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Reproductive Performance of Holstein Heifers Inseminated with Sex Sorted Semen in Various Herd Sizes

Research Article

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ABSTRACT

Nowadays, the use of sex-sorted semen is more commonplace in industrial dairy farms. However, the reproductive efficiency of this kind of semen is controversial among dairy farmers. Reproductive efficiency can also be influenced by herd size as a result of different management practices. The current study compares the reproductive performance of Holstein heifers inseminated either with sex-sorted or conventional semen in Isfahan province of Iran. Data were included the reproductive performance of 64070 heifers collected during 2007-2017 from 10 industrial farms with various sizes. Evaluated reproductive traits were conception rate, dystocia, stillbirth, abortion as well as days open and days from calving to the first service in heifers inseminated with various semen types and various farm sizes. Conception rate in the first to the third insemination of sex-sorted semen, respectively decreased by 18, 16, and 12 percent compared to the conventional semen. The chance of abortion, still birth, and dystocia when using sex-sorted semen were 0.095, 0.43, and 0.81. The result illustrated that using sex-sorted semen dramatically decreases the proportion of reproductive disorders, yet it led to lower conception rate, and it is estimated that conception rate is going to be improved through more efficient reproductive management in larger farm sizes. Herd size did not show a consistent effect on reproductive performance however reproductive efficiency was somehow better in medium-sized farms.

KEY WORDS heifer, reproductive performance, sexed semen.

INTRODUCTION

Semen sorting is a revolutionary technology which aims to increase production efficiency in dairy herds (Holden and Butler, 2018). Female sex ratio has been proved to be between 85-95% utilizing sex sorted semen as compared to the 50% sex ratio expected from conventional semen (Garner and Seidel, 2008). Numerous studies have reported lower conception rate of sexed versus conventional semen (Healy *et al.* 2013; Joezy-Shekalgorabi *et al.* 2017; Butler and Moore, 2018; Oikawa *et al.* 2019; Patel and Jathva, 2019; Bittante *et al.* 2020; Slozhenkina *et al.* 2020). However, few studies have demonstrated the effect of sex sorted semen on other reproductive deficiencies (Fetrow *et al.* 2007; DeJarnette *et al.* 2009; Norman *et al.* 2010; Joezy-Shekalgorabi *et al.* 2017). Fetrow *et al.* (2007) reported that using sex sorted semen reduces the rate of dystocia in heifers and cows by 3.7% and 1%, respectively. Their study revealed that dystocia is not affected by the type of sperm, and the likelihood of dystocia is influenced by age, insemination season, sex and weight of the calf in the birth. DeJarnette *et al.* (2009) detected no discrepancy in the rate of stillbirth of sex-sorted and conventional semen in various calving age. In another report, the proportion of stillbirth obtained by sexed semen accounted for 8.8%, which had a twofold increase compared to the control group (DeJarnette *et al*. 2009). A study by Joezy-Shekalgorabi *et al*. (2017) revealed no significant difference in dystocia and stillbirth when utilizing sex sorted and conventional semen. Studies have illustrated that the sperm type has no considerable impact on abortion (Jabarzareh *et al*. 2015; Joezy-Shekalgorabi *et al*. 2017). Nevertheless, a marginal decline in abortion rate of dairy heifers inseminate by sex sorted semen has been reported which could be due to better body condition of the inseminated heifers (Djedovic *et al*. 2016). Herd size is one of the major factors in herd profitability. It is declared that the size of herd affect reproductive efficiency of herd (Jago and Berry, 2011; Lemma and Kebede, 2011; Sasaki *et al*. 2016; El-Tahawy, 2017). A study in the USA revealed that farms with more animals and higher milk production utilize sex sorted semen more frequently. The frequency of using sex sorted semen in farms with 501-1000 cows was about 49% compared to the small size farms (with 51-100 cows) (which was about 21%) (Hutchison and Norman, 2009). Norman *et al*. (2010) reported that percentage of sexed semen breeding generally increased in larger farm size. The rate of sexed semen insemination was 17.2 and 4.5% for herds with ≤ 50 animals and 72.4 and 18.0% for herds with ≥ 1001 animals for heifer and cow, respectively. The exception was a slightly larger percentage (21.5%) of cow breeding with sexed semen for herds with 501 to 1000 animals. Mean sexed semen use within herd also increased (6.0 to 25.9%) for heifer breedings as herd size increased. In contrast, mean sexed semen use for cow breedings changed little as herd size increased (Norman *et al*. 2010).

In Iran, limited studies have analyzed the reproductive performance of sex sorted semen (Jabarzareh *et al*. 2015; Joezy-Shekalgorabi *et al*. 2017). Besides, the performance of sex sorted semen in terms of its effect on reproductive features such as dystocia, abortion and stillbirth are doubtful. On the other hand, none of the published studies have reported the rate of using sex sorted semen in various farm sizes in Iran.

In spite of the effect of herd size on reproductive efficiency, concurrent effect of semen type and herd size on reproductive performance of inseminated animals has not been taken into account. Isfahan province is a major core of dairy industry and milk production of Iran. In the current study we aimed to examine and to compare some reproductive performances (including conception rate, open days, dystocia, abortion and stillbirth) of dairy heifers inseminated with either conventional or sex sorted semen in various herd sizes based on the data collected from dairy farms of Isfahan province.

MATERIALS AND METHODS

Data

All procedures were carried out in accordance to the Science and Research Branch, Islamic Azad University, Tehran, Iran Guidelines for Animal Handling, and the project was approved by the Ethics Committee of Science and Research Branch, Islamic Azad University, Tehran, Iran. Data were collected from record registration unit in herds during January 2008 to December 2017 on 64070 heifers record reared in ten commercial farms (Table 1) in Isfahan province (32.6539˚ N, 51.6660˚). Isfahan province is located in an arid climate with 4 distinct seasons according to the Köppen climate classification. Months of birth were grouped into 4 seasons: January through March (winter), April through June (spring), July through September (summer), and October through December (autumn). Inseminations of heifers were performed using imported sexed and conventional semen. The size of the herd was divided according to the number of lactating cows. Data were consisted of herd code, registration number, parturition number, semen type (conventional and sex sorted), number of services per conception, open days, age at first calving, calving interval and information on reproductive disorders including dystocia, stillbirth and abortion. Herds were categorized according to the number of heifers: less than 500 (4 herds), 500-1000 (4 herds) and more than 1000 (2 herds). Data were analyzed according to average number of heifers in birth year in herds (n=64070 heifers in table 2). All of herds were under the ficial performance and pedigree recording. All animals were raised in an intensive production system with freestall barns. On all farms, cows were fed, 3 times per day, a balanced TMR that consisted of corn silage, alfalfa, dehydrated beet pulp, barley and corn grain ground, soybean meal, canola meal, cotton seed, cotton seed meal, corn gluten meal, extruded soybean, fish meal, protected fat powder, sodium bicarbonate, salt, macro- and micro-minerals, vitamin supplement, and feed additives but the composition of the diets differed depending on herd management. Water was freely available all the times. Lactating cows were milked 3 times per day. Estrus synchronization protocol was applied over all herds. Inseminations occurred approximately 12 hours after a cow was first observed standing for mounting. Heifers were artificially inseminated for the first time when reaching 380 kg of weight and pregnancy was detected by rectal palpation 60 days after service. Heifers were artificially inseminated by one person in each herd.

In order to avoid biased definitions, first, the disorders namely stillbirth, dystocia and abortion were defined as follows: For the stillbirth, the perished calf has been taken into account during a period of 260 days in pregnancy up to 48 hours after parturition. Any aid to calf birth including two or more persons help and cesarean were considered as dystocia and the rest were perceived as calving ease.
Losing pregnancy and calf perishing during day 45 of pregnancy up to day 260 were considered as abortion.
The meaning of first insemination to third insemination was insemination heifer to pregnancy.

Statistical analysis
Logistic regression analysis was applied in order to examine the effect of sexed semen on dystocia, abortion and stillbirth (SAS, 2004). For investigating the relation between sex sorted semen and reproductive performance the Linear model of Proc GLMIMIX of the SAS 9.4 was applied. The equations regarding the proportion dystocia, stillbirth and abortion are as followed in models 1, 2 and 3, respectively. The model for evaluating conception rate can be seen in model 4.

1) $\text{logit}(\text{gMI}\alpha + \text{herd}_i + \text{year}_j + \text{season}_k + \text{twin}_l + \text{spermk}_n + \text{size}_o)$
$\beta_{10}(\text{AFC}-\overline{\text{AFC}}) + \beta_{2p}(\text{pregnancy}-\overline{\text{pregnancy}})$

2) $\text{logit}(\pi) = \alpha + \text{herd}_i + \text{year}_j + \text{season}_k + \text{twin}_l + \text{dystocia}_m + \text{spermk}_n + \text{size}_o$
$\beta_{lo}(\text{AFC}-\overline{\text{AFC}}) + \beta_{2p}(\text{pregnancy}-\overline{\text{pregnancy}})$

3) $\text{logit}(\pi) = \alpha + \text{herd}_i + \text{year}_j + \text{season}_k + \text{spermk}_l + \text{size}_o$
$\beta_{lm}(\text{AFC}-\overline{\text{AFC}}) + \beta_{2n}(\text{pregnancy}-\overline{\text{pregnancy}})$

4) $Y_{ijklmno} = \mu + \text{herd}_i + \text{year}_j + \text{season}_k + \text{dison}_l + \text{twin}_m + \text{spermk}_n + \text{size}_o + e_{ijklmno}$

Where:
$\text{logit}(\pi)$: odds ratio of reproductive disorders (dystocia, stillbirth and abortion).
α: width of origin.
herd_i: herd effect.
year_j: effect of calving year.
season_k: fixed effect of calving season.
twin_l: twining effect.
stillbirthm: effect of stillbirth.
dystocia_m: dystocia effect.
twin_m: twin fix effect.
size_o: herd Size effect.
spermk_n, β_{lo} and β_{2p}: semen type (conventional and sex sorted semen), and regression coefficients for the first calving and gestational age, respectively.
AFC and pregnancy: respectively were related to the age at first calving and the length of pregnancy.
$Y_{ijklmno}$: variables of conception rate.
μ: mean effect.
$e_{ijklmno}$: residual effect.

RESULTS AND DISCUSSION

Features and statistics of the examined herds as well as the least square means of the productive and reproductive performances are presented in Table 2. The average use of sexed semen in the examined herds in the recent years accounted for 32.5% with the range of 27% to 50%, as is shown in Figure 1. Our results are consistent with the results reported by Norman *et al.* (2010) and Hutchinson *et al.* (2013) who reported more use of sexed semen in larger herd size. Use of sexed semen, particularly for dairy heifers facilitates faster and more profitable herd expansion compared to the use of conventional semen (Hutchinson *et al.* 2013). The use of sexed semen to generate increased numbers of replacement dairy heifers could accelerate the increase in herd size at both the individual and national herd levels. Conception rate is one of the important factors in evaluating the reproductive performance. The average conception rate in the first to the third insemination is presented in Table 3. According to the results, conception rate in heifers inseminated with sexed semen was considerably lower than that of conventional semen (Table 3). Conception rate of sex sorted semen at the first, the second and the third insemination was lower by 18%, 16% and 12%, compared to the conventional semen, respectively ($P<0.01$). Dier *et al.* (2020) reported that the percentage of inseminations by sex sorted semen decreased from 59.7% in the first service to 6.6% in the fourth service. They also reported that most of services using sex sorted semen were occurred in the first and the second services. The reason for less use of sex sorted semen after the first service could be due to the lower conception rate of sexed semen in the second and higher services, which was also confirmed in our study. Various studies have reported lower conception rate of sexed versus conventional semen (DeJarnette *et al.* 2009; Chalmeh *et al.* 2012; Healy *et al.* 2013; Joezy-Shekalgorabi *et al.* 2017; Oikawa *et al.* 2019; Patel and Jethva, 2019).

Joezy-Shekalgorabi *et al.* (2017) reported that average empirical conception rate for sex sorted semen was 48.3% (ranging from 41 to 50.4 over various herds). In fact, the reduced performance is resulted from the lower concentration of sperms in sexed semen's straw. lower conception rate of sex sorted semen could be also due to less fertility of sexed semen (Hayakawa *et al.* 2009) or less vigorous fetuses and calves obtained from this kind of semen (Djedoic *et al.* 2016).

Table 1 Number of heifers and their percentage in the prepared dataset

Herd	Heifer count	Percent
1	12080	18.9
2	3300	5.2
3	3770	5.9
4	6075	9.5
5	2620	4.1
6	11650	18.1
7	2770	4.3
8	8245	12.8
9	6380	10.0
10	7180	11.2

Table 2 Productive and reproductive performance (Mean±SD) of the studied herds

Variable	Herd size		
	< 500	500-1000	> 1000
Milk (kg)	11300±1820.0	11384±1679.0	11400±1785.0
Fat (kg)	305.8±102.80	310±92.0	309±96.0
Protein (kg)	280.1±71.80	290±66.0	287.8±69.00
Open days	150.7±77.00	145±62.0	145.8±35.00
Age at first calving (day)	747.8±80.00	738±73.0	740±80.0
Gestation length (day)	276.0±6.00	275.7±5.70	275.6±6.30
Stillbirth rate (%)	9.1±0.50	5.9±0.20	6.1±0.30
Dystocia rate (%)	28.3±1.60	25.1±1.10	27.9±1.70
Abortion rate (%)	8.7±0.60	11.9±0.70	10.4±0.40

SD: standard deviation.

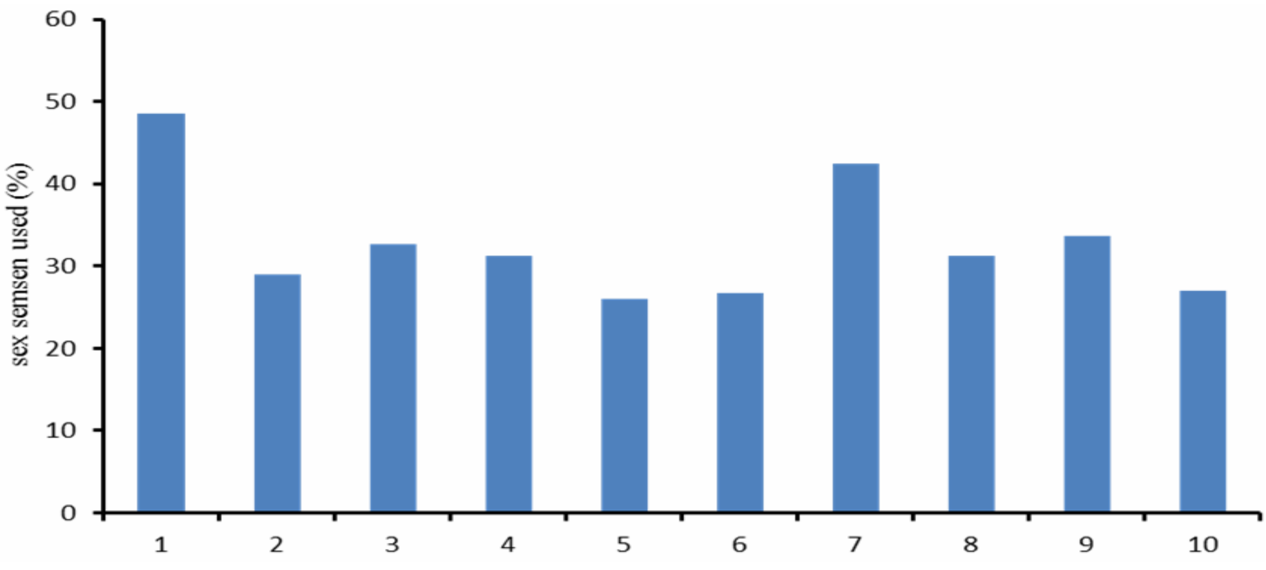

Figure 1 Sexed semen usage in the examined herds

Table 3 Least square means of reproductive performance of conventional and sex sorted semen

	Conventional semen	Sexed semen	P-value
Open days	136.12±4.46	158.50±4.53	P < 0.01
Days from calving to first service	74.3±1.9	78.7±2.1	P < 0.05
Conception rate (%)			
First insemination	67.1±2.79	49.58±1.83	P < 0.01
Second insemination	52.2±2.41	36.67±1.67	P < 0.01
Third insemination	45.46±1.76	33.64±1.92	P < 0.01

Oikawa *et al.* (2019) reported lower conception rate of sex sorted semen at the beginning of warmer months. This indicates more sensitivity of sex sorted semen to heat stress. Efficient reproductive management as well as using qualified inspectors and careful implementation of artificial insemination can helps in improving conception rate of sex sorted semen to values near the conventional semen (De Vries, 2008; Chalmeh *et al.* 2012; Oikawa *et al.* 2019). Recently Bittante *et al.* (2020) found similar conception rate for sexed and conventional semen after correcting herd, production, number of parities, insemination order, lactation stage and cow breed effects from the model of analysis. The average conception rate in the first to the third insemination in different farm sizes is presented in the Table 4.

According to the results, conception rate in herds with less animals was considerably lower than herds with more animals. In a recent study, larger farms (>200 cows) represented better service rate compared to small size farms (Rethmeier *et al.* 2019). In accordance to our results, El-Tahawy (2017) reported that small and medium size farms need more service per conception. Conversely, Lemma and Kebdede (2011) found less service per conception in medium sized farms. Conception rate decreases by increasing the number of services per conception. Increase in the number services per conception is related to frequent artificial insemination at the wrong time. Insemination of animals with sex sorted semen needs more precise insemination time.

Open days (OD) and days from calving to first service (DFS) are among the major influencing factors on the efficiency of dairy farms. Open days have been widely used as a success measure of reproductive programs and can be affected by the replacement rate. In dairy herds, cows with extra days open get more harmed and become potentially more at the risk of being culled. The size of herd influenced open days and days from calving to first service in the studied herds (Figure 2). In herds with less than 500 cows, OD and DFS were 79 and 150, respectively. These values were greater than that of herds with 500 and > 1000 animals. Open days in big size farms were considerably lower than those of small size farms (Table 2). Similarly, Singh *et al.* (2016) and Lemma and Kebede (2011) reported longer open days in small size farms compared to the medium and large farms. However, El-Tahawy (2017) revealed that days open of the large farms were longer (158.072.36 days) than that of small and medium sized farms. This discrepancy could be due to different management practices in the studied herds. Open days was significantly greater for heifers inseminated with sex sorted semen (Table 3). In contrast to our results, Diers *et al.* (2020) reported no difference in days from calving to first insemination in calves obtained from either sex sorted or conventional semen.

Dystocia is among the most significant secondary economic traits, which is important in terms of both economic benefit as well as animal welfare (Eriksson *et al.* 2004; Haugaard and Heringstad, 2013). Dystocia consequences entail increased stillbirth, calf death, increased dam and calf mortality rate, reduced production, reduced fertility, increased probability of infertility, greater likelihood of illnesses after calving and culling of the dam from the herd (Fetrow *et al.* 2006; Norman and Youngquist, 2007). The rate of dystocia in herds with > 1000 animals were lower than that of herds with < 500 animals (Table 2). A downward trend in the level of dystocia was observed for both semen types in the study duration (Figure 3). There was a moderate downward trend in dystocia in sex sorted semen, falling from 19.7% in 2009 to 15.6% in 2017. By contrast, there existed broader fluctuations in occurrence of dystocia in conventional semen, rising from 33.7% in 2008 to 37% in 2014 before declining to 27% in 2017. The dystocia level differed in single birth and twin birth heifers and in twin birth it was greater (36.72%) ($P<0.01$). The highest and the least occurrence of dystocia was in winter (34.8%) and spring (23.3%), respectively ($P<0.01$). One obvious result of this study was the considerable reduction in dystocia in sexed semen inseminations ($P<0.01$). Heifers inseminated with sex sorted semen (with an average dystocia occurrence of 16.6%) had a lower chance to experience dystocia (OR=0.81 sexed semen *vs.* conventional semen). Similar studies verify our results (Weigel, 2004; DeJarnette *et al.* 2009; Norman *et al.* 2010; Joezy-Shekalgorabi *et al.* 2017). In a study, the rate of dystocia decreased from 6% to 4.3%. This reduction was more considerable in cows, falling from 2.6% to 0.9% (Norman and Youngquist, 2007). Fetrow *et al.* (2007) reported that using sexed semen reduces the rate of dystocia in heifer and cow by 3.7% and 1%, respectively. The study revealed that dystocia is not affected by the type of sperm, and the likelihood of dystocia is influenced by age, insemination season, sex and weight of the calf in the birth.

In contrast to our results, Diers *et al.* (2020) reported that dystocia is not affected by the semen type. Generally, lower prevalence of dystocia is expected in female calves, due to their lower weights, as compared to the male calves (Weigel, 2004; Norman *et al.* 2010). Considering larger proportion of female calves obtained from sex sorted semen, less dystocia is expected from this kind of sperm. Although, there was no significant difference in the occurrence of dystocia in different herd sizes (Table 5), there was a greater chance of dystocia in larger farms. This, somehow, could be resulted from the fact that in larger herds, in Iran, semen selection is more intensive toward productive traits and less attention is paid to the reproductive performance of the selected sires.

Table 4 Least square means of reproductive performance of herd size

Conception rate (%)	Herd size			P-value
	< 500	500 to 1000	> 1000	
First insemination	59.1±2.29[c]	64.1±2.31[b]	67.6±2.53[a]	P < 0.05
Second insemination	51.4±1.83	57.3±1.89	54.4±1.87	P > 0.05
Third insemination	43.5±1.36	48.1±1.57	44.4±1.52	P > 0.05

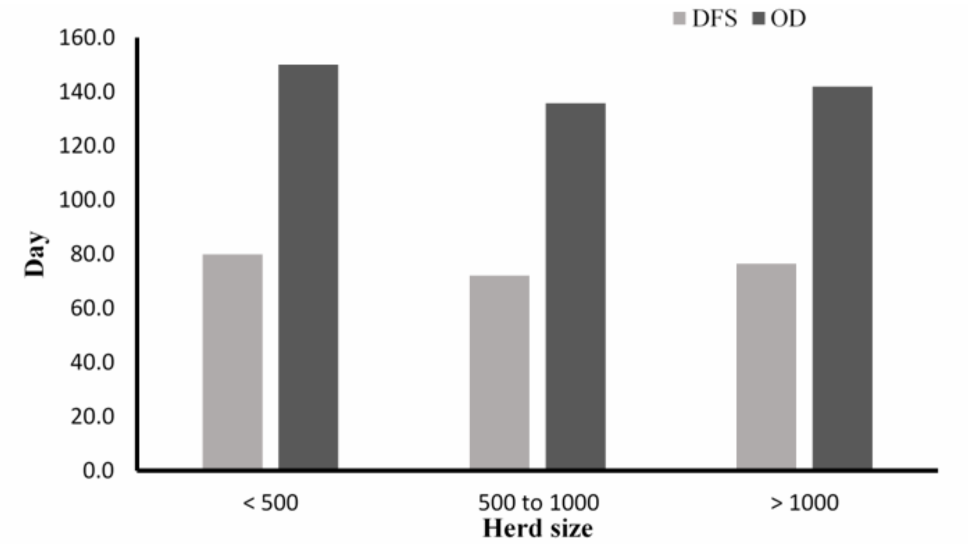

Figure 2 Effect of herd size in open days (OD) and days from calving to first service (DFS) in the studied herds

Table 5 The odds ratios of dystocia at various calving seasons, birth types and semen types

Variable	Occurrence percentage	Odd ratio (confidence interval)	P-value
Semen type			P < 0.01
Conventional semen	32.8	Reference	
Sex sorted semen	16.6	0.81 (0.73-1.01)	
Calving season			P < 0.01
Spring	23.33	Reference	
Summer	27.08	1.18 (1.06-1.36)	
Autumn	29.07	1.23 (1.08-1.35)	
Winter	34.85	1.25 (1.09-1.56)	
Birth type			P < 0.01
Single	25.8	Reference	
Twin	36.72	1.39 (0.78-2.15)	
Herd size			P > 0.05
< 500	26.72	Reference	
500 to 1000	21.31	0.78 (0.51-1.64)	
> 1000	28.25	1.05 (0.81-2.21)	

On the other hand, reproductive performance in small size herds could be due less efficient reproductive management compared to the medium sized herds.

Stillbirth is defined as calves either born dead or died within the first 48 hours after birth. Stillbirth is important due to its great economic value and its effect in profitability of dairy herds (Ghiasi *et al.* 2016). The rate of stillbirth in herds with > 1000 animals were lower than that of herds with < 500 animals (Table 2).

Stillbirth illustrated a downward trend between 2008 and 2017 for both sexed and conventional semen (P<0.05). The likelihood of stillbirth in heifers inseminated with sexed semen was considerably lower than that of conventional semen (OR=0.4 for sexed semen *vs.* OR=1 for conventional semen). As is demonstrated in Table 6, sexed semen halved the rate of stillbirth by 5.8%. In 2008, the highest stillbirth was about 10.8 and 8.1 percent for conventional and sexed semen, respectively (Figure 4).

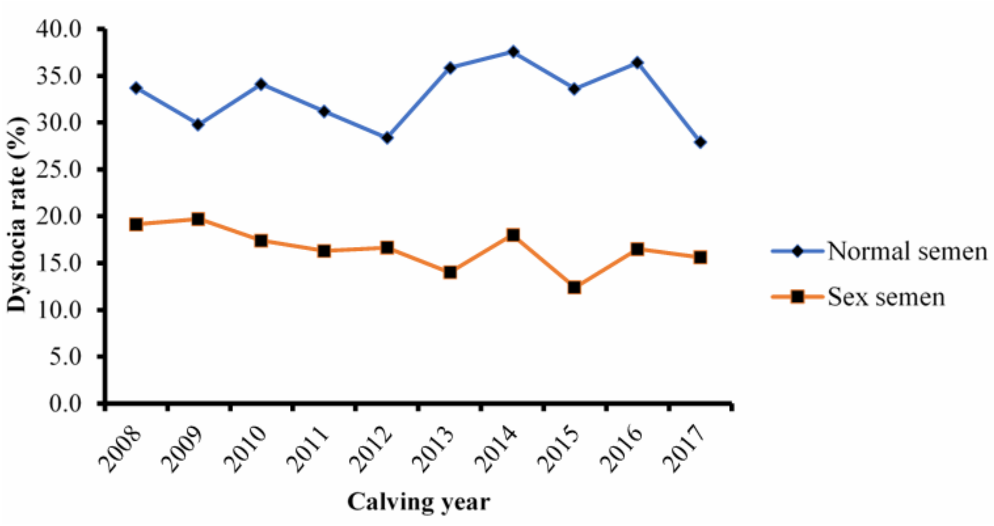

Figure 3 The incidence of dystocia on heifers inseminated with various semen types

Table 6 The odds ratio of stillbirth in various calving season, birth types and semen types

Variable	Occurrence (%)	Odd ratio (confidence interval)	P-value
Semen type			P < 0.01
Conventional semen	9.4	Reference	
Sex sorted semen	5.8	0.43 (0.11-0.68)	
Calving season			P < 0.01
Spring	6.67	Reference	
Summer	7.34	0.95 (0.90-0.96)	
Autumn	7.9	1.02 (1.01-1.11)	
Winter	8.6	1.14 (1.1-1.38)	
Twining			P < 0.01
Single	7.1	Reference	
Twin	8.17	1.25 (1.01-1.55)	
Dystocia			P < 0.01
Calving ease	6.6	Reference	
Dystocia	11.56	2.19 (1.56-3.23)	
Herd size			P > 0.05
< 500	8.77	Reference	
500 to 1000	6.05	0.63 (0.39-0.98)	
> 1000	6.50	0.74 (0.41-1.02)	

Dystocia had a considerable impact on stillbirth (P<0.05). Dystocia increased the level of stillbirth by about two-fold (11.5% for dystocia and 6.6% for calving ease). Twin birth drastically increased the likelihood of stillbirth (OR=1.25 for twinning *vs*. OR=1 for singleton, P<0.01). Birth at different seasons was accompanied by different stillbirth rate (P<0.01).

Joezy-Shekalgorabi *et al.* (2017) revealed no significant difference in stillbirth rate when utilizing sex sorted and conventional semen; however, stillbirth in cold climate was greater and it was discussed that the increased damage during sperm separation can lead to lower probability of embryo survival. Several studies have reported greater incidence of stillbirth for single male calves obtained from sexed semen (Borchersen S. and Peacock, 2009; DeJarnette *et al.* 2009; Norman *et al.* 2010; Diers *et al.* 2020). Tubman *et al.* (2004) did not found any difference in stillbirth of male and female calves obtained from sex sorted semen. It is reported that including the fix effect of climate in the model of analysis do not change the overall result of the effect of sex sorted semen on stillbirth (Joezy-Shekalgorabi *et al.* 2017). Translocation of large DNA content of Y chromosome and its concentration in X chromosome or the incidence of aneuploidy, especially trisomy, may enhance the stillbirth rate of male calves obtained from sex sorted semen (Mikkola *et al.* 2015; Diers *et al.* 2020).

Although, there was no significant difference in occurrence of stillbirth in different herds size, but it represented an upward trend in large herds (Table 6). DeJarnette *et al.* (2009) found the influence of herd, season of calving and sire within semen type on female stillbirth rate. It could be argued that differences in management and data recording have led to these partly divergent results (Diers *et al.* 2020).

Abortion is widely defined by the death and fetal exertion during 42 and 260 of pregnancy days (Peter, 2000; Thurmond *et al.* 2005). Abortion rate in cows is an indicator of enhanced fertility and reproduction. The year of birth influenced the abortion rate (P<0.05). As is illustrated in Figure 5, the rate of abortion underwent a downward trend in both semen types. In 2008, conventional and sexed semen accounted for the highest and the lowest abortion rate, with 9.8% and 7.1%, respectively. The lowest level of abortion in 2017 was reported to be 3.3% and 3.8% respectively.

Joezy-Shekalgorabi *et al.* (2017) reported negligible increase in abortion rate of sexed semen compared to the conventional semen while the effect of the calf sex, insemination year, insemination season and calf birth weight on parturition type (abortion, stillbirth) were not significant. In a study by Healy *et al.* (2013), abortion rates for sexed and conventional semen were 6.1 and 6.5%, respectively, and were affected by heifer age at breeding. As represented in Figure 6, the rate of abortion in the studied herds was different (P<0.01).

Herds 1 and 5 accounted for the highest and the lowest abortion rate, by 9% and 4.5%, respectively. Herd 1 had the largest number of heifers (heifer count=12080) and herd 5 with the lowest number of heifers (heifer count=2620).

As is demonstrated in Table 7, the occurrence of abortion was significant (P<0.05) at different herd sizes. Various calving seasons had significant impact on abortion rate (P<0.01).

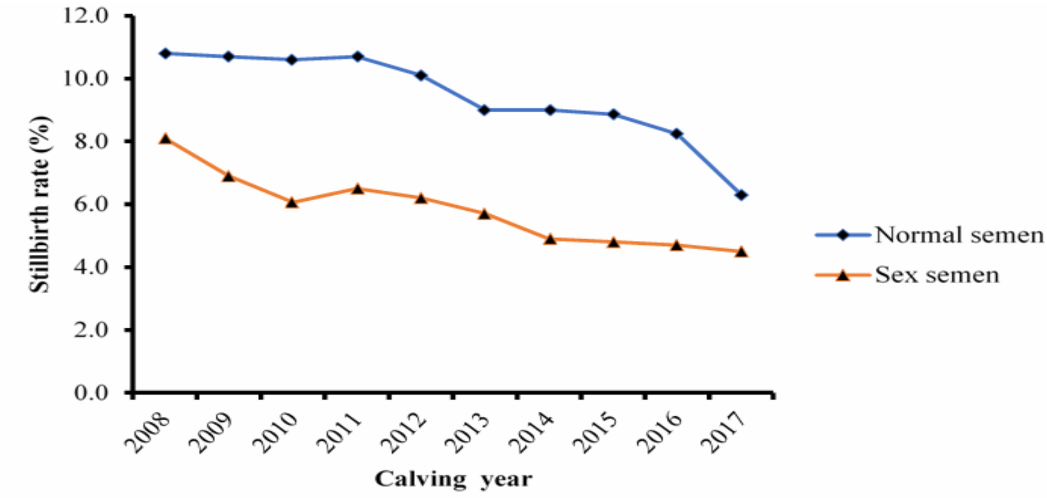

Figure 4 The incidence of stillbirth in various semen types

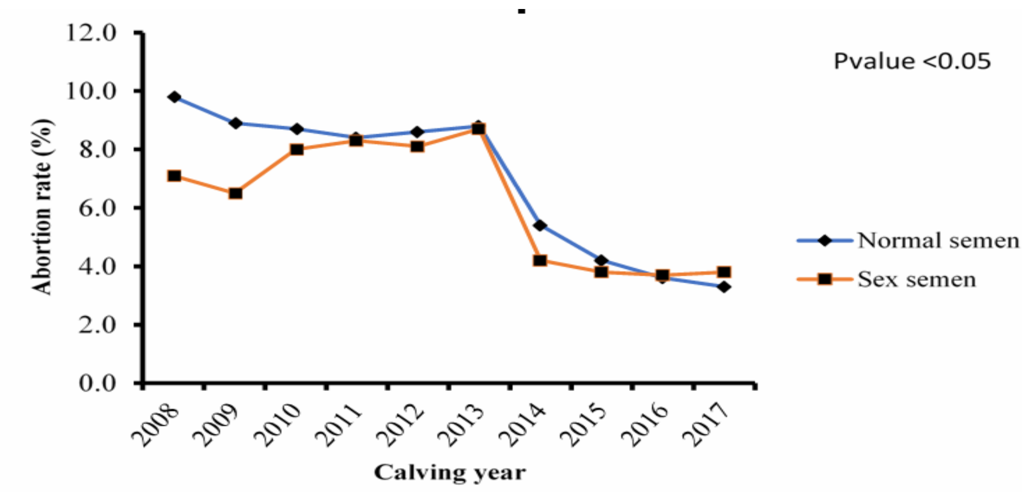

Figure 5 The incidence of abortion in various semen types

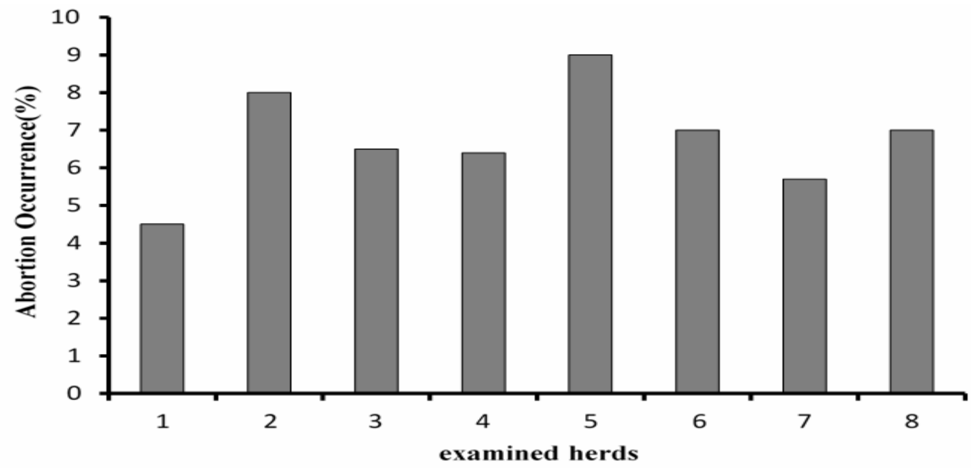

Figure 6 Abortion rate in the studied herds

Table 7 The odds ratio of abortion in various calving seasons, birth types and semen types

Variable	Occurrence percentage	Chances of catching (confidence interval)	P-value
Semen type			P > 0.05
Conventional semen	7.3	Reference	
Sex semen	6.2	0.95 (0.82-1.07)	
Calving season			P < 0.01
Spring	6.7	Reference	
Summer	7.2	1.05 (0.82-1.38)	
Autumn	7.9	1.24 (0.97-1.63)	
Winter	7.7	1.21 (0.98-1.53)	
Herd size			P < 0.05
< 500	8.61	Reference	
500 to 1000	12.02	1.23 (0.89-1.98)	
> 1000	10.23	1.11 (0.94-1.51)	

As is illustrated in Table 7, occurrence of abortion was greater during fall (7.9%). Besides, the chance of abortion dramatically raised on the fall compared to the spring (OR=1.24; fall *vs*. OR=1; spring). Various applied semen types did not have any noticeable impact on abortion rate (P=0.09).

In addition, the chance of abortion when utilizing sexed semen declined compared to the conventional semen (OR=0.95; sexed semen *vs*. OR=1; conventional semen). In accordance to our results, Joezy-Shekalgorabi *et al*. (2017), Tubman *et al*. (2004) and DeJarnette *et al*. (2009) did not find significant difference among abortion rate resulted from sex sorted or conventional semen. Nevertheless, a marginal decline in abortion rate of dairy heifers inseminate by sex sorted semen has been reported which could be due to better body condition of the inseminated heifers (Thumban *et al*. 2004).

CONCLUSION

The result of this study revealed that utilizing sex sorted semen can drastically declines reproductive disorders such as stillbirth and dystocia. In spite of these advantages, yet, a small part of aritificial insemination (AI) market is allocated to sex sorted semen. The main drawback of sex sorted semen is its lower conception rate compared to the conventional semen. However, improvement of semen sorting technology in the recent years is reducing the difference in fertility of sexed and conventional semen. The results of our study showed that reproductive performances were better in medium farm size which indicates more efficient reproductive performance in medium size herds compared to small and large herds. The fertility of dairy cows is strongly influenced by the level of milk production. Generally, large farms have greater level of milk production. Considering the limited selection goal in the selection of semen (which put more emphasize on productive traits) in Iran, and due to the reverse relation of productive and reproductive performance, lower reproductive performance is expected from large farm sizes. On the other hand, in small herds, culling due to the reproductive problems is related to weak management practices. However, further studies need to be performed to prove this hypothesis.

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