The Use of Triaxial Accelerometers During the Semen Collection Process in Boars

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***Abstract*—Artificial insemination is the main method used for sows' fertilization in pig farms. Therefore, boar fertility is a key parameter of the economic efficiency of a livestock company. Stress (e.g., thermal) influences both libido and semen characteristics, and might be the reason for "seasonal infertility", which negatively affects the economic status of pig farms. In this work we show that overall dynamic body acceleration (ODBA) derived by accelerometer data from boars during the semen collection process is correlated to both ambient and body temperature. It may also provide useful information about a boar's sexual behavior and, hopefully, fertilization efficacy, but further research is necessary on this issue.**

Keywords—boar, artificial insemination, accelerometer, overall dynamic body acceleration

I. Introduction

Artificial insemination with extended boar semen is the main method used for sows' fertilization in pig farms, worldwide, since it minimizes the risk of disease spreading and supports the farm's biosecurity, sustainability, and financial status. Therefore, boar fertility is a key parameter of the economic efficiency of a livestock company, while purchase and distribution of boars to pig farms for semen production and collection is an internationally established marketing practice with huge direct and indirect economic interest.

However, boar's semen quality is affected by several seasonal, environmental, and individual animal features. It is well known that summer is related to boar ejaculates of lower volume, as well as to degraded semen of lower motility, concentration, and higher percentage of morphological abnormalities [1]. The phenomenon of "seasonal infertility" negatively affects the economic status of pig farms because it increases the return to estrus rate and decreases the farrowing rate and litter size. Stress (thermal, acoustic, psycho-kinetic, etc.) influences both libido and semen characteristics [2], [3]. In a previous study, the consumed time for dummy mounting and the total time for boar semen collection were recorded with a digital timer, while sperm concentration and motility were estimated. A correlation between these parameters and the breed of the boar was noticed [4].

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The use of (wireless) sensors for observing and understanding animal behavior is rather recent and only in the past few years has received greater attention. One of the first research articles in this scientific area concerned the creation of a wireless sensor platform for animal behavior monitoring [5]. In this study, the authors did not only implement a wireless sensor network, but they also developed an algorithm for distinguishing the different activities of the animals under test. Moreau et al [6] introduced the use of a triaxial accelerometer and the need of automated recording for the classification of the goat's grazing behavior.

In the last decade accelerometers constitute the basic tool for the construction of the activity budgets of the animals. In [7] newly developed acceleration-logging devices were created for the characterization of the behavior in small animals. In [8], [9] and [10] the use of triaxial accelerometers enabled the characterization of the behavior of cows, sheep and calves, respectively.

In the present study an accelerometer was used to characterize the 'liveliness' of boars as a potential predictor of fertilization efficacy. The parameters evaluated from the data recorded were compared to well-known parameters associated with the libido and semen quality of the animals.

II. Materials and Methods

A. Animals

The study was approved by the Ethics Committee on Animal Use of the Aristotle University of Thessaloniki, Greece. All procedures were carried out according to the Aristotle University Guidelines for animal research (96385-19929/2020 - Project Number: HFRI-FM17-2040).

TABLE I. Boars Included in the Study

Boar ID	Breed	Age (months)
498	PIETRAIN	20
499	PIETRAIN × DUROC	16,5
530	PIETRAIN	14
531	PIETRAIN	14
600	LANDRACE	12

Semen collection was carried out in a commercial Greek pig farm in the region of Central Macedonia. The pig farm has a maximum capacity of 150 sows. At the time of the study the farm hosted five adult healthy boars, aged 12-20 months, of

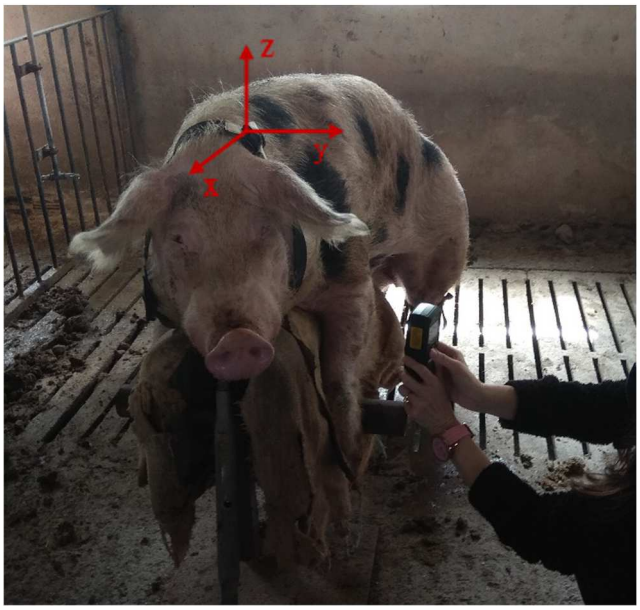

Fig. 1. Motion sensor (IMU) placed on the boar.

various breeds (Table I), which were involved in the artificial insemination program of the farm. The boars were housed in individual pens and under controlled conditions of temperature (15-25°C), humidity and ventilation. During the one year of experimentation for the current study, 94 ejaculates (18-19 ejaculates/boar) were collected bi-weekly.

B. Measurement equipment

An Inertial Measurement Unit (IMU) (MBIENTLAB, San Francisco, USA), comprising an accelerometer, a gyroscope and a magnetometer was mounted on the nape of the boar, using a specially constructed collar (Fig. 1). Tri-axial acceleration data were recorded with a sampling rate of 100 Hz and the overall dynamic body acceleration (ODBA) was calculated:

$$ODBA = DBA_x + DBA_y + DBA_z \quad (1)$$

where *DBA* is the dynamic body acceleration or static acceleration, calculated by subtracting a running mean from the raw acceleration data from each axis. The parameter was calculated with a moving average window of 5 s (500 samples) using a script in Matlab 2021a (MathWorks, Natick, Massachusetts, USA).

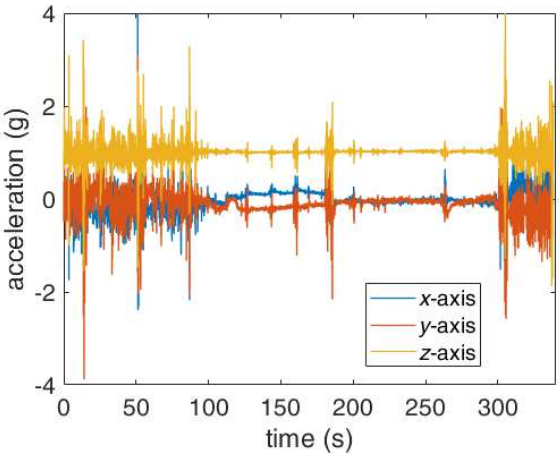

Fig. 2. Raw data from the motion sensor (IMU) sensor placed on boar with ID 499.

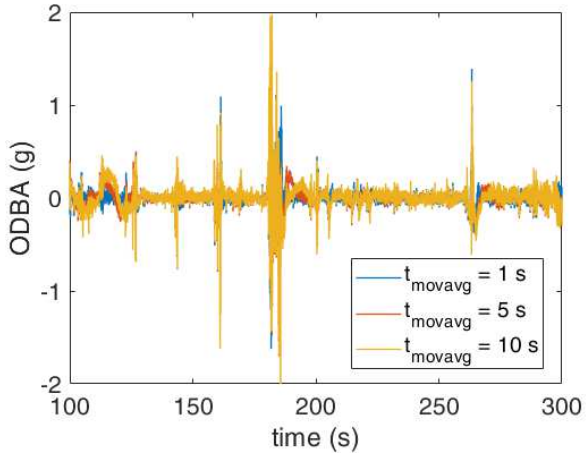

Fig. 3. ODBA calculated for the data shown in Fig. 2 for three different moving average windows.

The temperatures of the animal's body and the dummy were recorded with an infrared (IR) camera (FLIR ONE Pro, FLIR Systems, Wilsonville, USA) and an IR thermometer, respectively. All signals and images were logged on a mobile device (either a smartphone or tablet) using a Blue-tooth connection and then transferred wirelessly to the cloud. The temperature of the dummy was recorded before the semen collection process started, so that it could be assumed as a good proxy of the temperature of the environment where the boars were housed. The whole process was timed with a digital chronometer and the time the animal spent mounted on the dummy was separately noted.

III. Results and Discussion

Fig. 2 shows the raw data obtained from the accelerometer for the boar with ID 499 during the whole semen collection process. The ODBA for the above measurement and for three different moving average time windows, i.e., 1, 5 and 10 s, is shown in Fig. 3. It is clear, that the time window does not affect the ODBA, particularly during the time the boar is mounted on the dummy (Fig. 2, 100 – 300 s). Therefore, the 5 s time window was chosen to evaluate for every measurement the mean and the median values of ODBA.

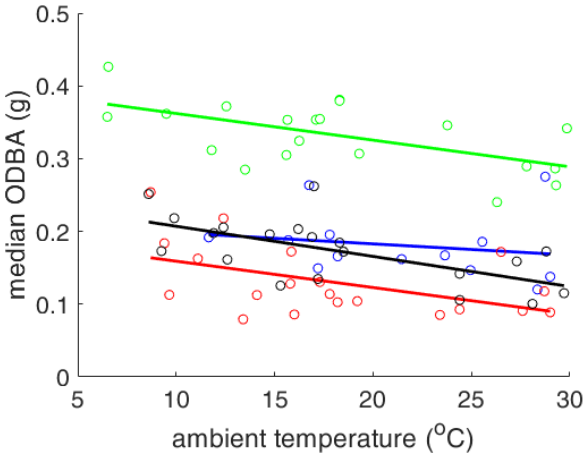

Fig. 4. ODBA as a function of ambient temperature for boars with ID 498 (blue), 499 (green), 530 (red), and 531 (black).

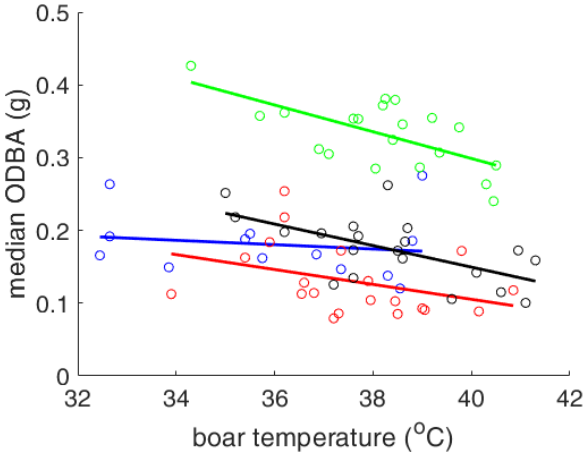

Fig. 5. ODBA as a function of body temperature for boars with ID 498 (blue), 499 (green), 530 (red), and 531 (black).

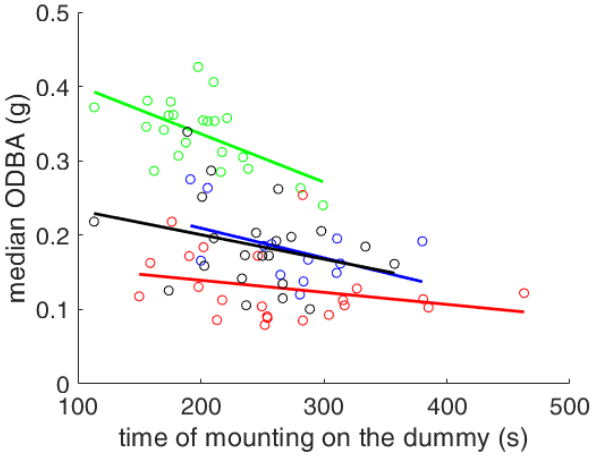

Fig. 6. ODBA as a function of time the animal spent for semen collection mounted on the dummy; boar ID 498 (blue), 499 (green), 530 (red), and 531 (black).

Fig. 4 depicts the change of median ODBA with ambient temperature for individual boars. The data for boar with ID 600, which had an age of 12 months, i.e., was the youngest of all five animals, are not shown, because they show no correlation between environmental temperature and ODBA. For the other four boars, it appears that ambient temperature reduces the mobility of the animals, because there is negative correlation between temperature and ODBA. The linear regression coefficients and intercepts for each boar were calculated with Matlab 2021a. It is interesting to note here that boars with IDs 530 and 531 are brothers and exhibit very similar behavior, as indicated by the intercept and regression coefficients: for boar with ID 530, intercept 0.1953 g and regression coefficient -0.0036 g/°C, p=0.026; for boar with ID 531, intercept 0.2485 and regression coefficient -0.0041 g/°C, p=0.003. It can be seen that $p < 0.5$, indicating that ambient temperature affects ODBA. Similar results can be obtained when comparing the animal's temperature with its 'liveliness', as expressed in terms of ODBA (Fig. 5).

One result that is contra-intuitive is shown in Fig. 6. It seems that the ODBA of a boar is negatively associated to the time it spends mounted on the dummy, although one would expect that brisk animals (with high ODBA) would also have longer ejaculation times (spent on the dummy), which are indicators of the animal's libido. This result needs further research, because it may be associated with the age of the animals or their energy expenditure, with which ODBA has been correlated [11].

The factor of boar age merits further discussion in the context of factors affecting fertility. The used pig strains for meat production have been genetically improved and superior genetic lines are worldwide available. Depending on the produced meat quality characteristics and the consumers' tastes, different pig breeds are selected for different market and farming purposes. It is generally accepted that the gene expression of each breed is affected by environmental and nutritional factors, as well as by their interactions. In the present study all boars were fed and housed under the same conditions in a pig farm. No reports concerning sexual behavior differences between boar breeds are provided in the literature. However, it is well known that boar age contributes to the success of artificial insemination with preserved semen and should be considered. A previous study, where a huge number of 75567 boar ejaculates of 1417 Landrace and Large White boars were analyzed, reported a strong boar's age influence on semen volume, the total number and the functional number of spermatozoa [12]. On the other hand, no significant differences between breeds were observed in semen traits. In addition, the results of [13] revealed significant differences among crossbred boars of different ages in terms of sperm chromatin stability (SCI), morphology and sperm head morphometry. Young and old boars were more susceptible to SCI compared to mature boars, while the risk of obtaining low farrowing rates is higher after artificial insemination with semen from young than from mature and old boars. The above show that boar age is a more important factor than breed for fertilization efficacy.

IV. Conclusion

In this work we have used an IMU to collect acceleration measurements from boars during the semen collection process. The ODBA calculated with these data has been negatively correlated to the ambient and the animal's body temperatures, which might be correlated to "seasonal infertility". Therefore, ODBA, is another indicator of the 'liveliness' (or energy expenditure) of a boar, although its role in libido needs to be further researched.

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