.4
	Ad Lib	17.3	-	-	-	-	3.4	2.5
[15, 17]	Ad Lib	-	4	-	-	-	6.3	-

No. = number, ADFI = average daily feed intake in kg/day, Ad Lib = ad libitum *feeding regime, ME = metabolisable energy, and CP = crude protein.*
[a]ADFI in growing period estimated from weaning to approximately 30 kg live body weight.
[b]ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes, the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).

Table 4.
Summary of collected literature data on the average daily feed intake (in kg/day) in Sarda pig breed.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness (mm)		
						S[a]	At withers	At last rib
[10]	-	-	-	75	77.0	-	-	-
[15–17]	4	671	294	-	-	-	85	-
	4	671	171	-	-	-	30	-
	4	671	202	-	-	-	40	-
[18]	15	730	106	82	77.2	41	32	28

No. = number, BW = body weight and CW = carcass weight.
[a]S back fat thickness measured according to ZP method (above Gluteus medius *muscle (mm)).*

Table 5.
Summary of collected literature data on body composition and carcass traits in Sarda pig breed.

by Porcu [17]. PH values in *longissimus* muscle at 45 min and 24 h *post mortem* was 6.07 and 5.98, respectively. Objective colour measured in CIE L, a and b colour space was 48, 14.4, and 8.5 for L, a* and b*, respectively [15–18]. No data providing measurements of intramuscular fat content and fatty acid composition of intramuscular or back fat were found in considered studies.

Reference	No. of animals	pH 45	pH 24	CIE[a]		
				L*	a*	b*
[15–17]	4	-	-	48	16.0	9.9
	4	-	-	50	15.4	10.0
	4	-	-	52	14.9	10.1
[18]	15	6.07	5.98	40	11.2	4.0

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem*, and pH 24 = pH measured approximately 24 hours* post-mortem.
[a]CIE = objective colour defined by the Commission Internationale de l'Eclairage, L greater value indicates a lighter colour, a* greater value indicates a redder colour and b* greater value indicates a more yellow colour.*

Table 6.
Summary of collected literature data on meat quality in Sarda pig breed.

6. Use of breed and main products

More than 50% of Sarda pig farmers raise the animals for the entire cycle producing traditional cured meats used for family needs. The part exceeding self-consumption is sold on the local market, especially during the summer period with a high number of tourists present in the island. The main products are represented by sausages, bacon (rolled up or not), "guanciale" and "coppa" as well as cured ham and shoulder. Equally important is the consumption of piglets, slaughtered at the age of 35–45 days, which is one of the traditional dishes of typical Sardinian cuisine. Besides these classical products, it is possible to recognize three different local productions never recorded in the atlas of typical products: traditional ham, shoulder ham with bacon, and "sartizza a lorika". This last product is a very long sausage that can even exceed 3 metres in length with a spiral shape [19] and recalls the sausages known as the "longaones" [20] described in the Roman period. Currently, Sarda pig breed and its products face two major problems: the presence of ASF, difficult to control and eradicate due to the type of breeding and the presence of many unrecognized farms (for which it is difficult to establish the real consistency of the animals belonging to the native breed; [21]).

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Chapter 20

Schwäbisch-Hällisches Pig

Matthias Petig, Christoph Zimmer, Rudolf Bühler and Nina Batorek-Lukač

Abstract

The traditional, local breed Schwäbisch-Hällisches Schwein is originally located in the region of Hohenlohe in Baden-Württemberg, which still is the main breeding area. The breed was developed since nearly 200 years ago by the local farmers and is well adapted to the regional conditions. Next to the genetic value of the old breed in terms of biodiversity, it is the basement for a sustainable local pork chain. In terms of scientific substantiation, their performances and products are mainly untapped. Thus the aim of the present chapter is to present history and current status of Schwäbisch-Hällisches pig breed, its exterior phenotypic characteristics, geographical location, production system and main products from this German autochthonous breed of pigs, one of the local pig breeds investigated in the project TREASURE. Moreover, a collection and review of available literature data, available until August 2017, on reproductive and productive traits of Schwäbisch-Hällisches pig breed were carried out. Meat quality of *longissimus* muscle completed the conventional productive traits as it is of great interest in autochthonous breeds. Although studies on Schwäbisch-Hällisches pig are scarce, current review gives the first insight into this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Schwäbisch-Hällisches, Germany

1. History and current status of the breed (census)

The Schwäbisch-Hällisches is a breed of domestic pig originating from Schwäbisch Hall in Baden-Württemberg. It is the oldest autochthonous pig breed in Germany. Arising in 1821, when Chinese pigs were crossed with local pigs in Württemberg, the breed got regional importance in Northern Württemberg [1–3]. The fact that this breed developed most successfully in the area of Schwäbisch Hall explains its name. In the following decades, the breed was prosperous in many parts of Württemberg. At the beginning of the twentieth century, the import of pig breeds from England leads to a melting pot of different breeds, and the original Schwäbisch-Hällisches could only be found in its traditional region Schwäbisch Hall/Hohenlohe. With the establishment of breeding associations in the 1920s, the breed developed well and population increased [4]. The most remarkable prosperity period in its long history was the 1950s. The highest population of 3149 herdbook animals, which means 12% of the West-German pig herdbook population, was counted in 1954 [5–7]. Next to herdbook sows, there were counted about 18,000 Schwäbisch-Hällisch sows in 1939 and about 33,000 in 1955 [8, 9]. The low lean meat content of the breed together with a rapidly decreasing demand for fat caused the demise of Schwäbisch-Hällisch pigs in the 1960s and 1970s. The herdbook was closed in 1970, and only few farmers preserved the breed in their herds. In the

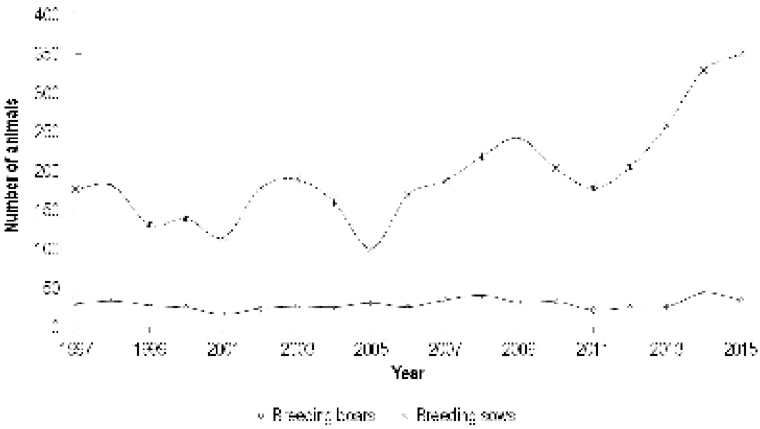

Figure 1.
Census of Schwäbisch-Hällisches pig breed, presenting number of sows and boars per year, development since the late 1990s.

1980s, the breed was nearly extinct [3]. The Schwäbisch-Hällisch pig was saved by the Farmers' Association of Schwäbisch Hall (BESH), which was build up to find new sales channels for the old breed. The breeding association Züchtervereinigung Schwäbisch-Hällisches Schwein (ZVSH) started in 1986. Two years before, the registration of few remaining sows and boars founded the new herdbook of the old breed. Nowadays the pigs are slaughtered at a slaughterhouse owned by BESH, and the meat products are sold in the regional marketing programme with focus on prominent meat quality. As a consequence of the success of the marketing programme, the population recovered in the following years and grew until now in a sustainable way. Presently there are 15 registered farms of Schwäbisch-Hällisches pig with about 350 breeding sows and 35 boars in the latest available status (August 2015). Moreover there are more than 3000 sows which are used for cross-breeding [10]. The census of Schwäbisch-Hällisches pig breed is presented in **Figure 1**.

2. Exterior phenotypic characteristics

The Schwäbisch-Hällisches pig breed morphology information is summarised in **Table 1**. It is a medium to large size breed, white in the centre, with a black head and rear and narrow grey bands at the transition from white to black skin (**Figures 2** and **3**). The legs are white in general. The breed's typical attributes are furthermore large lop ears and, as a heritage of the Chinese pigs, a wrinkled forehead. The Schwäbisch-Hällisches is a typical mother breed. Due to breeding activities towards high fertility and milk production, the number of teats is high (**Table 1**). On average there are 15–16 teats per animal [10, 11].

Measurement (average)	Adult male	Adult female
Body weight (kg)	350	280
Ear length (cm)	28	27
Height at withers (cm)	95	86
Number of teats	14–20	14–20

Table 1.
Summary of morphology information on Schwäbisch-Hällisches pig breed.

Figure 2.
Schwäbisch-Hällisches sow with piglets.

Figure 3.
Schwäbisch-Hällisches boar.

3. Geographical location and production system

Schwäbisch-Hällisches pig is raised mainly in the region of Hohenlohe in Baden-Württemberg, Germany. The traditional and actual locations of Schwäbisch-Hällisches pig are in particular the administrative districts Schwäbisch Hall, Hohenlohe, Rems-Murr, Tauberbischofsheim, Ostalbkreis and Ansbach (all in all about 8000 km^2). Moreover there are, with lower density, Schwäbisch-Hällisch pigs in some neighbour districts of the core region and in addition singular farms in other parts of Germany, also in Austria [10]. The animals are housed in barns where they have, in comparison to the conventional German pig husbandry, more space allowance and additional straw bedding [3, 12]. The farms are, typical for the region, small and medium scaled, which means that they are family farms with, in most cases, no other employees. High standards, namely, the raising and slaughtering in the autochthon area of the breed, animal friendly husbandry, abandonment of antibiotics in the fattening period and GMO-free feeding, fulfil the PGI specification and therefore allow the farmers to sell the pigs in this programme (Protection of Geographical Indications), a standard given by the European Commission [13]. In summer, there are also pigs on the pasture. The pastures are equipped with shelters and feeding/water stations. Additional to free intake of grass, these pigs have access to a feed mixture based on grain, acorn and a protein source. The outdoor keeping and the acorn feeding are two special traits which define significantly the premium programme "Eichelmastschwein" [14].

4. Organisations for breeding, monitoring and conservation

Since 1986, Schwäbisch-Hällisches pig breed is run and monitored by the breeding association ZVSH.[1] Fifteen herdbook breeders perform pure breeding through planned mating to preserve and develop the breed Schwäbisch-Hällisches pig. Special attention is given to the nine different boar lines of the population and avoidance of inbreeding in general. Artificial insemination (four boars are on a boar station) as well as natural mating is practised. A defined sample of semen is stored in a national cryobank. The selection of young breeding animals takes place with an age of 6–7 months. Only the best animals regarding pedigree, conformation and growing can be used for pure breeding later on. The BLUP animal model is used for breeding value estimation [10].

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 2**. The age of sows at first parturition is approximately 12.7 months [17, 18]. The sows of Schwäbisch-Hällisches pig breed have 2.2 litters per year [15, 17] with 10.6–11.6 piglets [15–17] of 1.6 kg live body weight [16, 17]. Stillborn percentage of piglets is 5.7% [16], whereas piglet mortality rate until weaning in the considered studies ranges between 5.6 and 10.3% [15–17]. Duration of lactation is prolonged in comparison to modern intensive systems (to 32 days [16]); the length of the farrowing interval 169 [15, 17] is higher as well. Although data on reproduction performance of Schwäbisch-Hällisches pig breed are scarce, it can be concluded that this breed of pigs has excellent fertility, especially in comparison to other traditional breeds of pigs.

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 3** and **4**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as stage of lactation and growing phase (in this case from birth to approximately 30 kg

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Duration of lactation (d)	Farrowing interval (d)
[15]	–	2.2	10.6	–	–	5.6	–	167
[16]	–	–	11.6	1.6	5.7	10.3	32	–
[17]	13.3	2.1	10.7	1.6	–	9.3	–	171
[18]	12.0	–	–	–	–	–	–	–

No. = number, mth = month, d = days.

Table 2.
Summary of collected literature data on reproduction traits in Schwäbisch-Hällisches pig breed.

[1] Züchtervereinigung Schwäbisch-Hällisches Schwein (ZVSH); Raiffeisenstraße 5, 74,549 Wolpertshausen, Germany; Web address: https://www.besh.de/erzeuger/zvsh/; E-Mail address: christoph.zimmer@besh.de

Reference	Feeding	No. of animals	ADG lactation and growing[1]	ADG fattening[2]			ADG birth-slaughter
				Early	Late	Overall	
[16]	–	25	404	–	–	761	–
	–	24	406	–	–	760	–
	–	9	403	–	–	763	–
[18]	–	–	–	–	–	850	–
[19]	–	40	355	–	–	800	–
[20]	–	–	378	–	–	776	–
[21]	–	–	384	–	–	773	–
[22]	Ad Lib	51	–	–	–	828	–
[23]	–	31	–	–	–	700	–
[24]	–	147[3]	420	671	730	721	609

No. = number; ADG = average daily gain in g; Ad Lib = ad libitum feeding regime.
[1]*ADG in lactation and growing period estimated from birth to approximately 30 kg live body weight.*
[2]*ADG in period of fattening is reported for early and late fattening stages estimated between approximately 30–60 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as the overall).*
[3]*The average number of animals observed (min 52, max 210).*

Table 3.
Summary of collected literature data on growth performance in Schwäbisch-Hällisches pig breed.

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]		
					Early	Middle	Overall
[19]	–	16	17	40	–	–	2.39
[20]	–	14	17	–	–	–	2.34
[21]	–	13	16	–	–	–	2.42
[22]	Ad Lib	13	–	51	2.45	2.45	–
[23]	–	–	–	31	1.98	2.34	–

No. = number, ADFI = average daily feed intake in kg/day; Ad Lib = ad libitum feeding regime, ME = metabolisable energy, CP = crude protein.
[1]*ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30–60 kg and 60–100 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).*

Table 4.
Summary of collected literature data on average daily feed intake (in kg/day) in Schwäbisch-Hällisches pig breed.

live body weight) and the overall growth rate for the whole fattening stage (defined as overall). There is data about the growth from birth to slaughter as well. It should also be noted that majority of collected studies simulated practical conditions of the production systems used. Only the study of Brandt et al. [22] actually aimed at evaluating the breed potential for growth in ad libitum conditions of feeding, showing that maximal growth rate of Schwäbisch-Hällisches pig is 828 g/day in overall fattening stage (observed from 32 to 115 kg live weight; [22]). The average daily gain in the stage of lactation and growing phase was approximately 393 g/day (355–420 kg/day [16, 19–21, 24]) and 773 g/day in the overall fattening stage (700–850 kg/day [16, 17–24]), which is comparable to modern breeds of pigs.

In considered studies, the information on feed intake and feed nutritional value were limited (max n = 3), which also limits the evaluation of growth potential. Average daily feed intake increased from approximately 2.2 kg/day in the early fattening stage to approximately 2.4 kg/day in middle fattening stage [22, 23], whereas average daily feed intake in the overall fattening stage was in average 2.4 kg/day [19–21].

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 5**. In considered studies, pigs of Schwäbisch-Hällisches pig breed were slaughtered at approximately 183 days of age (178–192 days [19–21]) and at an average of 112 kg live weight (109–120 kg [19–23]) and reached an average dressing yield of 76% (74–78% [19–23]). The backfat thickness value measured on the withers was 46 mm [22] and at the position of the last rib 28 mm in average [19–22]. Within the considered studies, lean meat content was approximately 52% [22, 23], and loin eye area of *longissimus* muscle was 40 cm^2 [22, 23].

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat quality traits measured in *longissimus* muscle that could be found are presented in **Table 6**. In few studies reporting meat quality of Schwäbisch-Hällisches pig, pH measured in *longissimus* muscle at 45 min and 24 h *post mortem*

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)		Loin eye area (cm^2)
							withers	last rib	
[18]	–	–	–	90	–	–	–	–	–
[19]	40	178	109	85	77.6	–	–	29	–
[20]	55	178	109	84	77.4	–	–	29	–
[21]	56	192	110	94	76.6	–	–	30	–
[22]	51	–	115	85	74.4	51.7	46	25	40
[23]	31	–	120	–	76.2	52.9	–	–	41

No. = number, BW = body weight; CW = carcass weight.

Table 5.
Summary of collected literature data on body composition and carcass traits in Schwäbisch-Hällisches pig breed.

Reference	No. of animals	pH 45	pH 24	Intramuscular fat content (%)
[19]	40	6.38	5.48	2.1
[20]	55	6.41	5.55	2.3
[21]	56	6.65	5.62	2.1
[23]	31	–	–	1.8

No. = number, pH 45 = pH measured approximately 45 min post mortem; pH 24 = pH measured approximately 24 h post mortem.

Table 6.
Summary of collected literature data on meat fat quality in Schwäbisch-Hällisches pig breed.

were 6.48 and 5.55 [19–21], respectively. The intramuscular fat content ranged from 1.8 to 2.3% [19–23], whereas data providing measurements of objective colour and fatty acid composition of intramuscular fat or backfat were not provided within the considered studies.

6. Use of breed and main products

Fresh meat and ham, sausages and other products made of pork are sold on a premium market for high-quality regional products. The meat is labelled as protected geographical indication (PGI [25]). The pigs have to be born, raised and fattened in the county Schwäbisch Hall or in one of the five neighbouring counties. Only the herdbook breeding is allowed to take place outside the PGI region. The sausages are produced directly at the slaughterhouse. They are produced without any technological or artificial additives. Only natural ecological herbs and spices are used. For producing without phosphate, the sausages are manufactured with warm meat directly after slaughtering. The association of farmers "Bäuerliche Erzeugergemeinschaft Schwäbisch Hall" organises the marketing and distribution of the products. It has seven own markets and 350 butchers as customers. The PGI-SH-Meat is produced with special standards comprising the region, animal welfare and GMO-free feed. Next to this niche market, there are two others which are smaller: ecological meat from Schwäbisch-Hällisches pigs and Eichelschwein meat from Schwäbisch-Hällisches pigs (acorn-fed Schwäbisch-Hällisches pigs). The last production line includes obligatorily acorn feeding and outdoor keeping on the pasture and/or in the forest. Only pure breed Schwäbisch-Hällisches pigs are allowed. For the first two production lines, Schwäbisch-Hällisches pure breeds and crossbreeds with a stress-resistant boar-line are possible.

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Chapter 21

Turopolje Pig (Turopoljska svinja)

Danijel Karolyi, Zoran Luković, Krešimir Salajpal, Dubravko Škorput, Ivan Vnučec, Željko Mahnet, Vedran Klišanić and Nina Batorek-Lukač

Abstract

Turopolje pig is a fatty-type pig breed created during the Middle Ages in Turopolje region in Central Croatia. Due to its modest demands, resilience and good adaptation to outdoor rearing, the Turopolje pig has been an important food source for the local population for centuries. However, with the transition from extensive to intensive pig production in the middle of the twentieth century, this autochthonous pig breed almost disappeared. Currently, despite the state support, Turopolje pig is still endangered, with a population of only 116 sows and 14 boars. Hence, to preserve Turopolje pig breed in a more sustainable way, the breed needs to be more economically exploited and scientifically explored. Thus, the aim of this chapter is to present history and current status of Turopolje pig breed, its exterior phenotypic characteristics, geographical location, production system and main products. Moreover, a collection and review of available literature data (available until August 2017) on reproductive and productive traits, including growth performance, carcass traits and meat and fat qualities of Turopolje pig breed, were carried out. Although studies on Turopolje pig are scarce, the present review gives the first comprehensive insight into this still untapped local breed of pigs investigated in the project TREASURE.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, Croatia

1. History and current status of the breed (census)

Turopolje pig is a native Croatian breed, created during the early Middle Ages in Turopolje region near Zagreb in Central Croatia. It is a medium-sized, primitive, fatty-type pig breed. As it developed over a long period of time, the breed perfectly adapts to its natural environment, primarily continental climate conditions and lowland forest ecosystems. Due to the modest demands, resistance and good adaptation to local marsh pastures and oak and beech forests, the Turopolje pig breed for centuries has been an important food source for the local population. However, the rapid penetration of imported lean pigs in the second half of the twentieth century, as well as the ban of forest grazing, significantly reduced the interest in this breed. The result was an emerging decrease of the population size, and since 1996, the Turopolje pig breed is under the state protection. Unfortunately, despite the support the Turopolje pig breed is still endangered, and the renewal of the population has been very slow. Census of Turopolje pig breed is presented in **Figure 1**. Presently, there

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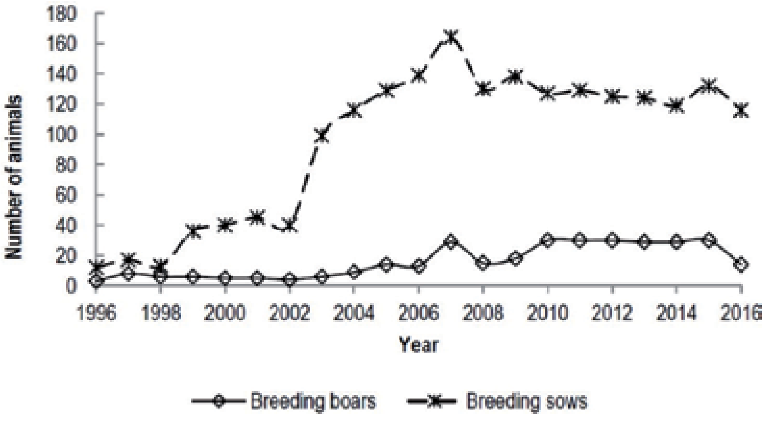

Figure 1.
Census of Turopolje pig breed, presenting number of sows and boars per year, starting with the year of heard book establishment.

are only 12 registered farms of Turopolje pigs with about 116 breeding sows and 14 boars in the latest available status (August 2016 [1]). In the past, the meat of Turopolje pig was considered better than meat of other pig breeds [2], but today its use is sporadic and almost completely replaced with the meat of modern pig breeds and hybrids. However, as a part of the current trends in the protection of local breeds and their sustainable farming systems, it becomes justified to review the breeding of Turopolje pig breed for production of meat and local meat products. Renovation of traditional link between breed and its products and their technological and marketing development may, by itself, represent the best way for recovery and long-term preservation of Turopolje pig breed on economically sustainable base.

2. Exterior phenotypic characteristics

The Turopolje pig breed morphology information is summarized in **Table 1**. It is a medium-size breed with distinctive sporadic black spots on a white or gray coat, mostly curly hair and drooping, half-folded ears (**Figures 2** and **3**). Head is medium long with slightly concave profile and sturdy snout, which ensures a good

Measurement (average)	Adult male	Adult female
Body weight (kg)	106.0	96.6
Body length[1] (cm)	70.0	72.7
Head length (cm)	28.0	27.0
Tail length (cm)	30.0	29.9
Ear length	22.0	22.5
Chest girth (cm)	116.0	111.2
Height at withers (cm)	67.0	65.2

[1]*Measured from the tip of the nose to the starting point of the tail.*

Table 1.
Summary of morphology information on Turopolje pig breed.

Figure 2.
Turopolje sow with piglets.

Figure 3.
Turopolje boar.

rooting ability. Body constitution is firm, but not muscular. Legs are high, with solid joints. Frame is short and not too deep. Back is medium in width and slightly lowered at croup; shoulders and hams are less developed. Breed is lively tempered and curious.

3. Geographical distribution and production system

Turopolje refers to a plain extending over a 45-km-long and 23-km-wide alluvial plateau, occupying an area of about 600 km^2, with an average altitude of 110 m above sea level. It is located between Posavina (wetland plains along the Sava River) in the north and the Vukomeričke gorice (low altitude hills) in the south. The Odra River flows through it with the Lomnica tributary. Characterized by lowland oak forests, periodically flooded pastures and continental climate, Turopolje has always been suitable for outdoor livestock production, especially pig breeding. In the past Turopolje pig breed spread from Turopolje to Sisak and Draganić, later to the parts of Slavonija and Podravina and all the way to the south-western parts of Hungary. However, with the transition from extensive to intensive pig production in the mid of twentieth century, its farming drastically reduced and the breed almost disappeared. Today, Turopolje pig is reared only in a few localities, mainly in Turopolje forest and Nature Park Lonjsko Polje (**Figure 4**), where traditional way of pig farming has been maintained. Basically, it comprises a low-input technology of animal housing and feeding in a fully outdoor system on pasture at local forests and marsh meadows. Pigs are provided with only a simple shelter, water and some supplemented feed (e.g., 0.5–2 kg

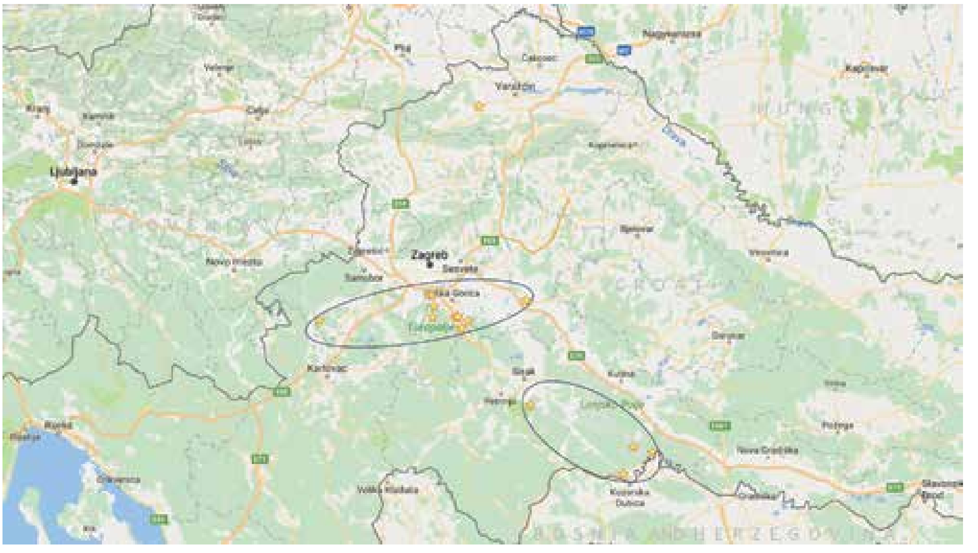

Figure 4.
Geographical distribution of Turopolje pig farms.

of corn per animal daily), while the majority of animal's diet is supplied from natural resources (e.g., acorn, grass, worms, snails, shellfish, etc.). Finishing at high-grain diet, prior to slaughter is usual. Indoor housing and intensive production systems are rarely practiced.

4. Organizations for breeding, monitoring and conservation

The Association "Plemenita Općina Turopoljska" (*Universitatis nobilium Campi Turopolya*) is the responsible breeding organization for Turopolje pig breed, assisted by Croatian Agricultural Agency, which monitors the population and keeps herd books (**Table 2**). Conservation of Turopolje pig breed started once Croatia signed Convention on Biological Diversity (CBD) in 1997, and breed was added to the FAO list of endangered breeds in category of regional breeds [3]. After CBD ratification a national biodiversity strategy was established, including an action plan for the conservation of endangered breeds. Since then Turopolje pig breed is under the state of renewal and *in situ* protection. Funds for conservation are provided by the state.

Name of organization	Address	Web address
Plemenita Općina Turopoljska (POT)	Zagrebačka 37, 10,410 Velika Gorica, Croatia	http://turopolje.hr/
Croatian Agricultural Agency (Annual reports 2008–2015)	Ilica 101, 10,000 Zagreb, Croatia	http://www.hpa.hr/sektori/sektor-za-razvoj-stocarske-proizvodnje/odjel-za-svinjogojstvo/izvorne-pasmine/

Table 2.
Contact details of breeding organization for Turopolje pig breed.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. The age of sows at first parturition is approximately 23 months [8, 9]. Sows of Turopolje pig breed have 0.5–2.5 litters per year [1, 4, 6, 8] with 4.5–6.7 piglets [1, 5–9] of 1.2 kg live body weight [5, 8]. The percentage of stillborn piglets and piglet mortality rate until weaning is relatively high in the considered studies (5.2–22.1 [1, 5–7] and 7.4–26.5% [1, 6], respectively). Duration of lactation is prolonged in comparison to modern intensive systems to 42 days [5, 7], which leads to a longer farrowing interval (312 days on average [1, 4, 6, 8]), but not to a higher weaning weight (4.2 kg [7]).

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. In Turopolje pig breed, studies provided only growth rate in period of lactation and the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that majority of collected studies simulated practical conditions of the production systems used and that only a smaller part of the studies actually aimed at evaluating the breed potential for growth. The average daily gain in Turopolje pigs during lactation is 101 g/day [7], which is less than expected in modern pig breeds. Also, an average value obtained for the overall fattening stage is characterized by a considerably slower growth rate (429 g/day [10–12]) than modern pig breeds. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values, because it can be assumed that the maximum figures exhibit the growth potentials of Turopolje pigs in ad libitum conditions of feeding (≈ 556 g/day in the overall fattening stage [12]).

In considered studies, the information on feed intake and feed nutritional value were scarce, which limits the evaluation of growth potential. Average daily feed intake reported was around 2.0 kg/day in the overall fattening period [11, 12].

Reference	Sow age at first parturition (mth)	Litters per sow per year	No. of piglets alive per litter	Piglet live weight (kg)	Stillborn per litter (%)	Mortality at weaning (%)	Piglet weaning weight (kg)	Duration of lactation (d)	Farrowing interval (d)
[1]	–	1.1	4.7	–	10.7	26.2	–	–	335
[4]	–	2.5	–	–	–	–	–	–	146
[5]	–	–	6.3	1.3	18.2	–	–	42	–
[6]	–	1.2	4.2	–	5.2	7.4	–	–	307
[7]	–	–	6.7	–	22.1	–	4.2	42	
[8]	23.5	0.8	5.3	1.2	–	–	–	–	462
[9]	22.1	–	4.5	–	–	–	–	–	–

No. = number, mth = month, d = days.

Table 3.
Summary of collected literature data on reproduction traits in Turopolje pig breed.

Reference	Feeding	No. of animals	ADG lactation[1]	ADG fattening[2]
[7]	–	60	101	–
[10]	–	20	–	556
[11]	Ad Lib	15	–	340
[12]	Ad Lib	12	–	392

No. = number, ADG = average daily gain in g, Ad Lib = ad libitum feeding regime.

[1]*ADG in a period of lactation regardless of how long it was.*
[2]*ADG in a period of fattening is reported as the overall growth rate for the whole studied period (from approximately 30 kg body weight until slaughter).*

Table 4.
Summary of collected literature data on growth performance in Turopolje pig breed.

Reference	Feeding	ME content of feed (MJ/kg)	CP content of feed (%)	No. of animals	ADFI fattening[1]
[10]	–	–	–	20	2.30
[11]	Ad Lib	13.4	17.6	15	1.23
[12]	Ad Lib	12.9	15.5	12	2.51

No. = number, ADFI = average daily feed intake in kg/day, Ad Lib = ad libitum feeding regime, ME = metabolizable energy, CP = crude protein.

[1]*ADFI in a period of fattening is reported as the overall growth rate for the whole studied period (from approximately 30 kg body weight until slaughter).*

Table 5.
Summary of collected literature data on average daily feed intake (in kg/day) in Turopolje pig breed.

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**. In considered studies, pigs of Turopolje breed were slaughtered at approximately 437 days of age (140–679 days [5, 10–13]) and average 96 kg live weight [5, 10, 12, 13]. Dressing yield was around 80% [5, 10, 12, 13] and lean meat content around 40.0% (SEUROP

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Lean meat content (%)	Backfat thickness (mm)			M[1] (mm)	Loin eye area (cm^2)
							S[2]	At withers	At last rib		
[5]	10	679	100	80	79.9	40.6	–	–	32	–	–
[10]	20	253	102	82	80.3	–	–	61	39	–	–
[11]	8	140	–	58	–	43.6	29	–	–	47	22
	7	175	–	70	–	41.4	32	–	–	46	25
[12]	20	552	95	75	79.1	35.8	41	54	40	51	–
[13]	10	584	82	66	80.1	38.2	–	–	–	–	–
	9	679	100	80	79.8	40.5	–	–	–	–	–

No. = number, BW = body weight, CW = carcass weight.

[1]*M muscle thickness measured according to ZP method [at the cranial edge of gluteus medius muscle (mm)].*
[2]*S backfat thickness measured according to ZP method [above gluteus medius muscle (mm)].*

Table 6.
Summary of collected literature data on body composition and carcass traits in Turopolje pig breed.

Reference	No. of animals	pH 45	pH 24	CIE[1]			IMF (%)	IMF fatty acid composition (%)				BF fatty acid composition (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[5]	10	–	–	–	–	–	3.0	39.6	54.8	5.6	–	37.0	50.8	12.2	–
[11]	8	6.10	5.47	–	–	–	–	–	–	–	–	–	–	–	–
	7	5.99	5.59	–	–	–	2.2	–	–	–	–	–	–	–	–
[12]	20	6.44	5.84	44.6	19.3	5.7	2.9	37.2	47.4	15.4	13.7	39.3	46.8	13.9	12.8
[13]	10	–	–	–	–	–	5.3	–	–	–	–	–	–	–	–
	9	–	–	–	–	–	5.8	–	–	–	–	–	–	–	–
[14]	10	–	–	–	–	–	3.0	–	–	–	–	–	–	–	–

No. = number, pH 45 = pH measured approximately 45 min post-mortem, pH 24 = pH measured approximately 24 h post-mortem, IMF = intramuscular fat, BF = back fat tissue, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids.

[1]*CIE = objective color defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter color, a* greater value indicates a redder color and b* greater value indicates a more yellow color.*

Table 7.
Summary of collected literature data on meat quality in Turopolje pig breed.

classification or dissection [5, 10–13]). The backfat thickness values were measured at the position of withers averaged 57 mm [10, 12], at the level of the last rib 37 mm [5, 10, 12] and at the level of gluteus medius muscle 34 mm [11, 12]. Muscularity was measured as loin eye area averaged 23 cm^2 [11] and as muscle thickness above gluteus medius 48 mm [11, 12].

5.4 Meat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in longissimus muscle that could be found are presented in **Table 7**. In the studies reporting meat quality of Turopolje pigs, pH measured in longissimus muscle at 45 min and 24 h *post-mortem* were around 6.1 and 5.68, respectively [11, 12]. The intramuscular fat content ranged from 2.2 to 5.8 (3.7% in average [5, 11–13], and color measured in CIE L*, a* and b* color space was 44.6, 19.3 and 5.7 for L, a* and b* [12]. SFA, MUFA and PUFA content of intramuscular fat in longissimus muscle in the considered studies were around 38, 51 and 11%, whereas SFA, MUFA and PUFA content of back fat tissue were approximately 38, 49 and 13%, respectively [5, 12].

6. Use of breed and main products

Resilient and capable of foraging, Turopolje pig breed has always been able to survive in free range, which makes it particularly suitable for low-input, extensive production systems. Its use today represents a potential alternative to intensive farming, and it should be intended primarily for production of pork meat and products of premium quality. Meat is darker and redder in color than in standard pork, with fine muscular texture, which seems to be characteristic for this breed [4, 9]. There is a higher level of accumulation of fat tissue, especially in the subcutaneous area, and between the muscles. Meat of Turopolje pigs in today's gastronomy is mainly used in special occasions for the preparation of various local food specialties (e.g., "turopoljska kotlovina", goulash, various pork roasts—**Figure 5**). It is also suitable for processing in typical meat products (e.g., dry-cured ham—**Figure 6**, bacon, dry-fermented sausages, etc.), which are highly appreciated by local consumers but for now rarely available in the market. In 2017, the breeding association "Plemenita Općina Turopoljska" applied for the registration of fresh meat from Turopolje pig with the protected designation of origin (PDO) label, and the procedure is underway at national level.

Figure 5.
Turopolje pig roast at local food fair.

Figure 6.
Turopolje ham (photo by Blaž Šegula).

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Section 3

Analytical Review of Productive Performance of Local Pig Breeds

Chapter 22

Analytical Review of Productive Performance of Local Pig Breeds

Marjeta Čandek-Potokar, Nina Batorek Lukač, Urška Tomažin, Martin Škrlep and Rosa Nieto

Abstract

Traits of interest concerning reproductive performance, growth performance, carcass and meat quality of local pig breeds involved in H2020 project TREASURE were collected from the available literature, unpublished data available to partners or results recorded in the experiments within the project. The survey revealed great variability in the availability and quality of information. Reproductive performance of local pig breeds is lower than in conventional modern pig breeds, not only due to their genetic background but also due to the management. Data on growth rates reflect the heterogeneity of different production systems and feeding regimes used. The growth potential of the majority of local pig breeds is not well exploited, and their nutritional requirements are not known. Generally, local pig breeds show low muscular development and high potential for fat tissue deposition and are slaughtered at older age and weight, which results in higher intramuscular fat and more intense colour of meat. However, considerable differences exist between them and their potentials, not only in their production systems. For many local pig breeds studied in the project, the collected information provides the first in-depth overview of their productive performance in their preserved, present-day phenotype.

Keywords: local pig breeds, reproductive traits, growth rate, carcass traits, meat quality

1. Introduction

Data on phenotypic traits of local pig breeds involved in the project TREASURE were collected to perform multi-criteria evaluation and comparative analysis of the breeds. As the aim was to assess the present-day phenotype, not the historical data existing on the breed, only the recent studies (up to 20 years) were considered. Selected traits of reproduction and growth performance, as well as carcass and meat quality traits, were analysed. The individual data considered in the analysis and the list of references from which the data were extracted are documented in the individual chapter of each breed.

2. Material and methods

Data on productive traits (see Chapters 2–20) were collected either from the available literature (articles, theses, congress proceedings), unpublished data available to project partners or breed associations, or recorded in the experiments of TREASURE. In rare cases, when data were not available, Domestic Animal Diversity Information System (DAD-IS) database of Food and Agriculture Organisation of United Nations (FAO) organisation was also consulted (http://www.fao.org/dad-is/en/). The goal was to acquire and summarise the information on productive traits for all the breeds in the project. This task revealed the difficulties related to the availability of the information (i.e. the number of available studies and variability of conditions in which the data were acquired) as well as the big variability in the quality of the collected data with respect to the circumstances in which the results/data on productive performance were obtained. This aspect represents a major obstacle for the analysis and puts limits to the possible analytical approaches, comparisons and conclusions, as it was difficult to find the common denominators among studies. Furthermore, presented analysis is thus mainly descriptive and based on basic statistical parameters.

In the current analysis, the experimental unit was a study, experiment or part of the experiment (e.g., treatment group, growth stage and diet), depending on the experimental design of the study; therefore, in some cases, several experimental units could be derived from one single publication. Pooled breed averages were calculated from the values derived for each record (experimental unit), which were all given an equal weight, regardless of the number of pigs behind and if they had been recorded in practical or experimental conditions. Basic statistical parameters are provided in the Appendices 1–27. When only one source of data per trait was available, this was taken as representative of the breed. For data analyses, the procedure UNIVARIATE of SAS® software was used, calculating basic statistical parameters, mean, minimum and maximum together with 'n' which denotes the number of records per trait. Due to the well-established effect of body weight (BW) on carcass traits and the fact that body/carcass weight varied strongly between studies, in the case of carcass traits, means were additionally adjusted for the final live body weight, that is, LSMEANS were calculated using GLM procedure of SAS® with breed as main effect and carcass weight as covariate in the model (for **Figure 3**). **Figures 2–6** represent an attempt to illustrate the positioning of the breeds with respect to some traits of interest (e.g., daily gain) which is based on standardised values using feature scaling of values between 0 and 1 (quadrants are split at the middle point of the scale, i.e., 0.5).

3. Reproductive performance

Reproductive performance shows great variability among breeds, whether in terms of data availability or the reported results (cf. Appendices 1–8). Local pig breeds are mostly characterised (if compared to modern breeds) by less intensive use, as demonstrated by an older age of sows at first parturition, less litters per sow yearly and longer lactation periods. They also exhibit, for the most part, smaller litter size and higher piglet mortality. This can be related to breed genetic or intrinsic characteristics, but also to the management conditions, particularly nutrition, associated to the extensive or semi-extensive production systems in which these sows are reared. It has been shown for some local breeds, like the Spanish Iberian [1] or the Hungarian Mangalitsa pigs [2], that they exhibit lower prolificacy due to smaller uterine capacity. It has also been demonstrated that the nutrition of sows during gestation can affect the weight of newly born piglets which further affects their vitality [3, 4]. The undernutrition of sows affects piglets' birth weight and exhibits long-term consequences for post-natal performance of pigs [4]. It is noteworthy that despite the considerably smaller number of live-born piglets at farrowing than in modern, and more prolific breeds, the reported birth weight of piglets was also lower for the majority of local pig breeds than the usually reported for conventional breeds [5]. This contradicts the common view that a higher litter size is associated with lower litter birth weight [6, 7]. The reproductive performance can also be negatively affected by inbreeding [8], which is likely critical in the case of breeds with critically small population size. Although the litter size is, for the majority of breeds, considerably smaller than in modern breeds, there seem to be some breeds with higher prolificacy, in particular, the Schwäbisch-Hällisches (with a pooled average of reported studies of 11.0 live-born piglets per litter, cf. Appendix 4). On the other hand, some breeds are characterised by extremely small litter size, like the Swallow Bellied Mangalitsa or Turopolje pig (with a pooled average of 5.3 live-born piglets per litter; cf. Appendix 4). If we consider the number of litters per sow per year as an indicator of a higher reproductive efficiency, we can observe the highest one (2.2 litter/year, cf. Appendix 2) in Iberian and Schwäbisch-Hällisches, two of the breeds which have the most economically important use and developed pork value chains. These data are indicative of more intensive or technified systems of these breeds, consistent with the observed negative correlation ($r = -0.59$, $P < 0.01$; data not shown) between the age at culling and number of litters per sow per year. Other indicators such as the percentage of piglets lost during lactation and piglet weight at weaning can also be indicative of how well the sows are nursed in individual breeds. Moreover, the scarcity and reliability of the data are also an issue as in many of these untapped breeds, the economic incentive and data recording are very often not in primary focus.

Overall, it can be concluded that, despite the efforts invested into data collection, the information remains limited for a better evaluation of breeds' potentials. However, it can be speculated that in many cases breeds are not optimally managed.

4. Growth performance

For a better illustration, growth performance was evaluated for every phase of production. We defined production phases very approximately due to big differences between studies with regard to weight range covered. Growth rate of piglets during lactation was taken as it was reported, regardless of its duration. For the post-weaning (i.e., growing) phase, the studies considered were those that reported live body weight or daily gain between weaning and approximately 30 kg live weight, for the early fattening phase between approximately 30 and 60 kg (fattening I), for the phase of fattening between approximately 60 and 100 kg (fattening II), and for the last phase of fattening, the studies that reported growth rate above 100 kg live weight (fattening III). Sometimes, the data source provided only the overall growth rate for the whole studied period or this could be calculated from the data provided on weight. Concerning the feeding level associated with growth results, the information provided was very variable. Feed intake and feed nutritional value were often not provided which limits the comparisons of growth potential among different breeds. It should also be noted that a big part of the collected studies simulated practical conditions of the production systems. Accumulated data show great variability, let it be in terms of data availability among breeds or in the results reported. The studies were made in different conditions of feeding and management, with only a small number of studies indicating the breed potential for growth; many of the studies just reflect their practical use. For these reasons, it was very difficult to establish a harmonised approach in data analysis and evaluation and comparisons between studies or breeds. Despite these strong limitations, some interesting conclusions could be drawn showing knowledge gaps and needs for further investigation in order to better characterise and consequently better optimise the use of local pig breeds.

4.1 Feed intake

Information on daily feed intake is important for the assessment of growth performance which is, besides the genetic potential, directly related to energy and nutrient supply. Based on the literature survey made per breed (see Chapters 2–20), it is evident that the data on the capacity for feed consumption in local pig breeds is relatively scarce or limited (exception being the Iberian breed). For the post-weaning period (until ≈30 kg of piglet live weight), a small number of studies reported data for daily feed intake, and the gathered information is available only for few breeds (five of them). For the growing period, the reported feed intake was between 0.5 and 1.8 kg/pig/day with a pooled average of 1.2 kg/pig/day. The lowest value reported was 0.5 kg/pig/day (Razmaite, personal communication), which is very low and challenges the reliability of the recorded information, considering that in this early stage of growth, pigs are normally fed *ad libitum*. The highest figures reported (1.6–1.8 kg/pig/day for Iberian [9] and Sarda breed [10]) could be indicative of the capacity of intake in this stage of growth. For the early fattening phase (up to ≈60 kg live weight), the average feed intake was reported for 10 breeds and it was situated between 1.0 and 2.5 kg/pig/day (**Figure 1**). For the latter fattening stages, average feed intakes reported were between 0.9 and 3.5 kg/pig/day (phase II) or 1.3–6.3 (phase III) with average feed intake of 2.5 and 3.2 kg, for phase II and III, respectively (**Figure 1**). Based on these figures, it can be speculated that feed allowance was often limited in the referred studies, as shown in **Figure 1** presenting the comparison with the estimated theoretical intake at a certain body weight (BW) based on the assumption that voluntary feed intake equals approximately 3–4 times the metabolisable energy (ME) needs for maintenance (106 kcal ME per kg $BW^{0.75}$ per day) [11]. The range of the actually reported feed intakes agrees with the expected ones in growing and early fattening phase denoting *ad libitum* feed allowance in these stages. In contrast, it is below the expected intake in the case of late fattening phases, suggesting the use of restricted feed allowance in the majority of the studies. It is of interest to look at the extreme values reported, where we can detect that high intake can be observed in the case of *ad libitum* feed allowance. In this sense, it has been shown that selection for

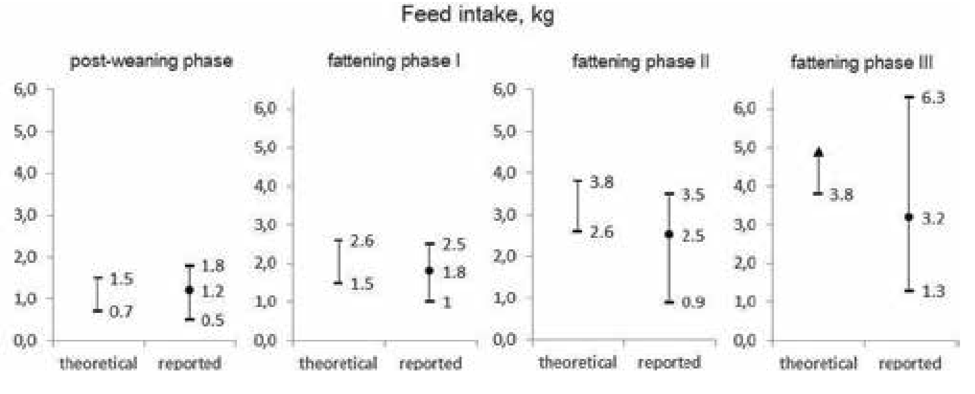

Figure 1.
Estimated theoretical voluntary feed intake in comparison with empirical (reported) values according to production phase. Breeds that were included in empirical values are: for post-weaning (growing) phase (KRP, IBR, LVI, LBA, SAR), for fattening I phase (ACL, ALT, BAS, GAS, KRP, IBR, MAN, MOR, SAR SWH), for fattening II phase (ACL, ALT, BAS, BIS, GAS, KRP, IBR, MAN, MOR, NSC, SAR), for fattening III phase (ACL, ALT, BAS, CAS, CSE, KRP, IBR, MAN, MOR, PNM, SAR).

feed efficiency and lean growth is associated with lower feed intake capacity [12]. In experiments involving both Iberian and conventional pigs in similar experimental conditions, the higher intake capacity of the autochthonous breed has been shown [13]. The few available data in the present study corroborate that these non-selected breeds (e.g. feed intake of 6.3 and 5.6 kg daily per pig in Sarda [14] and Iberian breed [15, 16], respectively) show high intake capacity compared to modern genetically improved breeds. However, it should be noted that the value of 6.3 kg of feed per pig described in the study indicates the quantity of distributed feed [14], while the value of 5.6 kg of feed per pig per day corresponds to feeding with acorns [15]. The highest consumption of feed mixture fed *ad libitum* was 4.7 kg in the case of Iberian pig [16]. Overall, despite limited information on capacity of feed ingestion, this general picture on feeding is important for the consequent assessment of growth performance.

4.2 Growth rate

4.2.1 Lactation

The pooled average value obtained for daily gain of piglets in the lactation period was 206 $\pm$ 48 g/day (cf. Appendix 9). Despite the longer lactation period in local pig breeds (47.2 days in average, cf. Appendix 3), the reported values are in general somewhat lower than the values reported for modern leaner breeds in intensive management system [17]. Pre-weaning growth is associated with sow milk production and producers' management of sows during lactation [18], so it may be speculated that the results observed could reflect the management and the nutrition of sows (likely suboptimal in many cases). In spite of that, studies in Iberian suckling pigs suggest that lower performance of lactating piglets in comparison to piglets of conventional breeds may be related to a lower efficiency of milk nutrient utilisation, rather than a lower milk yield or milk nutrient intake, when appropriate corrections for litter size are performed [19].

4.2.2 Post-weaning (growing)

The comparison between the empirical and estimated theoretical feed intake for the growing phase (**Figure 1**) suggests that in this period pigs are mainly fed *ad libitum*, and consequently, the recorded daily gain would indicate their growth potential. However, the pooled average daily gain for all breeds was 354 $\pm$ 94 g/day (cf. Appendix 10) which is somewhat lower than the values reported for modern breeds and management systems [20, 21]. The observed maximal values indicate that the growth potential of local pig breeds at this stage is likely higher, and therefore, performance in this period could be improved beyond these observations. In this context, it is also of interest to consider the data on Iberian pig whose growth potential has been established in controlled and optimal experimental conditions. The pooled average for the studies for the growing period on Iberian pig was 404 g/day, which is similar to achieved growth rate in controlled conditions of 416 g/day [22], but even at these early stages, a higher pre-disposition to fat gain is found. Overall, these data demonstrate a big knowledge gap for the majority of breeds (Iberian breed being an exception) about their potential for growth in that stage and open also the issue of need for future research in nutritional requirements for optimal feeding and improved productivity of growing pigs of autochthonous breeds.

4.2.3 Fattening

If local pigs do not exhibit considerably different growth rate from modern breeds during the early growing phases (lactation, post-weaning), a different

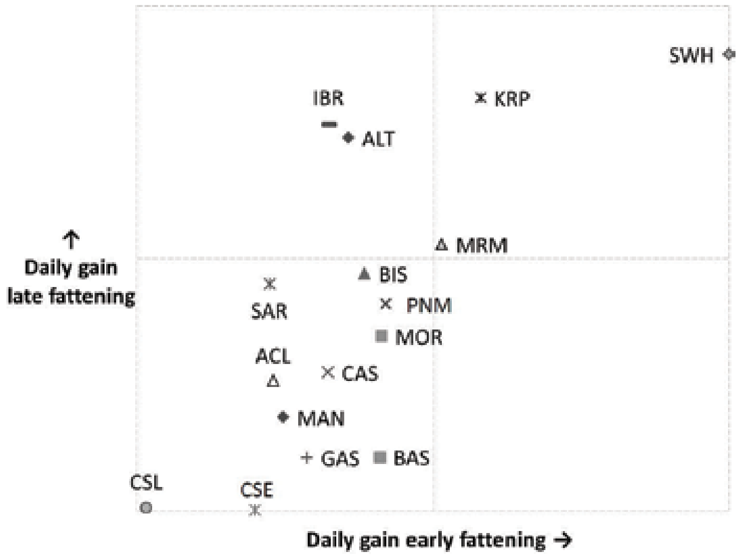

Figure 2.
Positioning of breeds with regard to daily gain in early and late fattening phase using standardised values (0–1).

situation is observed in the fattening phase, characterised by substantially slower growth rate than in genetically improved breeds, which are well known to reach daily gains above 1000 g in optimal conditions of intensive systems. Moreover, the collected data (cf. Appendices 11–14) show enormous heterogeneity not only among breeds but also in studies within the same breed, which relates to the fact that this overview includes the studies where management systems and feeding levels practised were extremely different. Here as well, it is of interest to look at the extreme values as they could (in some cases) indicate the growth potential of the breed. Indeed, if we look at the example of Iberian pig for which the studies assessing growth potential in nearly *ad libitum* conditions are available [16, 23, 24], higher growth rates can be observed (559, 854 and 918 g/day for the fattening periods 25–50, 50–100 and 100–150 kg, respectively) than what shows the literature in average. Other observations that can be extracted from this set of data refer to the special case of Iberian and Alentejano breeds which are characterised by smaller daily gains in early than late fattening stage (**Figure 2**). This observation agrees with their typical sylvo-pastoral production system (Spanish 'montanera' or Portuguese 'montado'), that is, restricted feed allowance in early fattening phase and *ad libitum* allowance in late fattening phase [25]. In contrast, for the other breeds, it is more usual to observe reduced growth rate during late fattening or in both early and late fattening (**Figure 2**). These results agree with the summarised data on feed intake (**Figure 1**), which demonstrates that in average, the reported values for feed intake are below the expected values for this production stage.

5. Slaughter age, body weight and carcass traits

Data survey showed that local pig breeds are, with few exceptions (e.g., Schwäbisch-Hällisches and old-type Lithuanian white pig), slaughtered at higher age and weight than the conventional pigs (cf. Appendices 14 and 15). Consequently, even though growth rates are below those found in conventional pigs along the productive cycle, the live weight of these pigs at slaughter is higher, and a big

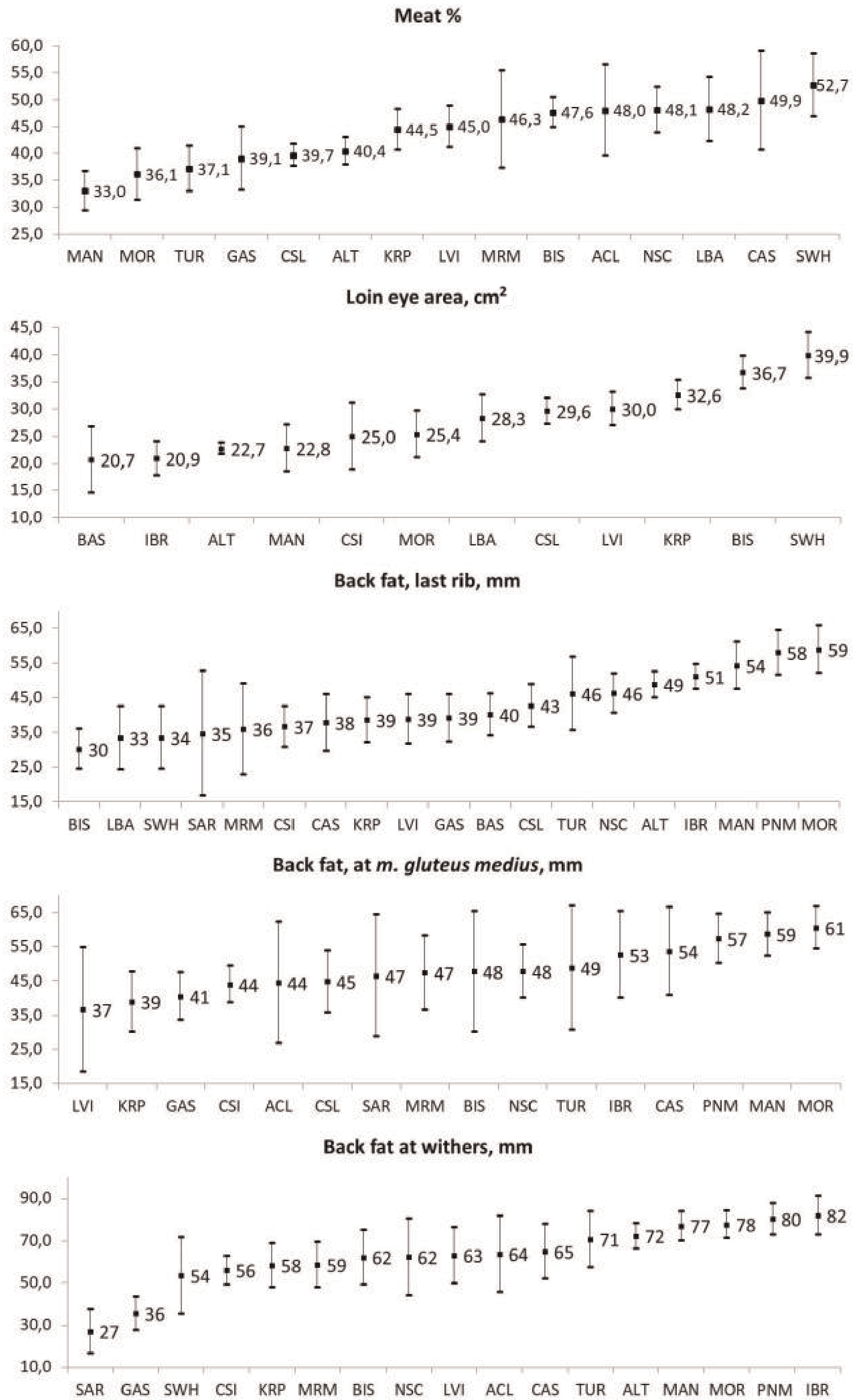

Figure 3.
Adjusted means (LSMEANS) and 95% confidence interval for carcass traits according to breed.

heterogeneity exists between and within breeds. It should be noted that some of the recorded cases of lower slaughter weight (and age), due to study objectives, correspond to experimental observations that do not follow the usual practices and slaughter weights.

For this overview and comparison, we considered only the studies where the final live body weight was above 70 kg and dealt only with some of the most commonly encountered traits, i.e. back fat thickness at withers, last rib, above the *m. gluteus medius*, lean meat percentage assessed according to SEUROP classification system or by dissection, or loin eye area (cf. Appendices 20 and 21).

Consistent with the diversity of fattening conditions and final body weights (breed averages between 96 and 163 kg), the reported values for carcass traits show high variability. Average muscularity (measured as lean meat %) varied between breeds from 32.9 to 52.3% and the loin eye area (average) from 18.1 to 40.3 cm^2. The back-fat thickness values spanned (breed averages) on the withers from 46 to 85 mm, at the level of last rib from 24 to 61 mm and at the level of *m. gluteus medius* from 28 to 61 mm.

Due to the wide range of final live weights within and between the breeds, we performed additional statistical comparison of breeds by adjusting the data to a common final live weight. The adjusted means (LSMEANS) and their 95% confidence interval are graphically presented in **Figure 3**.

Data on the backfat thickness confirm that pigs of these breeds are eligibly called fatty pigs. Low average lean meat percentage and loin eye area demonstrate limited muscular development. However, although these breeds are fatter and less muscled than genetically improved modern pig breeds, important variability in body composition, and consequently, carcass traits exist between them. Due to the big differences in rearing and feeding systems of studies from which the data derive, the comparisons between breeds are difficult and limited. Moreover so, since for some breeds few studies were available, which creates even more uncertainty to draw the conclusions. Nevertheless, we tried to position the breeds with regard to lean content indicators (meat percentage or loin eye area) and back-fat thickness adjusted for the final body weight (**Figure 4**). Based on this rough positioning, there seem to

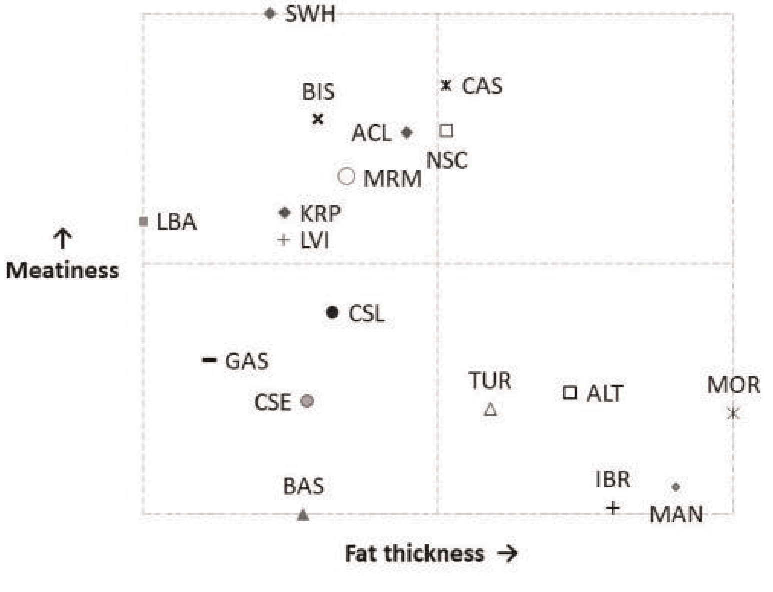

Figure 4.
Positioning of breeds with regard to lean content indicators (meat % or loin eye area) and back fat thickness using standardised values (0–1).

be three clusters; the upper left quadrant comprises the most muscular and least fatty breeds and the lower right quadrant the least muscular and most fatty breeds. The lower left quadrant is represented by breeds with both below-average fatness and muscularity.

6. Meat and fat quality

The summary on main descriptive statistics (cf. Appendices 22–27) was possible for *longissimus dorsi* intramuscular fat, meat pH values and colour, whereas it was not possible for water-holding capacity due to the big variety of methods used between studies and breeds. By far, the most interesting is the information on the intramuscular fat content of the *longissimus dorsi* muscle, which is important for sensory quality of meat and dry-cured products. In agreement with a higher capacity for subcutaneous fat deposition, most of local pig breeds stand out also with high levels of intramuscular fat. The average pooled values for breeds spanned from 2.1 to 10.2%. Based on the positioning of breeds with regard to fat deposition indicators (**Figure 5**), it could be observed that intramuscular fat content is particularly high in Swallow bellied Mangalitsa, while in some of the breeds, it was comparable to the conventional breeds. In certain breeds, the level of intramuscular fat was even below or near the benchmark (<2.5%) for sensory appreciation.

With regard to pH values of *longissimus dorsi* muscle, the pooled average per breed for 45 min post-mortem (pH 45) spanned from 6.07 to 6.57. The lowest pooled averages of pH 45 (<6.10) were observed in Krškopolje, Swallow bellied Mangalitsa and Sarda pigs (cf. Appendix 23). For Krškopolje pig, the result may be due to the incidence of RYR1 gene mutation which is relatively high in this population, i.e. 0.24 [26]. The pooled breed averages for 24 h post-mortem (pH 24) spanned from 5.35 to 5.98, and in several breeds, it was somewhat higher than what is reported in modern breeds, which could be indicative of lower glycogen stores prior to slaughter. It is difficult to know if higher pH 24 is due to higher stress

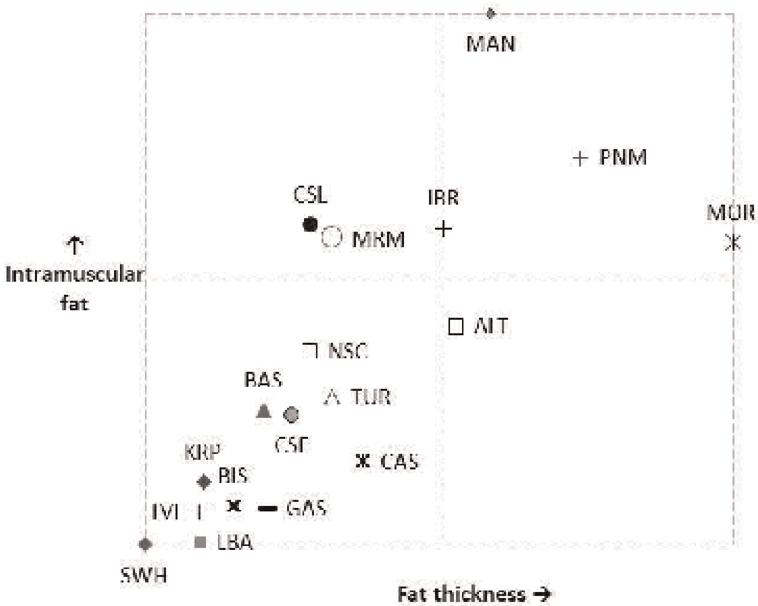

Figure 5.
Positioning of breeds with regard to fat thickness and intramuscular fat content using standardised values (0–1).

susceptibility, depleting glycogen stores prior to slaughter or to more oxidative muscle metabolism. It can also be related to the measurement uncertainty associated with the studies. Anyhow, the breeds with high intramuscular fat content exhibit also high pH 24 which could be indicative of more oxidative muscle metabolism. In this sense, in comparative studies with young pigs of Iberian and conventional breed, the former shows higher intramuscular fat and oxidative metabolism in the longissimus muscle under identical nutrition and management conditions [13]. Colour measurements (Minolta L, a and b values) corroborate with pH 24 values and show more intensive (darker, redder) colour of meat in many cases, in agreement with their higher age at slaughter.

For what regards fatty acid composition, the interpretation of the collected information is again difficult due to the important differences among studies with respect to diet and feeding, final body weight and age, and fatness, all these factors affecting fatty acid composition of tissues. Although it is difficult to make comparisons due to the differences in rearing and management conditions, the collected data indicate that local pig breeds in general exhibit higher proportion of monounsaturated fatty acids (MUFA) and lower proportion of polyunsaturated fatty acids (PUFA) as compared to the fatty acid profiles generally reported in conventional pig breeds [27–29]. The proportion of MUFA is mainly above 50% and PUFA below 12–13% in fatty acid profiles of intramuscular and back fat for the breeds considered, although in that respect, some of the breeds are closer to the conventional ones (**Figure 6**). The high proportion of MUFA and low proportion of PUFA are due to their high synthesis of MUFA (in particular, oleic acid (C18:1) produced from synthesis *de novo*) and SFA which increases with age [30]. It agrees with their higher genetic potential for lipid deposition. While PUFA are mainly related to nutrition as they cannot be synthesised *de novo* in pigs and come from exogenous supplies [31], their relative quantities in pig tissues can be altered by oxidation processes and other fatty acids synthesised *de novo*. In the context of the variability between studies in terms of nutrition and final body weight and age, it is difficult to evaluate to which degree the collected data and the differences observed were influenced by genetic or production system factors, but the importance of the genetic control of fatty acid composition and potential for selective breeding has been emphasised in different pig genotypes [32–35]. Regarding the nutritional value of pork which has generally high n-6/n-3 ratio, much above the recommended one (<5), studies on local pig breeds show huge variability; however, in some breeds, in

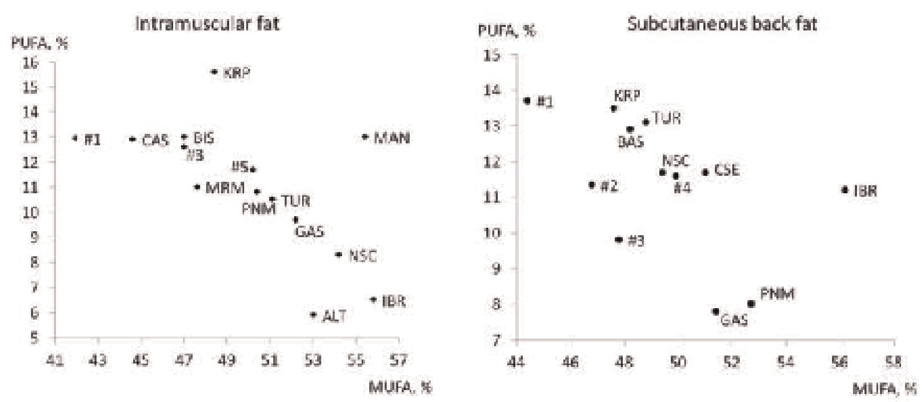

Figure 6.
Positioning of breeds with regard to fatty acid composition (MUFA and PUFA) of M. longissimus dorsi *intramuscular fat and subcutaneous back fat. Studies on modern breeds are indicated with #1–#5).*

particular, Iberian in 'montanera' production, the observed values approach the mentioned recommendation [15, 36, 37].

7. Conclusions

The information presented, even if limited, is very valuable since it may represent the only available data for some of the most representative autochthonous pig breeds in Europe, and provide a unique opportunity to analyse the considered traits in a common frame. Despite the limitations and drawbacks of the information gathered, the following conclusions can be drawn based on the analyses:

- Reproductive performance is considerably lower than in conventional pig breeds, in part, due to genetic limitations but also due to a less intensive use, adapted to local conditions, which could be improved in many breeds, with more adequate management and nutrition.

- Early postnatal growth in local pig breeds is comparable with values found in conventional breeds when pigs are allowed to eat *ad libitum*.

- Fattening phase is mostly characterised by low growth rates and big heterogeneity, in agreement with the diversity of the production systems and feeding levels encountered. In the majority of local pig breeds, limited feed allowance is practised in fattening to avoid excessive fat deposition.

- Iberian pigs (here comprising the Alentejana breed) are a particular case; they are characterised by limited growth rate in early fattening phase and voluntary feed allowance, with high daily gains in the late fattening, due to the typical and seasonal outdoor production system.

- Extreme values for daily gain observed in some local pig breeds are indicative of their maximal growth potential.

- Extreme values on feed intake indicate a high intake capacity of local pig breeds and higher appetite compared to conventional pigs.

- Even though, in general, local pig breeds show low muscular development and high potential for fat tissue deposition, important differences exist between the breeds.

- Local pig breeds are usually slaughtered at older age and weight which results in higher intramuscular fat and more intense colour of meat.

- Local pig breeds differ in fatty acid profiles from those reported for modern pig breeds.

Data on growth rate (especially fattening phase) reflect the heterogeneity of management systems and feeding regimes used. The growth potential of the majority of local pig breeds is likely not well exploited and their nutritional requirements remain to be investigated. In the project, the studies aiming to evaluate nutritional requirements have only been performed in few breeds (Iberian and Cinta senese). Muscularity and fat tissue characteristics observed in this review indicate that the differences between breeds are important, and studies on one breed cannot be directly extrapolated to another. Hence, there is a need for more studies on nutritional requirements in a controlled environment as a prerequisite for the optimisation of management practices and production systems, and thus enhance sustainability through optimal efficiency and minimal environmental impact.

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Conflict of interest

The authors declare no conflict of interest.

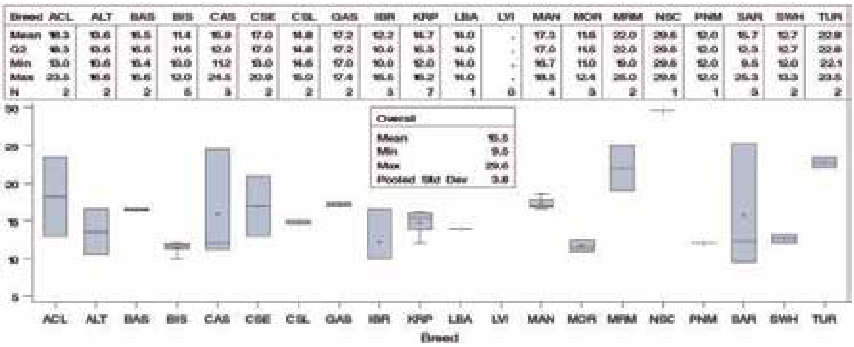
Nomenclature

The following abbreviations are used for the breeds:

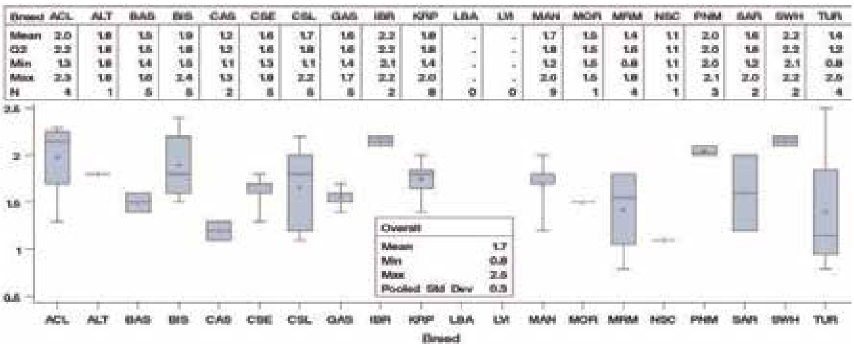
ACL	Apulo Calabrese
ALT	Alentejana
BIS	Bísara
BAS	Basque
CAS	Casertana
CSE	Cinta Senese
CSL	Crna slavonska (Black Slavonian)
GAS	Gascon
IBR	Iberíco (Iberian)
KRP	Krškopoljski prašič (Krškopolje pig)
LBA	Senojo tipo Lietuvos baltosios (old-type Lithuanian white)
LVI	Lithuanian indigenous wattle
MAN	Mangulica (Swallow bellied Mangalitsa)
MOR	Moravka
MRM	Mora romagnola
NSC	Nero siciliano
PNM	Porc negre mallorquí (Majorcan black pig)
SAR	Sarda
SWH	Schwäbisch-Hällisches
TUR	Turopoljska svinja (Turopolje pig)

A. Appendices—figures

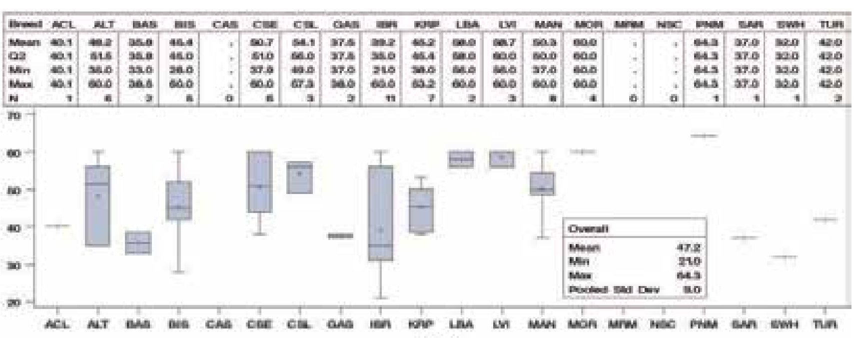
Basic statistical parameters are provided in the following figures (Appendices 1–27). Individual data and references used to build the figures in Appendices 1–27 are provided in the respective chapters (per breed).



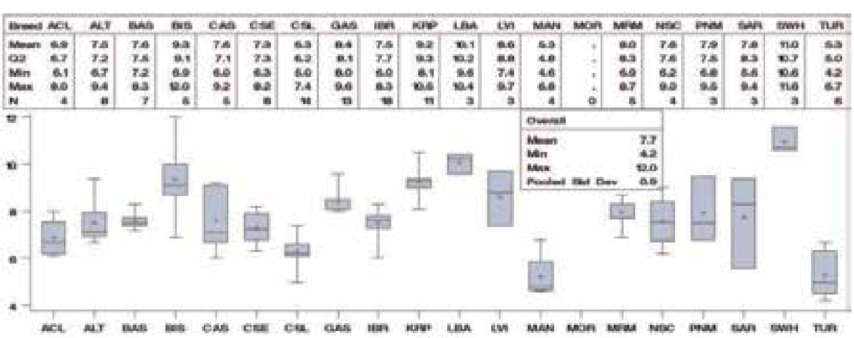
Appendix 1. Reproductive performance (age of sows at first parturition, months) according to breed.



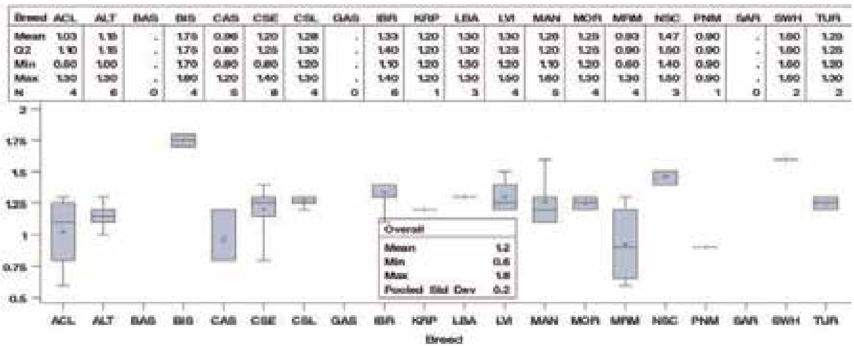
Appendix 2. Reproductive performance (number of litters per sow per year) according to breed.



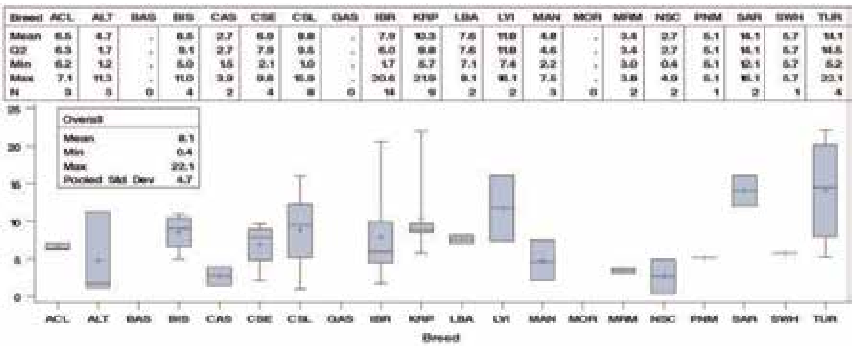
Appendix 3. Reproductive performance (lactation, days) according to breed.



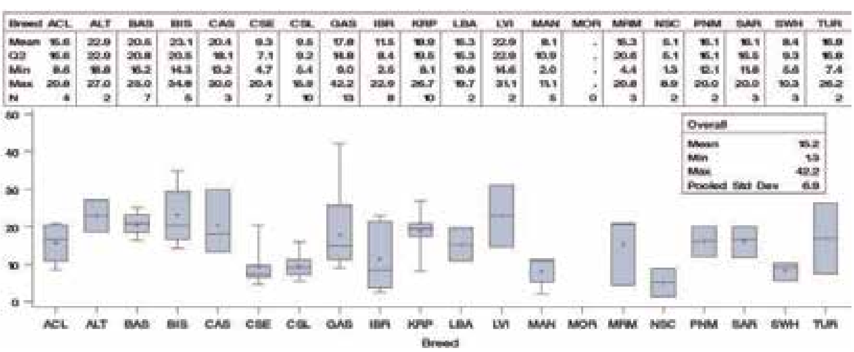
Appendix 4. Reproductive performance (number of live-born piglets per litter) according to breed.



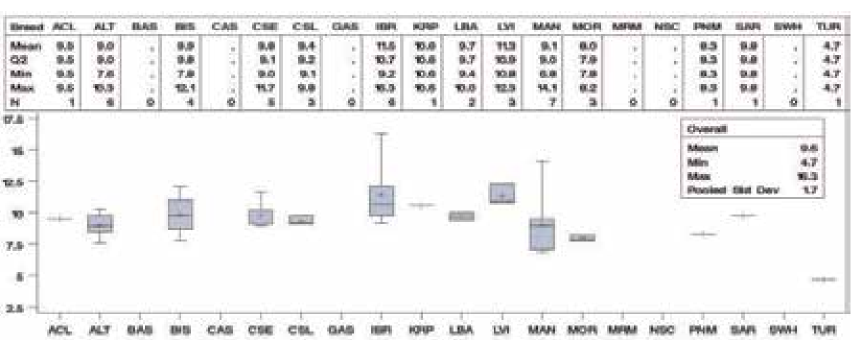
Appendix 5. Reproductive performance (piglet birth weight, kg) according to breed.



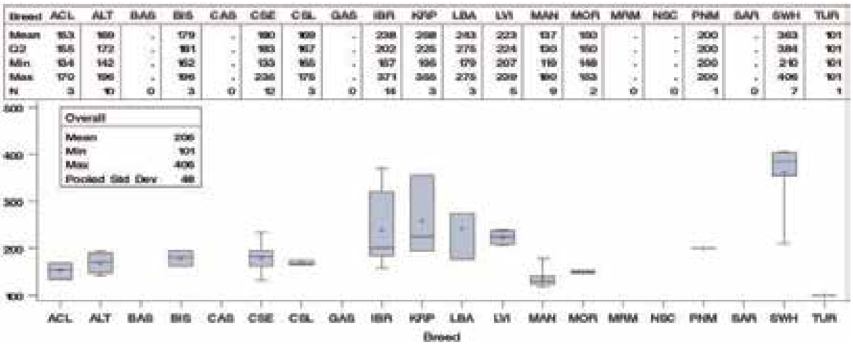
Appendix 6. Reproductive performance (% of stillborn piglets) according to breed.



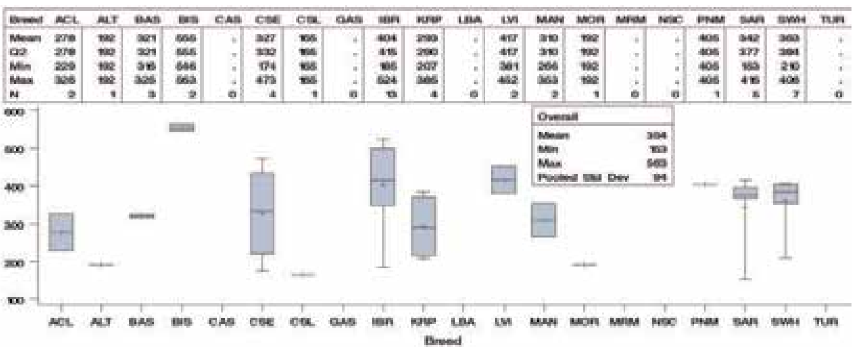
Appendix 7. Reproductive performance (% mortality at weaning,) according to breed.



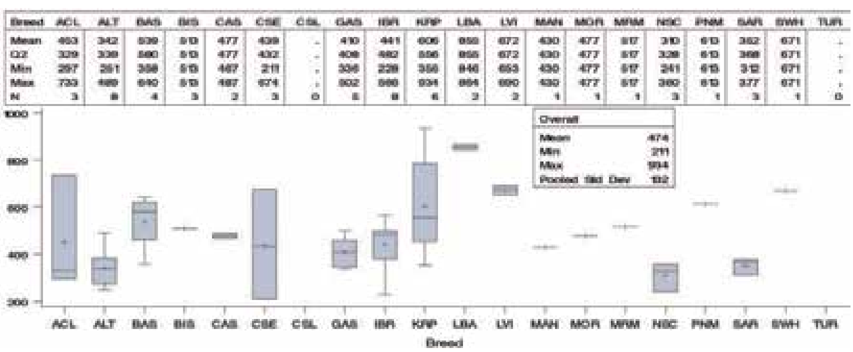
Appendix 8. Reproductive performance (piglet weight, kg at 47 days of lactation) according to breed.



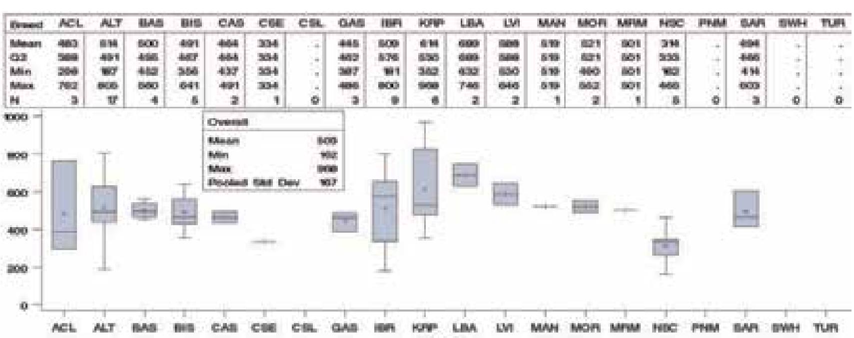
Appendix 9. Growth performance (in lactation, g/day) according to breed.



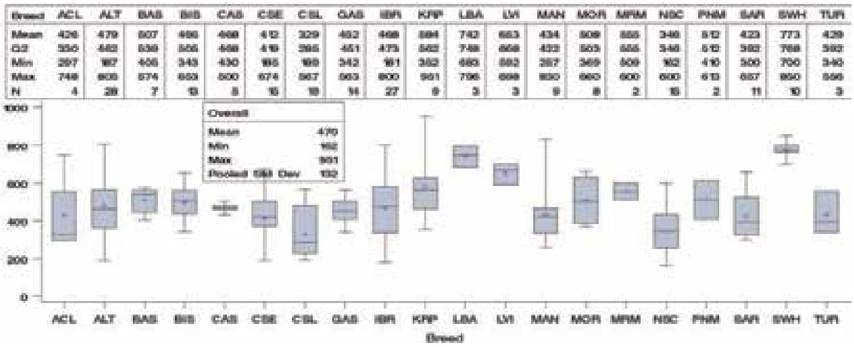
Appendix 10. Growth performance in post-weaning phase (g/day) according to breed.



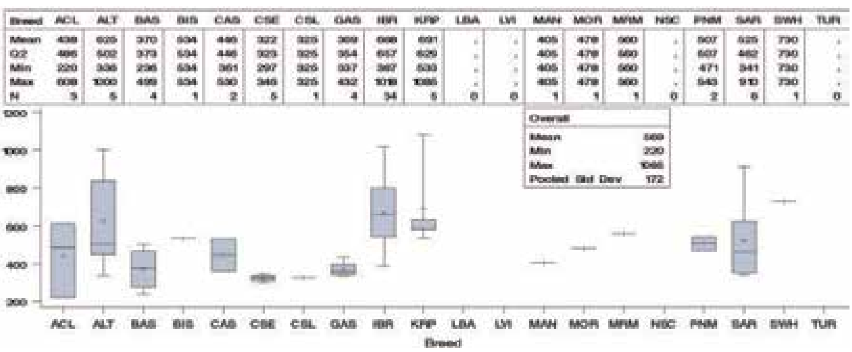
Appendix 11. Growth performance in fattening phase I (approximately 30–60 kg live weight; g/day) according to breed.



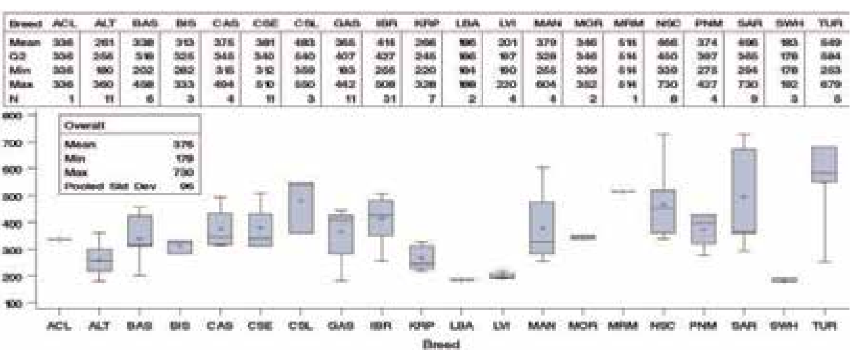
Appendix 12. Growth performance in fattening phase II (approximately 60–100 kg live weight; g/day) according to breed.



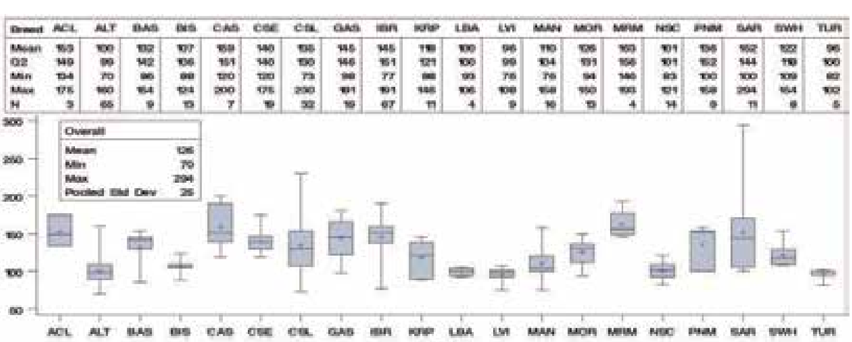
Appendix 13. Growth performance in fattening phase I and II (30–100 kg live weight; g/day) according to breed.



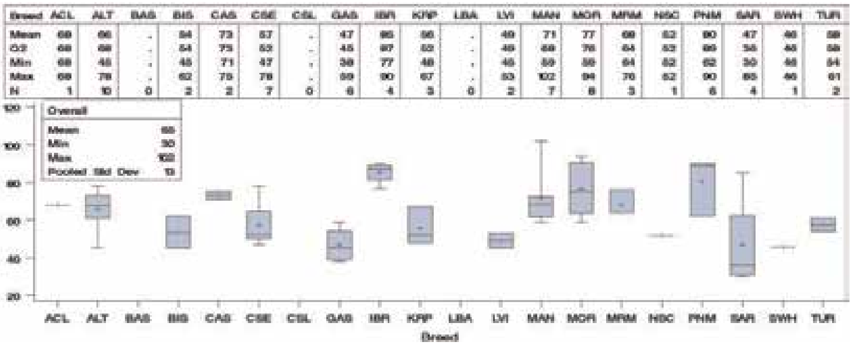
Appendix 14. Growth performance in fattening phase III (above 10o kg live weight; g/day) according to breed.



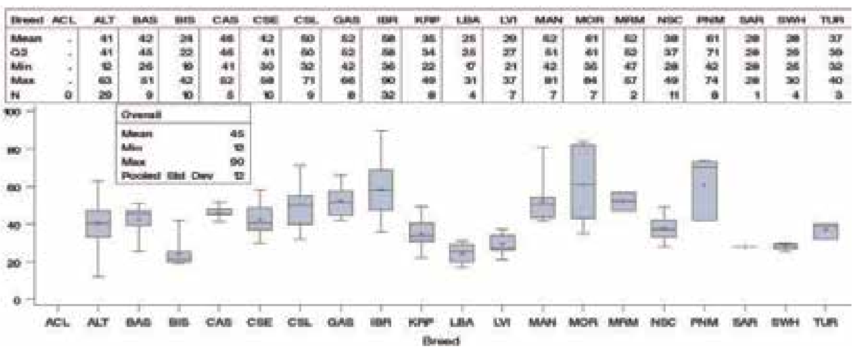
Appendix 15. Age at slaughter (days) according to breed.



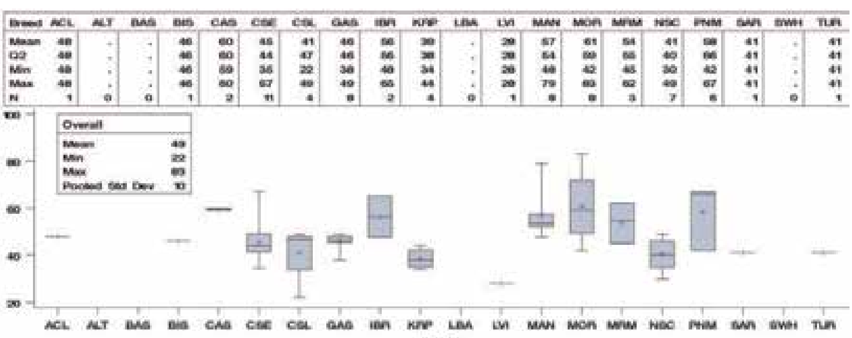
Appendix 16. Weight at slaughter (kg) according to breed.



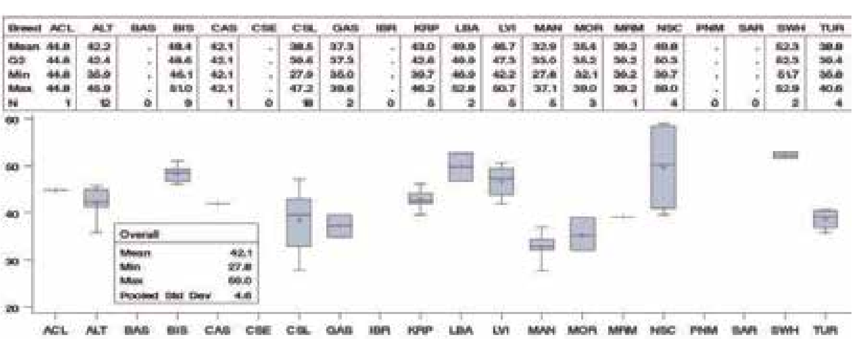
Appendix 17. Subcutaneous fat thickness (mm, at withers) according to breed.



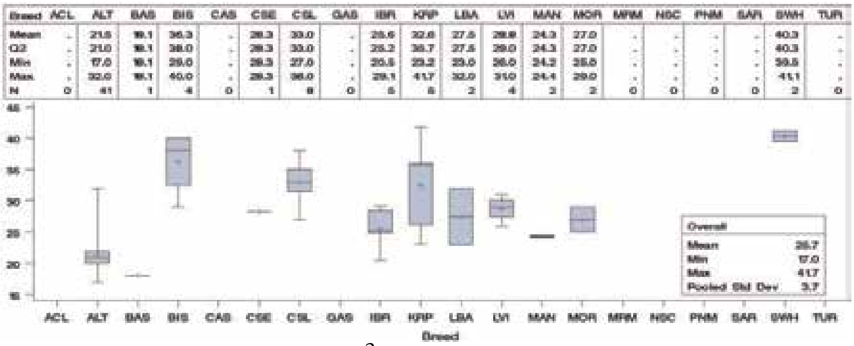
Appendix 18. Subcutaneous fat thickness (mm, at last rib) according to breed.



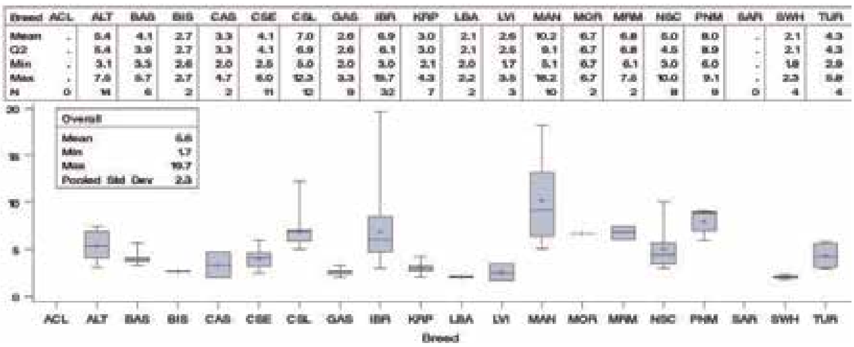
Appendix 19. Subcutaneous fat thickness (mm, at m. *gluteus medius*) according to breed.



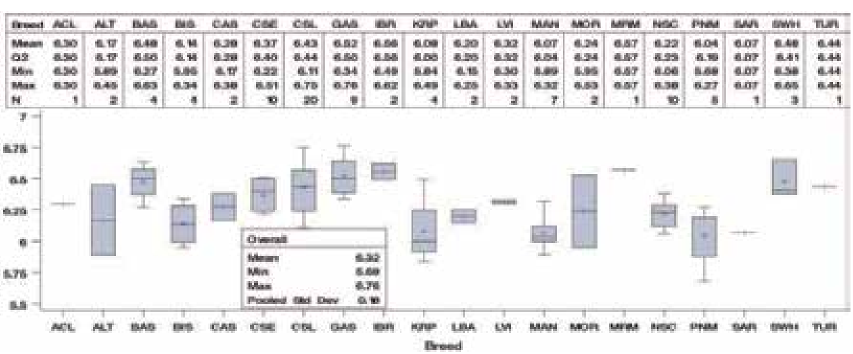
Appendix 20. Lean meat content (%) according to breed.



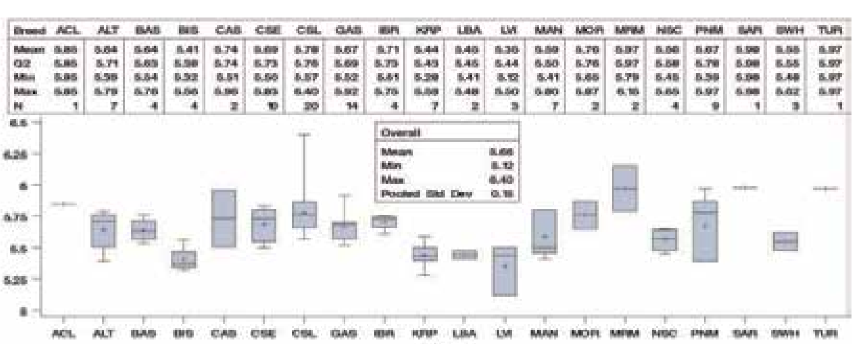
Appendix 21. Loin eye area (cm^2) according to breed.



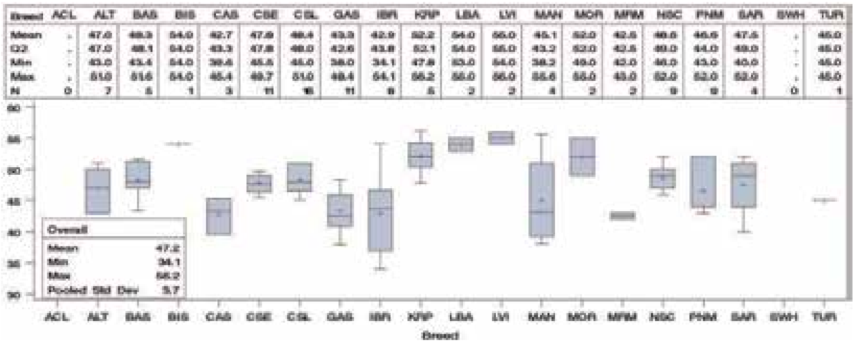
Appendix 22. Intramuscular fat content (%) according to breed.



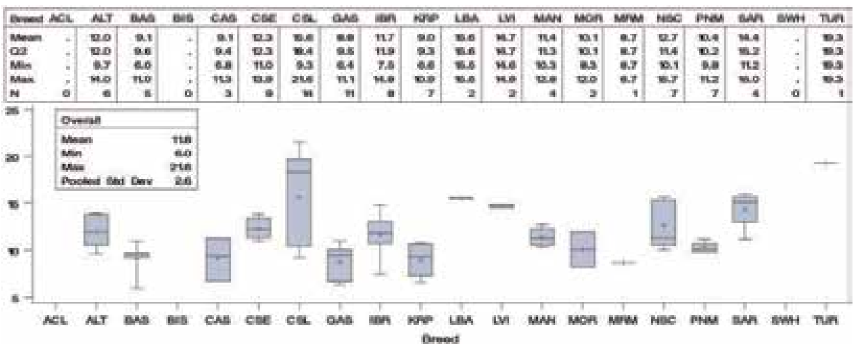
Appendix 23. pH value ≈45 min post-mortem (*M. longissimus* dorsi) according to breed.



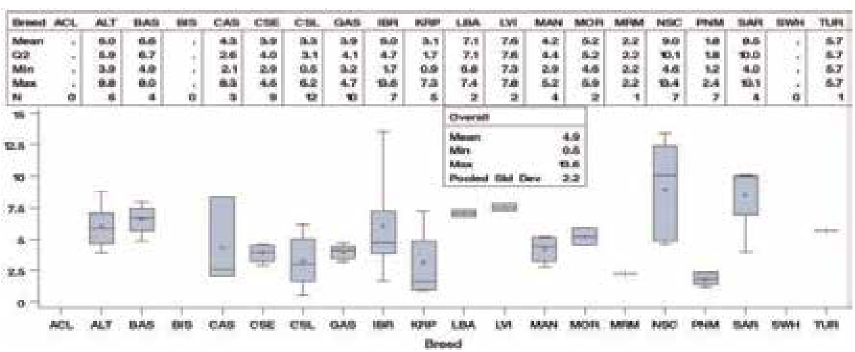
Appendix 24. pH value ≈24 h post-mortem (*M. longissimus* dorsi) according to breed.



Appendix 25. Meat colour—Minolta L—according to breed.



Appendix 26. Meat colour—Minolta a—according to breed.



Appendix 27. Meat colour—Minolta b—according to breed.

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Local or autochthonous pig breeds represent a pool of genetic diversity of porcine species and a link with old-style traditional production systems and traditional pork products. These breeds were largely abandoned because they were not competitive in the concept of modern, industrial type of pig production. Despite an increased interest for local pig breeds in the past years, they remain largely untapped and the knowledge about their characteristics is limited, which was a challenge undertook in the project TREASURE in the frame of multicriteria evaluation of local pig breeds. The book represents a valuable compendium of data on census, breeding organisations, production systems, and performances with ambition to present their contemporary (preserved) phenotype.

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