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—Review—

Saving Genetic Resources of Native Pigs in Occidental and Oriental Countries — Practical Examples of the Characterization and Utilization of Native Pigs in Hungary and Laos

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Abstract. Worldwide, only a few "fatty" pig breeds exist with different and/or regional utilization. Using the Hungarian Mangalica, which almost went extinct in Europe and the Lao Moo Lat pig, which still has a large population in South-East Asia as exemples, we wanted to demonstrate that indigenous (fatty) pig breeds may represent both national value and tremendous economic potential. Since these less prolific and less productive breeds cannot contribute to mass production, new market roles and methods should be established for them in the premium segment of pork trading. Thus their preservation and propagation needs the comprehensive collaboration of commercial, governmental actors and researchers. Briefly summarizing the history, we report the current results of reproductive physiology research. The commercial renaissance of Mangalica pigs is indebted to the enthusiastic efforts of basic scientists, pig breeding experts and dedicated Mangalica producers. Scientific achievements were applied to practical breeding and production of delicious pork and processed products, which ultimately made the economic success in the Mangalica sector possible. Both, research on and utilization of endangered (pig) breeds maintain not only breed diversities, but also may improve the livelihood of farmers worldwide.
Key words: Mangalica, Moo Lat pigs, Reproduction, Utilization

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Mangalica Pigs

Historical background

The Hungarian Mangalica, which belongs to the few breeds of fatty pigs worldwide, originated from crossing ancient pig breeds and the Serbian Sumadia in the Carpathian Basin beginning in 1833 [1]. The earliest descriptions of the Mangalica mentioned two types, namely the White and Black Mangalica [2]. Five color types were described for the latter (Blond, Black, Swallow-Belly, Brown and Red) [3], but now only the Blond, Swallow-Belly and Red Mangalica remain (Fig. 1). They were recently determined by molecular genetic analysis to be three different breeds [4].

The Mangalica is an extremely fatty pig breed. While adipose tissue is about 65–70% of the carcass, lean meat is less than 35%. Nevertheless, consumers do agree that its meat is at the highest level and very tasty. Until the 1920s, different fat products (i.e., bacon and lard) were the main food for average Hungarian people. Mangalica pigs were also the flagship Hungarian agriculture exports, and about half a million fattened or slaughtered pigs were annually exported to European countries. Up to the 2nd World War, the Mangalica population was growing enormously, and Hungarian lard, bacon, sausage and salami were well known and acknowledged products in Europe [1, 5].

However, consumption habits changed, and the need for lean pork increased considerably. An intensive crossing program with commercial breeds was created by the Research Institute for Animal Breeding during the 1950s to improve metabolic parameters, weight gain and pork quality suitable for different processed products [6–8]. Nevertheless, in the 1950s, the Mangalica stock rapidly decreased, and despite the former prosperous period, it nearly disappeared in the 1970s. Only 34 breeding sows could be found in the herd book for 1975 [9]. Fortunately, a renaissance began for the Mangalica in the 1990s when governmental, scientific and private programs were commenced to preserve, propagate and exploit unique Mangalica characteristics, like its ability to adapt to extreme and extensive climate and housing conditions, stress and disease resistance, motherliness and in particular excellent meat quality [10, 11]. Looking at commercial

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Fig. 1. Mangalica sows – (a) Blond, (b) Red and (c) Swallow-Belly Mangalica.

aspects, a large project was started in 1991 under the name "Real Mangalica" with special emphasis on in vivo gene preservation and development of premium quality meat products [11]; this was mostly the result of the appearance of new market demand coming from Spain, the homeland of premium ham and other processed pork products.

Reproductive physiological characteristics and application of reproductive techniques

In the past, Mangalica pigs were bred and kept in extensive environments, grazing on pastures and forests, except for pregnant sows, which were kept in farm-like settings. Gilts were also kept in free-range groups, where they mated with boars, sometimes wild boars. Generally, gilts attained puberty at 15–16 month of age and about 100 kg body weight [1, 5]. Seasonal cyclic activity and farrowing are described next. Typically, sows farrowed in spring months with a litter size of 4–6 piglets. As a result of the new breeding program, housing and feeding technology from the early 20th century, farrowing was modified to be twice a year [12, 13]. While the average litter size was 6.4 piglets, some farms could provide 7 to 8 piglets from selected sows with specially formulated diets [14, 15]. In the 1930s, 20% of the breeding sows farrowed 6.5 to 7.5 piglets [16]. Under improved housing and feeding conditions, gilts could be mated at 11 month of age, and lifespans were almost 6 years [17]. Increasing litter size demanded increased milk production; the measured milk production in an 8- to 10-week-long suckling period was 120 kg in the 1930s, and this increased stepwise to 200–300 kg in the 1950s [5, 18]. All in all, the past scientific data underlined that improved breeding and feeding strategies can markedly increase reproductive and productive efficiency even in old breeds like the Mangalica pig. Research has been focused on the background of the modest prolificacy of the Mangalica compared with modern breeds. The poor number of ovulated follicles in Mangalica sows compared with Berkshire sows (9.9 *vs*. 12.4) was noticed in only one study long ago [19]. However, the potential for a higher number of Graafian follicles was described after PMSG treatment, and the stimulated number of ovulations was comparable to that of commercial breeds [20, 21]. Observing ovarian luteal features at slaughter, gilts showed cycling activity at the age of 12 to 15 months under semi-intensive conditions [22]. Beside the lower ovulation rate, the quality of ovulated oocytes could be a reason for the lower fecundity in the Mangalica. According to observations in recent decades, a relatively low number of mature oocytes was found in Mangalica ovaries [22–24]. Significant morphologic differences in cumulus-oocyte-complexes confirmed different maturation periods in Mangalica gilts [22]. Thus, the proportion of oocytes with compact cumulus cells was higher in Mangalica gilts than in Landrace gilts (31 *vs*. 16%), but less oocytes had expanded cumulus cells (62 *vs*. 78%). The chromatin configuration of oocytes also differed between Landrace and Mangalica gilts, i.e. more matured oocytes (telophase I/metaphase II) were in Landrace sows (62 *vs*. 27%). Interestingly, the follicular steroid hormone milieu differed considerably in the two breeds [20]. Almost double the estradiol (E2) concentration (29.6 ± 6.8 *vs*. 16.9 ± 9.7 ng/ml) and a five times higher progesterone (P4) levels (2020.4 ± 1056.8 *vs*. 386.2 ± 113.7 ng/ml) were detected in Mangalica follicular fluid. A series of experiments was performed to elucidate sexual steroid secretion during the estrus cycle. Luteinizing hormone (LH), E2 and P4 contents were analyzed and compared with those of Landrace gilts [25]. Mangalica gilts had patterns of steroid hormone secretion that were similar to those of Landrace gilts. However, despite the lower number of corpora lutea, both the preovulatory E2-peak (46.5 ± 5.7 *vs*. 26.0 ± 6.8 pg/ml) and the P4 concentrations during the luteal phase (12.9 ± 2.6 *vs*. 9.3 ± 2.2 ng/ml) were higher in Mangalica gilts. This was confirmed in our recent study when a chronic catheter was inserted into the *V. cava cranialis* for blood sampling to better understand ovarian steroid secretion [26]. Based on the obtained data, it was concluded that the lower number of corpora lutea concomitant with the quite higher P4 levels, as well as increased leptin secretion (11.3 ± 0.6 *vs*. 3.0 ± 0.1, $P<0.05$) and altered LH secretion, could play a role in the modest reproductive capacity of the Mangalica. To obtain more profound data on genital tract development, morphometric parameters were obtained during the estrous cycle and pregnancy [22]. In cycling gilts, the mean oviduct length (24.3 ± 0.5 cm) and weight (3.2 ± 0.2 g), and uterine horn length (143 ± 5 cm) and weight (250 ± 12 g) were similar to those of commercial pigs. At the beginning of pregnancy, the length of both uterine horns were significantly shorter in the Mangalica (124 ± 5 *vs*. 188 ± 6 cm), and afterwards, the uterus did not elongate (within days 1 to 24) in contrast to pregnant Landrace gilts, in which the uterine horns were continuously growing. The weight of the uterus started to increase significantly later in Mangalica gilts (from days 12 to d 24) compared with Landrace gilts (from days 1 to d 12), respectively. This study strengthened the concept that apart from the diminished ovarian activity and oocyte development, restricted uterine development may affect early pregnancy and can be an additional reason for lower prolificacy [22].

Previous information on semen collection and parameters in Mangalica boars, and on artificial insemination results are not available. However, semen parameters and endocrine and testicular characteristics of Mangalica boars were described recently [27–30]. Testicular function of 48 Mangalica boars was examined after GnRH challenge treatment. The effects of age, live weight, testis volume and basic testosterone level as independent factors were analyzed in relation to GnRH-induced testosterone increase, and the combined effect proved to be strong on the testosterone increase [30]. The mean semen volume was 177.8 ± 18.92 ml, and the mean sperm concentration was $490 \pm 160 \times 10^6$ spermatozoa/ml. The mean sperm cell number was $894 \pm 308.1 \times 10^8$ per ejaculate. All samples had high sperm motility (75 ± 7%). Semen volume was less whilst total number and sperm cell concentration were much higher in Mangalica ejaculates compared with other commercial breeds [31]. Slight seasonal changes in volume and endocrine function of the testes have also been described [29].

Since artificial insemination (AI) is one of the most important methods in modern pig breeding, our definite intention was to apply it to practical Mangalica breeding. However, training of Mangalica boars with regard to phantom jumping and semen collection is much more difficult than in any other "modern" commercial breed; only less than 40% of the Mangalica boars could be trained successfully. In some cases, boars can be deceived by using sows in heat instead of a phantom. Furthermore, extenders for liquid conservation of Mangalica semen are of importance. Altogether, six extenders were tested, and the best results were attained by using the Standard (Pigletplusz 2004, Budapest, Hungary) extender, with the percentage of live motile sperm cells being over 60% following three days of storage [26]. Use of frozen/thawed (F/T) semen could be of high value for Mangalica breed propagation. For freezing, semen was diluted 1:1 with Standard (Pigletplusz 2004) extender followed by incubation for 3 h at 15 C and subsequent centrifugation at 400 *g* for 10 min at 15 C. Then the pellets were re-diluted with lactose-egg yolk extender (LEY) and incubated 2 h at 5 C. The concentration was adjusted to 10^9 sperm cells/ml with the LEY+glycerine+equex es paste combination. Straws were frozen in nitrogen vapor for 8 min and then plunged into liquid N_2. This method was suitable to produce frozen Mangalica semen with high post-thawed motility and a high intact/live sperm cell rate [32]. Based on our experience, such a semen freezing protocol is applicable under field conditions. Different AI methods were tried for optimizing the use of frozen/thawed (F/T) Mangalica semen [33]. However, both laparoscopic and deep intrauterine AI with F/T semen were not effective enough or not applicable due to the behavior of sows, respectively. It became evident that cervical AI with F/T semen required a higher sperm concentration (5×10^9 cells per dose) and double insemination. It was helpful to check the ovarian status of sows by ultrasound and to perform insemination about 24 and 36 h after the onset of estrus.

Ultrasonographic pregnancy diagnosis was also involved in improving "on-farm" reproductive management, and it was beneficial to increasing the reproductive efficiency of the Mangalica [34]. The number of litters/sow/year increased (from 1.55 to 1.77), as did the average number of total born (from 7.55 to 7.74) and weaned piglets (from 6.57 to 7.05), after using the early pregnancy check.

Moo Lat Pigs

The experience with how the Mangalica physiology had been investigated and commercial track had been determined allowed us to start similar projects with other indigenous pig breeds even far away from Europe and Hungary. In the framework of Lao-Hungarian cooperation, we initiated investigations and experimental work on the native Moo Lat pig (Fig. 2), which is a native (fatty) pig breed in South East Asia with the largest populations in the Lao People's Democratic Republic (Laos). Pig production continues to be an important agriculture activity in Laos based on traditional methods, however, it is increasingly affected by social and market pressures. More than 80% of the pig population is native and belongs to small farmers. The Moo Lat pig is one of the four indigenous swine breeds with an average litter size of 5–6 piglets. Phenotypic characterization of the breed has been done already [35]; however, reproductive characterization is still needed. Since the morphology of the reproductive organs could affect reproductive performance, a study was conducted to obtain information about the number of corpora lutea and the size of the reproductive tract in Moo Lat pigs. The reproductive organs of 34 gilts (6–11 months of age) and 13 sows (> parity 1) were recovered immediately after slaughtering to determine the number of ovarian features, the weight and diameter of the ovaries, and the weight and length of the oviducts and uteri, respectively. The mean number of ovulations was of 8.8 ± 2.9 and 10.5 ± 4.5 in gilts and sows, respectively. Mean oviduct length (26.3 ± 1.3 and 33.0 ± 3.1 cm) and ovarian weight (4.3 ± 0.6 and 5.3 ± 0.8 g) were not different between gilts and sows. Uterine weight and uterine horn length were significantly higher ($P<0.05$) in sows (219 ± 21 g and 229 ± 9 cm) compared with cycling gilts (131 ± 57 g and 76 ± 5 cm) [36].

Presently, liquid semen preservation and artificial insemination are used in Laos only in "exotic" breeds (i.e., Western breeds like the Large White, Landrace and Duroc); however, it could be beneficial to use this method in propagation and preservation of the native swine population, too. Different extenders were tested in a pilot study to determine how they influence sperm motility of liquid preserved Moo Lat boar semen. Semen was collected by gloved-hand method from three matured Moo Lat boars. Motility and morphology were determined immediately after collection. Only ejaculate with more than 80% motile and less than 15% abnormal cells were included in the trial. Mixed semen samples were diluted 1:5 with three different extenders (BTS, MRA and Acromax) and preserved at 17 C for five days. Motility was assessed every day during the preservation period. Live/dead cell rate was determined after Giemsa staining. There was no significant difference in the motility and dead cell rate between extenders during storage. However, after day 2 sperm parameters tended to be better in MRA extender. On day 3 more than 60% motile cells were observed only in MRA, and this declined to 45% on day 5. It was evident that all investigated extenders could be used to store semen for insemination within two days after collection, and MRA can be used for storage of semen for 3–4 days [37]. However, without doubt, further studies are needed to improve liquid preservation of Moo Lat boar semen.

Although "exotic" pig production is rapidly growing in Laos, the preservation and utilization of native genetic resources has ongoing

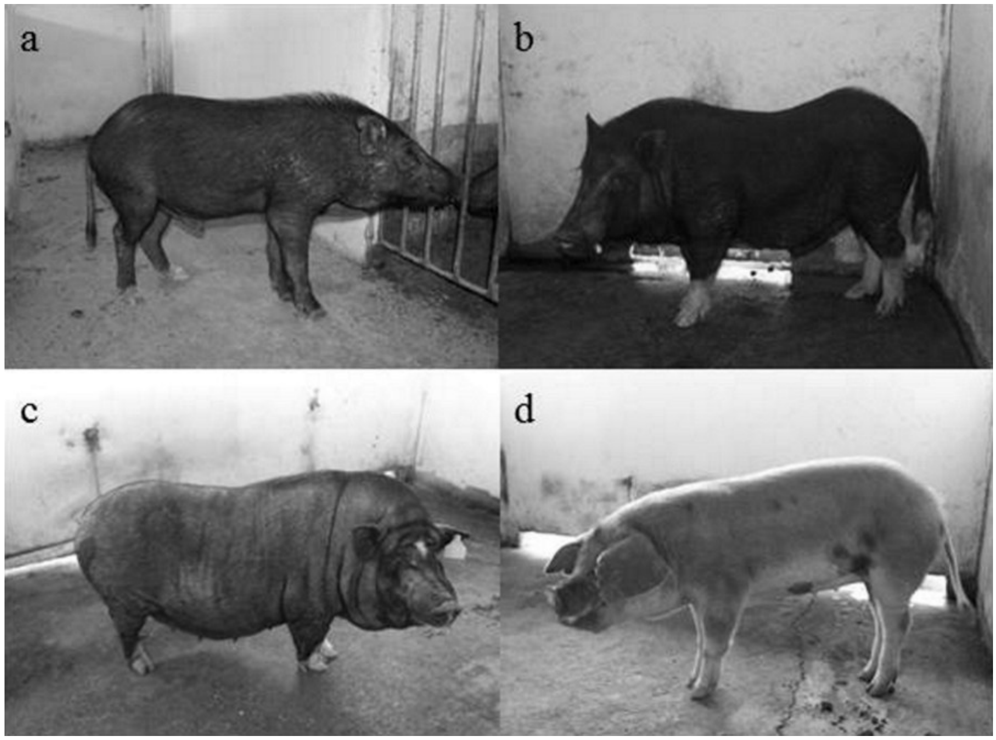

Fig. 2. Moo Lat pigs – (a) Type 1 (local names: Moo Chid, Moo Markadon or Moo Boua), (b) Type 2 (local name: Moo Lat), (c) Type 3 (local names: Moo Nonghad or Moo Hmong) and (d) Type 4 (Local names: Moo Deng or Moo Berk).

good chances. It can be expected that quality Moo Lat pork and its products can enrich the premium meat markets in Far Eastern countries. However, without further well-scheduled combined research and development and innovative commercial projects, these breeds could lose their economic roles, and the population could rapidly decrease or, in the worst case, disappear.

General Conclusion

Worldwide, only few "fatty" pig breeds exist with different and/or regional utilization (e.g., the Iberian in Spain and Portugal; Cul Noir Limousin and Gascon in France; Calabrian, Black Caserta and Sardinian in Italy; Wattle pig in Lithuania; Kolbroek in South Africa). Using the Hungarian Mangalica, which almost went extinct, and the Lao Moo Lat pig, which still has a large population, as examples, we wanted to demonstrate that indigenous (fatty) pig breeds may represent both national value and tremendous economic potential. Thus their preservation and propagation needs the comprehensive collaboration of commercial, governmental actors and researchers. Since these less prolific and less productive breeds cannot contribute to mass production, new market roles and methods should be established for them in the premium segment of pork trading. In such a case, these pig breeds would not become endangered, and would assist in maintaining breed diversity and improve the livelihood of farmers in Asia and in Europe, as well. Furthermore, such an approach could serve as an example for other endangered farm animal breeds.

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