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Linear model analysis of the influencing factors of boar longevity in Southern China

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ABSTRACT

This study aimed to investigate the factors influencing the boar herd life month (BHLM) in Southern China. A total of 1630 records of culling boars from nine artificial insemination centers were collected from January 2013 to May 2016. A logistic regression model and two linear models were used to analyze the effects of breed, housing type, age at herd entry, and seed stock herd on boar removal reason and BHLM, respectively. Boar breed and the age at herd entry had significant effects on the removal reasons ($P < 0.001$). Results of the two linear models (with or without removal reason including) showed boars raised individually in stalls exhibited shorter BHLM than those raised in pens ($P < 0.001$). Boars aged 5 and 6 months at herd entry (44.6%) showed shorter BHLM than those aged 8 and 9 months at herd entry ($P < 0.05$). Approximately 95% boars were culled for different reasons other than old age, and the BHLM of these boars was at least 12.3 months longer than that of boars culled for other reasons ($P < 0.001$). In conclusion, abnormal elimination in boars is serious and it had a negative effect on boar BHLM. Boar removal reason and BHLM can be affected by breed, housing type, and seed stock herd. Importantly, 8 months is suggested as the most suitable age for boar introduction.

1. Introduction

Boar longevity, which can be expressed as boar life days and boar herd life days, affects the productivity and economics of herds [1,2]. However, the predominant age of boars culled is only 1–2 years, which indicates a relatively short longevity [3]. In addition, the culling rate of boars is as high as 59.4% per year; hence, young boars may be overused, and boar longevity may decrease because of increasing reproductive problems [1,4]. Therefore, the reasons underlying boar removal and the factors influencing boar longevity should be ascertained for boar production.

Semen quality is the main reason for boar culling [5]. Nevertheless, different feeding conditions and culling levels recorded by producers may result in boar culling for various reasons. In Japan, the primary reasons for boar culling include old age and reproductive problems [2], whereas those in the USA and in Canada include genetic improvement, poor semen quality, and lameness [3]. Therefore, the boar culling patterns in China may differ from those in other countries because of the different modes of pig management and housing. Longevity can be influenced by gilt development, gilt pool management, age at puberty and first farrowing, nutrition, lactation length, body condition, repeat breeding, season, housing and sow behavior, lameness, management, and disease in sows [6]. However, only the effects of herd group and removal reason on longevity were evaluated in boars [2]. Studies on other factors influencing boar longevity are scarce.

Southern China is the main pork-producing [7] and boar-breeding region of the country. The present study aimed to

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determine the predominant reasons underlying boar removal and the factors influencing boar longevity in Southern China by using a linear model analysis.

2. Materials and methods

2.1. Herds and animals

This study was conducted on nine artificial insemination (AI) centers owned by a single large integrated pork production company located in Southern China. The inventory for these AI centers comprised 50–1000 boars, and purebred Duroc, Landrace, and Large White boars were the only three breeds raised in these nine AI centers. Boars raised in these nine AI centers were introduced from 10 seed stock herds, which were located at 10 different places and consisted of more than one breed for each seed stock herd. In addition, not all seed stock herds were presented in each of these nine AI centers. For the housing types, individual-pen mode was used in seven of the nine AI centers, whereas individual-stall mode was used in the two other AI centers. The Kingdee software (Kingdee International Software Group Co., Ltd., Shenzhen, China) and data recording system was used to record and store data on all AI centers.

2.2. Data collection and selection criteria

Producers of these AI centers were requested to submit their initial data on boar culling (from January 2013 to May 2016) to the College of Animal Science and Technology, Huazhong Agricultural University. The following information associated with culling was collected: name of AI center, boar tag number, removal reasons, age at herd entry, and seed stock herd for culling boars introduction. Data were contained in analyses as the following conditions were fulfilled: 1) including the complete information mentioned above; and 2) the age at herd entry for culling boars was between 5 and 12 months. The average culling rate of these nine AI centers was nearly at 40%, and totally 1794 were eliminated from January 2013 to May 2016. There were 164 culling boars were not included in the final analysis because they lacked of the information of seed stock herd and the age at herd entry, and also because the information of removal reason recorded by producers was not clear. Therefore 1630 culling boars of Duroc, Landrace, and Yorkshire derived from 10 seed stock herds were included for data analysis.

2.3. Definitions and category

The present study defined the boar herd life month (BHLM) as the number of months from birth date to removal date and was referred to as the longevity for boars. Age at herd entry was defined as the age in months (instead of days) when the boar was entered to the AI center [2]. The removal reasons and types recorded by producers were categorized into nine groups: 1) lameness (LA), 2) poor semen quality, 3) diseases, 4) death and stress, 5) poor libido, 6) old age (OA), 7) testicular abnormalities, 8) low semen volume, and 9) body condition abnormalities.

2.4. Statistical analysis

The BHLM data are presented as least square means with standard error. All analytical procedures were performed with SAS for data analysis (version 9.4; SAS Inst. Inc., Cary, NC). The five influencing factors included a mix of things that are controlled and things that are not controlled. In this model, the influencing factor of removal reason was considered as uncontrolled things, while the other influencing factors of boar breed, housing type, seed stock herd, and boar age at herd entry were considered as the controlled things. Prior to analyses, the BHLM data were tested for normality and homoscedasticity by using Shapiro–Wilk (PROC UNIVARIATE) and Levene's tests (PROC ANOVA). The *P*-values of Shapiro–Wilk and Levene's tests were 0.2693 and 0.3174, respectively. This indicated the distributions of BHLM data were adequate and fit to use in the next analysis.

The disposal reasons (PROC LOGISTIC) and BHLM (PROC GLM) were analyzed with the four controlled factors, firstly. To have enough cases for the large number of controllable factors being fitted, poor semen quality and low semen volume (PS), diseases, death and stress (DSD), and poor libido, testicular abnormalities and body condition abnormalities (OT) were combined, respectively. Boar age at herd entry with 10, 11 and 12 months were also integrated into one group. And then the BHLM was fitted into a model of controlled factors and disposal reason (PROC GLM). The two linear model equations with the controlled factors (model 1) and with all influencing factors (model 2) were presented as follows:

$$Y_{klmn} = \mu 1 + B_k + T_l + S_m + M_n + e_{klmn} \quad (1)$$

$$Y_{jklmn} = \mu 2 + R_j + B_k + T_l + S_m + M_n + e_{jklmn} \quad (2)$$

where the Y_{klmn} (model 1) was the value of the given BHLM for the kth breed, lth housing type, mth seed stock herd, and nth age at herd entry; the Y_{jklmn} (model 2) was the value of the given BHLM for the jth removal reason, kth breed, lth housing type, mth seed stock herd, and nth age at herd entry; R_j is the effect of the jth removal reason (j = 1,…, 5); B_k is the effect of the kth breed (k = 1, 2, 3); T_l is the effect of the lth housing type (l = 1 and 2); S_m is the effect of the mth seed stock herd (m = 1,…, 10); M_n is the effect of the nth age at herd entry (n = 5,…, 10–12); and e_{klmn} and e_{jklmn} were the residual effects of model 1 and model 2, respectively. The significance level was set at 5% in all statistical analyses.

3. Results

3.1. Effect of the controlled factors on boar removal reason

The results of the controlled factors on the removal reasons are summarized in Tables 1 and 2. Boar breed and age at herd entry both had significant impacts on boar removal reason ($P < 0.001$; Table 1). As shown in Table 2, compared with Duroc boars, Yorkshire boars had higher odds ratios of LA and OT than OA ($P < 0.05$). Compared with boars raised in individual pens, those raised in individual stalls had higher odds ratios of LA, PS, and OT than OA ($P < 0.05$). In addition, compared with boars aged 5 months at herd entry, those aged 10–12 months at herd entry had higher odds ratios of LA, DSD, and OT than OA ($P < 0.05$).

3.2. Effect of breed on the BHLM

Differences in the BHLM among purebred boars are presented in Tables 3 and 4. Duroc boars exhibited shorter BHLM than Landrace boars in both models ($P < 0.01$), while had shorter BHLM than

Table 1
Type III tests for logistic regression analysis.

Source	DF	Wald X^2	*P*-value
Breed	8	30.5218	0.0002
Housing type	4	8.3862	0.0784
Seed stock herd	20	30.2672	0.2756
Age at herd entry	40	108.1705	<0.0001