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The effect of dual-hemisphere breeding on stallion fertility

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ABSTRACT

Breeding records were analyzed from 24 Thoroughbred stallions that were subjected to dual-hemisphere breeding (DH), including novice (first-year; NOV; n = 11) and experienced (EXP; n = 13) stallions. Fertility variables included seasonal pregnancy rate, pregnancy rate per cycle, and first-cycle pregnancy rate. In addition, values for book size, total number of covers, distribution of mare type (maiden, foaling, and barren) within a stallion's book, cycles per mare, and mare age were examined. Some data were also categorized by mare type (maiden-M, foaling-F, and barren-B). Five separate analyses of the data were performed. For Analyses 1–3, the effects of hemisphere (northern hemisphere [NH] vs. southern hemisphere [SH]) and breeding order (refers to the first [O1] or second [O2] season within the first year of dual-hemisphere breeding) were examined for all stallions (combined group [CG]), NOV stallions only, and EXP stallions only, respectively. Fertility values were generally higher in the SH than the NH ($P < 0.05$), whereas book size, total number of covers, and cycles per mare were higher in the NH than the SH ($P < 0.05$). Book size and total covers were negatively correlated to first cycle pregnancy rate ($r = -0.57$, $r = -0.71$, respectively; $P < 0.05$) for NOV stallions. Pregnancy rate per cycle was also negatively correlated with total covers ($r = -0.58$; $P < 0.05$) for NOV stallions. Similar trends were noted for Groups CG and EXP, but the relationship was not as marked as for NOV stallions. The fertility of O1 was generally similar to O2 ($P > 0.05$).

For Analysis 4, fertility of DH breeding seasons was compared to single hemisphere (SIN) breeding seasons within the same 16 stallions and was found to be similar between the two groups ($P > 0.05$). For Analysis 5, the effect of the number of consecutive DH breeding seasons on fertility was examined and was found to remain unchanged ($P > 0.05$).

In summary, no adverse effects of DH breeding on fertility were detected. Fertility was higher when stallions were bred in the SH, as compared to the NH. Potential reasons for higher fertility achieved in the SH were smaller book sizes and better mare reproductive quality.

1. Introduction

Horses are long-day (seasonal) breeders. Mares tend to enter an anovulatory phase during the autumn and winter [1–3]. In contrast to mares, stallions do not experience seasonal infertility even though they may experience a reduction in testicular size and daily sperm output during the same time period [4,5]. Altered circulating concentrations of reproductive hormones have been associated with seasonal changes in photoperiod [4,6–8] and also with decreased fertility [6,7] of stallions. Perceptions of a seasonal reduction in fertility of stallions also exist based on various laboratory measures obtained throughout the year [4,9–11].

Dual-hemisphere (DH) breeding (i.e., shuttle stallions) is defined as the breeding of stallions in both the northern and southern hemispheres (NH and SH, respectively) within a single year. Such stallions are exposed to two periods of short and long day lengths annually. A previous report [9] suggested that DH breeding did not affect stallion fertility based on seasonal live-foal rates in differing populations of stallions. The aims of this study were to evaluate multiple fertility variables of; 1) stallions (combined group [CG] composed of both novice [NOV] and experienced [EXP] stallions) that were exposed to two breeding seasons in alternating hemispheres (one DH year); 2) NOV stallions during the first DH year; 3) EXP stallions during the first DH year examined in this study; 4) stallions whose DH breeding seasons were compared with single hemisphere (SIN) breeding seasons within stallion; and 5) stallions subjected to consecutive DH breeding seasons (up to 10 alternating NH/SH breeding seasons).

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2. Materials and methods

The data set for this study included records for 24 Thoroughbred stallions that were bred by natural cover to 6638 mares on 10,266 covers over a 9-year period (1998–2007). The stallions ranged in age from 3 to 13 years at the beginning of the study. An electronic spreadsheet (Excel, Microsoft, Redmond, WA) program was used to record all data in the study. To be included in the data set, each stallion was required to have bred at least one year that included both the NH and the SH breeding seasons. A single DH breeding year was defined as 2 consecutive breeding seasons, one in the NH and one in the SH. In general, the NH breeding season spanned from February 15 to June 30, whereas the SH breeding season spanned from September 1 to early December. Variables evaluated were seasonal pregnancy rate (%) for all mares (total number of mares diagnosed pregnant at the end of the breeding season divided by the book size x 100); seasonal pregnancy rate for maiden mares (mares that were bred for the first time in their life); seasonal pregnancy rate for foaling mares (mares that produced a foal in the same year in which they were bred); seasonal pregnancy rate for barren mares (mares that were bred the previous year but did not become pregnant or maintain the pregnancy); pregnancy rate per cycle (%) for all mares (total number of mares pregnant at the end of the breeding season divided by the total number of estrous cycles in which mares were bred x 100); pregnancy rate per cycle for maiden, foaling, and barren mares; first-cycle pregnancy rate for all mares (%; total number of mares pregnant to the first estrous cycle of breeding divided by the book size x 100); book size (total number of mares to which a stallion was bred in a breeding season [range 65–231]); total covers (total number of times a stallion bred mares in a breeding season; [range 91–360 covers]); percentages of maiden, foaling, and barren mares in a stallion's book; the average number of estrous cycles per mare that each mare group (overall, maiden, foaling, and barren) was bred; and the average age of maiden, foaling, and barren mares. Mares that aborted or were not bred the previous year were included in the barren mare category.

2.1. Data analysis

Analysis 1 (all stallions, first DH year) - The breeding records from the first DH breeding year from all stallions (CG; n = 24; ages 3–13 y) were analyzed. The numbers of mares included in this data set for the NH and the SH were 3738 and 2900, respectively. The effect of hemisphere (NH vs. SH), breeding order (refers to first [O1] or second [O2] season within the first year of dual-hemisphere breeding), and the interaction of hemisphere and breeding order were evaluated. The effect of book size and total covers on pregnancy rate per cycle for all mares and first cycle pregnancy rate for all mares were also evaluated.

Analysis 2 (novice stallions, first DH year) - The breeding records from the first DH breeding year of NOV stallions (n = 11; ages 3–4 y) were analyzed. These stallions had not bred a commercial mare prior to the beginning of the first breeding season. Seven NOV stallions began their DH year in the NH and four began their DH year in the SH. The numbers of mares included in the NOV stallion data set for the NH and the SH were 1917 and 1296, respectively. Similar to Analysis 1, the effect of hemisphere, breeding order, and the interaction of hemisphere and breeding order were evaluated. The effect of book size and total covers on pregnancy rate per cycle for all mares and first cycle pregnancy rate for all mares were also evaluated.

Analysis 3 (experienced stallions, first DH year) - The breeding records from the first DH breeding year from EXP stallions (n = 13; ages 4–13 y) were analyzed. Eight EXP stallions began their DH year in the NH and five stallions began their DH year in the SH at the start of this study. The numbers of mares included in the EXP stallion data set for the NH and the SH were 1807 and 1584, respectively. The effects of hemisphere, breeding order, and the interaction of hemisphere and breeding order were evaluated. The effect of book size and total covers on pregnancy rate per cycle for all mares and first cycle pregnancy rate for all mares were also evaluated.

Analysis 4 (stallions with both DH and SIN years)- The effect of DH breeding (includes both hemispheres) on fertility was compared to single hemisphere (SIN) breeding within stallion. Data from 16 stallions (3–13 y at the beginning of the study) were included in the analysis.

Analysis 5 (stallions with consecutive DH years) - The effect of the number of consecutive breeding seasons (range1–10) in which a stallion bred alternately in the NH and the SH on fertility was determined over all stallions.

2.2. Statistical analysis

The effect of hemisphere (NH, SH) and breeding order (O1, O2) were analyzed using a mixed-model analysis-of-variance procedure and the LSD statistic was applied for mean separation ($P < 0.05$; Proc MIXED; SAS Institute Inc., Cary, NC, USA). Percentage data were transformed to angles (arc sin square root) prior to analysis to meet assumption of normality; however, untransformed data are presented in tables for ease of interpretation. Correlation coefficients among dependent variables were also calculated (Proc REG; SAS Institute Inc., Cary, NC, USA).

3. Results

Book size, total covers, first cycle pregnancy rate for all mares, and pregnancy rate per cycle for all mares for 11 NOV and 13 EXP stallions in the NH and the SH during the first breeding year examined are summarized in Table 1. The table demonstrates the

Table 1
Descriptive table regarding book size, total covers, first cycle pregnancy rate (FCPR), and pregnancy rate per cycle (PCR) in 11 novice (1–11) and 13 experienced (12–24) Thoroughbred stallions in the northern hemisphere (NH) and southern hemisphere (SH) during the first breeding year examined.

Stallion	Book size		Total covers		FCPR		PCR	
	NH	SH	NH	SH	NH	SH	NH	SH
1	189	74	288	117	51	62	51	53
2	159	95	234	134	57	71	56	67
3	166	158	255	231	56	56	56	54
4	148	121	265	175	50	59	47	59
5	154	98	240	169	51	51	53	48
6	154	123	279	166	38	71	38	68
7	194	154	345	230	46	52	47	57
8	228	122	349	168	52	65	54	60
9	172	117	267	177	43	60	44	58
10	191	114	295	154	56	59	53	61
11	176	140	282	219	45	53	49	51
12	116	66	162	91	61	53	61	64
13	102	117	193	175	45	56	43	56
14	74	231	115	343	49	54	45	54
15	164	141	254	195	58	60	55	57
16	218	108	360	155	50	62	49	59
17	185	103	315	146	50	52	49	59
18	173	91	314	155	38	44	36	41
19	163	80	243	108	56	65	54	66
20	121	130	173	131	56	34	56	34
21	145	107	294	174	33	45	36	48
22	91	130	149	184	41	58	43	63
23	190	153	299	200	58	63	55	61
24	65	127	108	191	48	54	52	57