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The effect of age, interval collection and season on selected semen parameters and prediction of AI boars productivity

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ABSTRACT

The possibility of planning the production level has a special importance for AI stations, and its inaccuracy should be minimized by eliminating the factors differentiating the quantity and quality of the ejaculate. The aim of the study was to determine the effect of age, collection interval and season on selected quantitative and qualitative semen parameters and to develop equations for estimating production capacity for AI stations. The study included 48 117 ejaculates. Experimental groups were created according to: age of boar (8–9, 10–12, 13–18, 19–24, 25–30, > 30 months), collection interval (≤2, 3, 4, 5, 6, 7, ≥8 days), and season (Winter, Spring, Summer, Autumn). Selected quantitative and qualitative parameters were analyzed: semen volume (ml), spermatozoa concentration ($\times 10^6$ ml^{-1}), total number of spermatozoa in ejaculate ($\times 10^9$), number of motile spermatozoa in ejaculate ($\times 10^9$), and number of insemination doses obtained from one ejaculate (n). The most important role in shaping the results was played by interactions. The highest semen volumes were achieved for the oldest boars after 7-day interval collection during Autumn (about 300 ml). Interestingly, the lowest semen volumes were also noted during Autumn from the youngest boars after 1–2 and 7-day interval collection (a little over 160 ml). The highest spermatozoa concentrations (515×10^6 ml^{-1}) were observed in Autumn for 10–12 month-old boars with the longest interval collection, which clearly demonstrates the positive impact of long resting on young boars. The lowest spermatozoa concentrations – below 300×10^6 ml^{-1} – were reported for the oldest boars after 1–2 and 3-day collection intervals. The highest total number of spermatozoa in ejaculate and motile spermatozoa were noted during the longest collection interval in Winter at the ages of 13–18 months and 25–30 months, while the lowest occurred in the same season with a short interval from the 10–12 month boars. Almost all correlations were statistically proven at the level of $P \leq 0.05$ and $P \leq 0.01$, except for the correlation between the number of motile spermatozoa and the age of boars. Developed regression equations enable, with a high degree of accuracy, the estimation of the selected ejaculate parameters on the basis of age, collection interval and season. The solution proposed in the article is a useful tool, especially for AI stations or large farms with a high rate of boars producing semen for AI. AI stations assessing the long-term production capacity of boars should take into account the factors examined in this study. Underestimation of the interaction may, in fact, reduce the number of insemination doses by up to 5 portions of a single ejaculate.

1. Introduction

The aim of reasonable production policy in AI station insemination is to anticipate all factors that determine performance of AI stations. The possibility of planning the production level has a special importance for AI stations, and its inaccuracy should be minimized by eliminating the factors differentiating the quantity and quality of the ejaculate. Only the highest quality of insemination doses can be distributed for further sale (Broekhuijse et al., 2012), because offered product must satisfy market demand.

Numerous studies indicate that the results of quantitative and qualitative ejaculates parameters are influenced by factors both dependent, as well as independent of the boar. These factors include: breed (Knecht et al., 2014b; Smital, 2009), testes size (Clark et al., 2003), season (Claus and Weiler, 1985; Corcuera et al., 2002; Knecht et al., 2013, 2014a, 2014b), maintenance conditions (Rohrmann and Hoy, 2005; Huang et al., 2010) and feeding (Liu et al., 2015), but also age and collection intervals (Smital, 2009; Banaszewska and Kondracki, 2012; Schulze et al., 2014).

Boar age, collection interval and season are usually proposed factors that should also be considered in spermiograms of boars (Rodriguez-Martinez, 2003; Smital, 2009; Broekhuijse et al., 2012). These factors

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strongly determine the overall operating efficiency of boars, and so they should be included in the long-term production planning.

Boars have a decisive impact on the implementation progress in genetics and production in pigs. Improving pig production has led to a significant increase in fatteners and slaughter features. However, research results indicate a negative impact of increasing muscle on semen quality, sexual maturity, development of reproductive organs (especially primary) and hormonal balance (Andersson et al., 1999). Therefore, boars to be used for reproduction must be selected as soon as possible and this should be carried out according to the particular rearing methodology (Knecht et al., 2004). Only thanks to a special procedure can be achieved the best compromise between these characteristics. The main aim of AI boar development is to achieve reproductive maturity, which is mostly determined by age (Schulze et al., 2014). Boars become adolescent at different times, usually 9–10 months, and variability results from genotype and rearing conditions (Huang et al., 2010; Banaszewska and Kondracki, 2012). Most boars used in insemination stations start their reproductive performance at the age of 7–8 months, reaching full development and production capabilities at a later time (Banaszewska and Kondracki, 2012). The time needed for boars to reach full capacity during reproduction also depends on the organization, especially the schedule of jumps and collection intervals.

Collection interval is one of the most important external factors, which results from the organization of semen collection and production of insemination doses. It should be noted that this factor is highly human-dependent (Foxcroft et al., 2008). Valuable boars producing a large quantity of semen should be reasonably used throughout their long-term performance. Study results on the ejaculate parameters with different collection intervals are inconclusive. However, authors clearly state that overfrequent collection of ejaculate affects semen quality and the entire process of spermatogenesis, as well as overlong intervals lead to excessive deposition of spermatozoa in the epididymis (Colenbrander and Kemp, 1990; Bertani et al., 2002; Frangež et al., 2005). Collection intervals are closely linked to the economic results of AI stations, which is reflected in the length of use of boars and quality-production results. Frequent collection of ejaculates allows the production of a large amount of semen in a relatively short-time period (Huang et al., 2010). The temptation to increase the efficiency of boar insemination is so large that studies are constantly being carried out into the possibility of shortening the maximum rest time without adversely affecting the subsequent operation, including seasonal variation.

Boars are considered to be aseasonal and able to donate ejaculates with good quality throughout the year, although the seasonality of semen quality in a moderate climate has very often been signaled (Claus and Weiler, 1985; Flowers, 2008; Smital, 2009; Knecht et al., 2013, 2014b). The consequent improvement of breeding animals, may result in increased sensitivity of animals to their environment (Knecht and Duziński, 2014). Production results of boars in terms of the quantity and quality of the ejaculate obtained during a calendar year can vary by as much as 30% (Colenbrander and Kemp, 1990). This is mainly defined in temperate climates by day length light and temperature (Claus and Weiler, 1985; Andersson, 2000; Rivera et al., 2005; Knecht et al., 2013, 2014b). Therefore, semen quantity and quality may vary in different seasons, even if boars are kept in constant microclimate conditions. Research on the influence of age, collection interval and season have been carried out intensively in recent years. However, there is little long-term work on large populations including a number of observations, although only such observations can directly translate scientific results into practical application. A major shortcoming in existing published research is also the negligible interactive analysis of factors. This is due to the usually difficult presentation and readability of data. Interactions are the source of most precise information regarding the complex action of the main effects. Development of the tested parameters in the interactive system may, in fact, be different in relation to the main effects. AI stations need the most accurate information for detailed and thorough studies of long-term production plans.

This justifies the research undertaken to determine the effects of age, collection intervals and season and their interactions on selected quantitative and qualitative semen parameters and to develop equations for estimating production capacity for AI stations.

2. Material and methods

2.1. Study location and design

The study was carried out at the Boar Exploitation Station in Częstochowa (50°44'51.7"N 19°03'24.1"E) and included 48 117 ejaculates obtained from 368 boars over 5 years. The presented population was representative in proportion to the most common breed components used for AI in Poland, such as: Polish Landrace, Polish Large White, Duroc, Pietrain, Hampshire, Duroc × Pietrain, Hampshire × Pietrain, Duroc × Hampshire.

Experimental groups were divided according to: age of boar (8–9, 10–12, 13–18, 19–24, 25–30, > 30 months), collection intervals (≤ 2, 3, 4, 5, 6, 7, ≥ 8 days), and season (Winter, Spring, Summer, Autumn). Seasonal division of experimental groups was determined for temperate climate zone, based on the previously developed methodology taking into account day light length and temperature variation (Knecht et al., 2013, 2014b; Knecht and Duziński, 2014; Duziński et al., 2014). The proportion of tested ejaculates in each season and month were almost similar also taking into account other analyzed factors.

2.2. Semen analysis

The ejaculates collection from boars began at the age of 8 months. Before the start of semen collection, all boars were held in quarantine (37.24 ± 5.02 days). The boars were trained to ejaculate on a dummy sow. Selected quantitative and qualitative parameters were analyzed and calculated: semen volume (ml), spermatozoa concentration ($\times 10^6$ ml^{-1}), total number of spermatozoa in ejaculate ($\times 10^9$), number of motile spermatozoa in ejaculate ($\times 10^9$), and number of insemination doses obtained from one ejaculate (n). Ejaculates were collected by masturbation via the manual method (King and Macpherson, 1973). The gelatinous fraction was separated. Collections were made in almost homogenous terms during the season. Immediately after collection, semen volume was measured using a scalar cylinder. The concentration of spermatozoa was evaluated using a Model 12300/0500 SpermaCue device (Minitube International, Verona, USA). Based on the semen volume and spermatozoa concentration, the total number of spermatozoa in the ejaculate was calculated and expressed as 10^9 spermatozoa per ejaculate. The motility of spermatozoa was assessed under an optical microscope at ×200 magnification. For the assessments, aliquots of semen samples were placed on pre-warmed slides and covered with a glass cover slide (20 × 20 mm). The total numbers of motile spermatozoa were calculated by multiplying the total number of spermatozoa in ejaculates and the motility of spermatozoa. Semen dilution was effected using the same semen extender. Insemination doses of 80 ml contained a constant 2.75×10^9 spermatozoa. Semen was stored at 15 °C for not longer than 72 h. All produced insemination doses were held for sale. The overall characteristics of the study population are presented in Table 1.

2.3. Housing and feeding

Boars were single-housed and maintained in accordance with the European Union principles of animal welfare (Ordinance of the Minister of Agriculture and Rural Development, 2010). The individual pen area was 8 m^2/boar. The air temperature in all the boar pens was close to 15 °C (min 12 °C, max 20 °C). Relative humidity was close to 75% (min 65%, max 85%). The air circulation inside the building was equal to