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Artificial insemination in pigs today

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ABSTRACT

Use of artificial insemination (AI) for breeding pigs has been instrumental for facilitating global improvements in fertility, genetics, labor, and herd health. The establishment of AI centers for management of boars and production of semen has allowed for selection of boars for fertility and sperm production using *in vitro* and *in vivo* measures. Today, boars can be managed for production of 20 to 40 traditional AI doses containing 2.5 to 3.0 billion motile sperm in 75 to 100 mL of extender or 40 to 60 doses with 1.5 to 2.0 billion sperm in similar or reduced volumes for use in cervical or intrauterine AI. Regardless of the sperm dose, in liquid form, extenders are designed to sustain sperm fertility for 3 to 7 days. On farm, AI is the predominant form for commercial sow breeding and relies on manual detection of estrus with sows receiving two cervical or two intrauterine inseminations of the traditional or low sperm doses on each day detected in standing estrus. New approaches for increasing rates of genetic improvement through use of AI are aimed at methods to continue to lower the number of sperm in an AI dose and reducing the number of inseminations through use of a single, fixed-time AI after ovulation induction. Both approaches allow greater selection pressure for economically important swine traits in the sires and help extend the genetic advantages through AI on to more production farms.

1. Introduction

The success for breeding pigs using artificial insemination (AI) can be attributed to improvements in fertility, labor efficiency, genetics, and production [1]. Early contributions in the development of swine AI during 1926 to 1940 in Russia, the United States, Japan, Europe, and elsewhere and later from 1946 to 1959 have been reviewed [2–4]. The transition of swine production industries from natural service to AI was reported in the UK [5], a few European countries, and elsewhere in the 1960s [2]. By the mid-1980s, some European countries had as much as 50% to 75% of their commercial herds using AI, whereas others showed a much lower rate of adoption [6]. Artificial insemination centers were established in the 1980s where significant numbers of boars were stationed for semen production [1]. By the 1990s, AI records indicated that for several European countries, the majority of commercial pigs were generated through the use of AI. By the year 2000, increases in AI use around the world had occurred with several countries breeding nearly all pigs with AI [7]. Adoption of AI in many developing countries also occurred despite significant limitations to infrastructure. Today, commercial production efficiency and profit are tied to the use of AI. Industry records involving hundreds of thousands of sows showed as early as 1990 that reproductive rates for farrowing reached 80% to 90%, and litter sizes were between 11 and 13 pigs [8,9], with 2014 data for 1.3 million sows showing an 86% farrowing rate and 14 total born pigs [10]. The fertility level achieved with AI, despite considerable variation among countries and farms, can be attributed to a working technology for sperm production and AI that can be monitored for success using key measures for quality control and reproductive performance. The building blocks for the success of AI over time has resulted from years of research, education and improvements in herd health, genetics, technology, and breeding procedures. Widespread use of AI is an outcome from research and

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education programs originating from universities, governments, commercial companies, and production operations, with trade magazines and internet education sites helping with information dissemination around the world. At this time, AI now serves as a gateway technology for new reproductive technologies such as sexed semen [11], cryopreserved sperm, and new methods for gene transfer.

2. Advantages of AI

For livestock production, the advantages of AI were recognized in the 1950s. Successful extension and cryopreservation of bull semen allowed for valuable sire collection at one site and production of hundreds of AI doses that could be stored for any length of time before shipment to different farms at distances far removed from the stud site [8]. In cattle, semen could be preserved in frozen form for months to years. The ability to breed females without relocation of the sire for natural mating increased the rate of genetic progress, reduced the need for bulls on farm, limited spread of venereal disease, and improved the accuracy of reproductive records [12]. In pigs, although collection and preservation of semen in liquid form was successful, cryopreservation resulted in problems with sperm survival, damage, and fertility [3]. As a result, swine AI focused on extending sperm life and use in liquid form [1]. The advancements in production of semen in liquid extended form served as the spark for the start of the global AI revolution that occurred in the 1990s. It was recognized that similar to other species, even in liquid form, the rate of genetic progress in pigs could be dramatically increased with AI. Semen could be collected from high indexing sires and extended for use in breeding 10 to 20 females with a single boar ejaculate. In addition, in the early years, the life span of boar sperm in liquid form could be extended for up to 3 days which allowed semen shipment to distances that were not too far from the AI center. With advancements in the development of longer-term extenders, the ability to extend sperm life for an extended duration opened the door for rapid adoption of AI around the globe. In countries with large areas of space, remote farm sites, and less-developed transportation systems, the longer-term extenders allowed semen to be shipped with increased transit time without loss of fertility. The development of disposable supplies, such as AI catheters with modified tips, facilitated safe insemination for pigs, reduced the labor needed for cleaning, and helped limit spread of disease. Even today, commercial innovation in the development of supplies and equipment to aid in semen collection, analysis, packaging, and AI continues to transform the swine breeding industry. The decision to separate semen production operations from breeding farms was important for allowing AI centers to specialize in boar management for production of semen and breeding farms to focus on estrus detection, AI for production of litters. Specialization in AI centers allowed greater efforts in the areas of boar health, housing, and feeding, and it allowed more time for assessment of semen production and quality, which could help improve and identify problems in boar fertility. The health of the swine herds could also be improved by separation of the AI centers, with many sites able to reach specific pathogen–free status, where they operate as the highest health facilities in the genetic supply chain. In the past and into the present, the successful implementation of any AI scheme on a commercial operation requires practical consideration of the size of the farm, the animal housing system, and the availability of labor. These factors vary greatly among farms, with farm size and housing design influencing labor requirements. Artificial insemination has been successfully implemented on farms of all sizes and for animals housed in pens and stalls. However, the need for labor is a critical consideration on a breeding farm and is determined by the size of the breeding groups, the frequency of weaning, the housing system, the method for detection of estrus, and the methodology for AI. Advances in housing systems and higher investment for the swine breeding herd have enabled farms to capture the economies of size, with advantages in breeding with AI, production, labor, purchasing, transportation, marketing, and multisite production [13–17]. In the future, swine breeding farms will likely continue to follow the trend for increasing size and decreasing number. These farms will continue to face restrictions for animal density, siting proximity to human populations, animal welfare, disease control, and regulations pertaining to air, water, environment, and food safety. Financial sustainability with the increasing costs associated with meeting these regulations would favor producer cooperatives and larger farms.

3. Genetic improvement with AI

Genetic improvement programs are designed to capture the advantages of heterosis. The foundation of the system relies on maintaining the integrity of traits in the purebred breeds and selection within for improvement and distribution of those genes throughout the production chain. In the 1960s, the genetic pyramid system was developed in the UK and later adopted elsewhere [18]. The modern breeding pyramid is composed of a nucleus of purebred maternal breeds and lines that are used to create crossbred F_1 maternal-line, multiplier females. Depending on the number of breeds used, these multipliers may be mated to purebred or crossbred sires for generating commercial production sows which are subsequently mated to purebred or crossbred terminal sires for market pig production. Today, this modern genetic production scheme relies heavily on the entry of breeding females and semen into each of the production levels. However, an important trend that continues to evolve for reducing risk of disease entry involves herd closure to new animal entry and introduction of new genes exclusively through the use of semen. Herd closure can greatly reduce the risk of disease but requires that a proportion of herd production be dedicated toward generation of internal replacements and over time increases the degree of inbreeding in the herd. The genetic selection scheme for the modern industry has been instrumental in improving numerous terminal traits including feed efficiency, carcass measures, and growth performance, as well as maternal traits such as milking ability, litter size, and litter survivability. Genetic improvement has been dramatically accelerated through the use of AI. Selection of