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# Heifer Fertility Relationship with First Lactation Cow Traits of Friesian Dairy Cattle in Egypt

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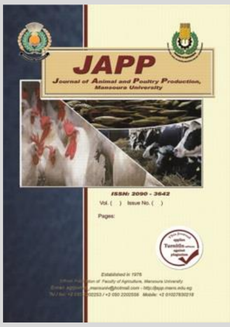


## ABSTRACT

Relationships were estimated between heifer fertility traits with first lactation traits of Friesian cows in Egypt. Data of 2914 calved animals covering the period from 1979 to 2013 in Saka and Elkarada stations were obtained. Multi-traits linear animal model was applied. The highest absolute genetic correlations were obtained between NSC0 and CR1 (0.827), between CR0 and CR1 (-0.763), between SP0 and NSC1(-0.793), and between each of AFB and AFC with CFS1 (-0.728 and -0.739). All phenotypic relationships between heifer and first lactation fertility traits were small and near to zero. Genetic relationships between fertility traits of heifers and first lactation cows were ranged from -0.999 to 0.999. The highest genetic correlations were obtained between DMY1 and each of NSC0, CR0 and SP0 (0.999, -0.999 and 0.997, respectively), between M305 with the same traits (-0.996, 0.997, -0.989, respectively) and between TMY1 with NSC0, CR0, SP0, AFB, ASB and AFC (-0.984, -0.984, 0.975, -0.998, -0.973, -0.984, respectively). All phenotypic relationships between fertility traits of heifers and first lactation cows were smaller than that of genetic correlations except between TMY1 and each of NSC0 and SP0 (-0.969 and 0.970).

***Keywords*:** Heifers, cow, fertility, milk production, correlations.

## INTRDUCTION

Due to genetic antagonistic relationships between fertility and milk production, selection for a long time selection to increase milk production neglecting selection to improve efficiency of reproductive traits led to deterioration of cow fertility, (Royal et. al., 2002), proving that selection for reproductive efficiency is necessary to genetically stabilize or improve fertility and should be included in the selection index (Andersen-Ranberg et. al., 2005, Jagusiak, 2006).

Deterioration in cow fertility has shifted breeding objectives toward those in today dairy cattle selection programs (Muuttoranta et al., 2019). Genetic improvement efforts are faced with many challenges like complexity of cow fertility and low heritability (Pryce and Veerkamp, 2001, Jagusiak, 2006 and Kuhn, et al., 2006 and Mokhtari et al., 2015). In addition, non-normally distributed cow fertility traits described either zero-inflated distributions, (SP), or interval traits with skewed (CFS, DO) or discrete traits, e.g., NSC, CR, (Andersen-Ranberg et al., 2005 and Berry et al., 2014). Genetic evaluation of dairy cows and selection of reproductive efficiency traits should be carried out, to at least slow the level of deterioration, or improve fertility (Fogh et al., 2003, Van Raden et al., 2004 and Van Doormaal et al., 2007).

Profitability of dairy farms are mainly affected by production and Function traits (Jagusiak, 2006, and Mokhtari et al., 2015). Reproductive efficiency of dairy cows are considered very important because of their effect on the economics of dairy farms. Numerous consequences of low reproductive efficiency were detected like higher breeding costs, fewer calves born, decrease of herd milk yield, increase in culling rate, less intensive selection (Hodel et al., 1995), and an obvious increase in the rearing cost of replacement heifers for dairy farms (Guo, et al., 2014).

The objective of the present study was to assess the genetic and phenotypic correlations between heifer fertility traits and both of cow fertility and production traits in first lactation.

## MATERIALS AND METHODS

Records of 2914 Friesian heifers covering the period from 1979 to 2013 were collected from Saka and ElKarada experimental stations, Dokki, Giza, Egypt. Heifer fertility traits were NSC0, (number of services per conception), CR0, (conception rate=100/NSC0), SP0, (service period, i.e., the number of days from first to last service), age at first breeding, AFB (i.e., days between birth to first breeding date), ASB (i.e., age at successful breeding, days from birth to successful breeding), and AFC (i.e., age at first calving, days from birth to first calving), First lactation traits were NSC1 (i.e., number of service per conception, CR1, (i.e., conception rate = 100/NSC1), CFS1, (i.e., calving to first service, days from calving date to first service date), SP1 (i.e., service period, days from first to last service date), DO1, (i.e., days open, days from calving date to last service date), M305 (305-day milk yield, kg), LP1 (days of lactation period), TMY1 (total milk yield, kg), DMY1 (daily milk yield in kg, TMY1/LP1).

The records that matched the following criteria were retained: AFB between 12 and 32 mo., ASB between 12 and 32 mo., AFC between 21 and 42 mo., NSC0 or NSC1 between 1 to 5, SP0 or SP1 between 0 and 200 d, CFS1 between 20 and 200 d, DO1 between 20 and 400 d, M305

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between 900 and 6232 kg, LP1 between 150 and 600 d, TMY1 between 900 and 9999 kg and DMY1 between 4 to 17 kg. To avoid selection bias, animals included in genetic evaluation had to have information either as a heifer or in first lactation.

MIXED procedure of SAS (2011) software was performed and the final fixed effects are described in table 1. Heritability, genetic, phenotypic and residual variance and genetic, phenotypic and residual correlations were estimated using VCE6 software (Groeneveld et al., 2010), after including animal and error as random effects with the fixed effects. Pedigree file was included to estimate EBV by PEST software (Groenenveld et al., 2001), fitting a multivariate linear animal model.

**Table 1. Model summary for multivariate analysis of heifer and cow traits.**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Heifer models[b]** | | | | | | | | |
| **Trait[a]** | **F** | **M1s** | **Y1s** | **FMY1s** | **AFBc** | **NSC** | | |
| AFB | X | X | X | X | | | | |
| NSC0,CR0, ASB, AFC | X | X | X | X | X | | | |
| SP0 | X | X | X | X | X | X | | |
| First lactation cow models | | | | | | | | |
| Trait[a] | F | M1c | Y1c | FMY1c | AFCc | NSC | DO | LP |
| NSC1, CR1, CFS1 | X | X | X | X | X | | | |
| SP1, DO1 | X | X | X | X | X | X | | |
| M305, TMY1 | X | X | X | X | X | | X | X |
| LP1,DMY1 | X | X | X | X | X | | X | |

**a: NSC0: number of services per conception, CR0: conception rate, SP0: service period, AFB: age at first breeding, ASB: age at successful breeding, and AFC: age at first calving for heifers; NSC1: number of services per conception, CR1: conception rate, CFS1:calving to first service, SP1: service period, DO1: days open, M305: 305-day milk yield, TMY1: total milk yield, LP1: lactation period and DMY1: daily milk yield for cows.**

**b: F: farm, M1s: month of first breeding, Y1s: year of fist breeding, FMY1c: farm-month-year of first breeding, AFBc: age at first breeding classes, NSCc: number of service per conception, M1c : month of first calving, Y1s: year of fist calving, FMY1c: farm-month-year of first calving, AFCc: age at first calving classes, DO: days open as a covariate, LP: lactation period as a covariate.**

## RESULTS AND DISCUSSION

### Heifer and cow fertility traits

### Genetic correlations

Genetic correlations between fertility traits of heifer and first lactation cow traits are presented in table 2. Genetic correlation between heifer NSC0 and cow NSC1 was negative (-0.565), however it was unfavorable positive with CR1, CFS1, SP1 and DO1 (0.827, 0.491, 0.065 and 0.696, respectively (Table 2). Mokhtari et al., (2015) found that genetic relationship between heifer NSC0 and each of cow NSC1 and DO1 were positive (0.862 and 0.638, respectively), however it was negative with CR1 (-0.776).

Genetic relationships between heifer CR0 and cow CR1, CFS1, SP1 and DO1 were negative (-0.763, -0.314, -0.263 and -0.683, respectively), however it was positive with NSC1 (0.475), table 2. Similarly, genetic correlations between heifer CR0 and each of cow NSC1, and DO1 were negative (-0.761 and -0.627, respectively), however it was positive (0.613) with CR1 (Mokhtari et al., 2015). In contrast, (Muuttoranta et al., 2019) reported that genetic correlation estimates between heifer CR0 and each of cow CR1, CFS1 were positive (0.72 and 0.24, respectively), however it was negative and near to zero (-0.09) with and SP1 (Mokhtari et al., 2015).

In the present study, negative genetic correlations were found between heifer SP0 and each of NSC1 and SP1 of cow (-0.793 and -0.077), however it were positive (0.517, 0.304 and 0.302) between heifer SP0 and each of cow CR1, CFS1 and DO1, respectively (Table 2). Genetic correlations between heifer SP0 and cow CR1 was negative (-0.567), however it were positive (0.272, 0.662 and 0.423, respectively) with CFS1, SP1 and CI1 (de Haer et al., 2013). Muuttoranta et al., (2019) found that estimates of $r_g$ between heifer SP0 with each of cow CR1 and SP1 were -0.64 and 0.53, respectively.

Estimates of $r_g$ between heifers and cows (Table 2) were medium (-0.565) between NSC0 and NSC1 and slightly high (-0.763) between CR0 and CR1 but negative and not differed significantly form zero for SP0 with SP1 (-0.077). Genetic relationships far from unity reveal that fertility is indeed a different trait when measured on heifers and cows, revealing that, the genes expression in virgin heifer might be different from those genes in a lactating cow (Tiezzi et al., 2012).

Heifers and cow reproductive traits should be considered as different traits, considering the advantage of heifer data is being less exposed to selection and also, heifers were not subjected to the same metabolic load as cows during the lactation period. Therefore, heifer and cow fertility traits should be analyzed as separate traits in multiple-trait animal model for fertility index (Abe et al., 2009; Buaban et al., 2015).

Estimates of genetic correlation between AFB and each of NSC1, CFS1 and DO1 were negative -0.240, -0.728 and -0.512, respectively (Table 2). Hansen et al., (1983) showed that genetic correlations between AFB and each of cow NSC1, CFS1, SP1 and DO1 were -0.13, 0.35, 0.02 and 0.15, respectively. de Haer et al., (2013) found that correlations between AFB and each of cow CR1, CFS1, SP1 and CI1 were 0.109, 0.249, 0.118 and 0.196, respectively. The differences between estimates of genetic correlation of AFB with cow fertility traits in different countries, can be attributed to the differences in body condition of heifers inseminated for first time among countries (Guo et al., 2014).

Relationship between ASB and each of cow NSC1, CFS1 and DO1 were negative (-0.403 -0.683 and -0.218), respectively, however it were positive (0.621 and 0.339) between ASB and each of CR1 and SP1 of cow (Table 2). In contrast, genetic correlations between ASB and each of CFS1, SP1 and DO1 (0.23, 0.90 and 0.32, respectively) were positive (Jagusiak and Zarnecki, 2007). Also, Raheja et al., (1989) reported that correlations between ASB with each of cow NSC1, CFS1 and DO1 were 0.01, 0.04 and 0.03, respectively.

**Table 2. Genetic correlations between heifer and first lactation fertility cow traits.**

| **Traits[a]** | **NS1** | **CR1** | **CFS1** | **SP1** | **DO1** |
|---|---|---|---|---|---|
| NS0 | -0.565 | 0.827 | 0.491 | 0.065 | 0.696 |
| CR0 | 0.475 | -0.763 | -0.314 | -0.263 | -0.683 |
| SP0 | -0.793 | 0.517 | 0.304 | -0.077 | 0.302 |
| AFB | -0.240 | 0.480 | -0.728 | 0.193 | -0.512 |
| ASB | -0.403 | 0.621 | -0.683 | 0.339 | -0.218 |
| AFC | -0.270 | 0.505 | -0.739 | 0.387 | -0.251 |

**a: abbreviations as described in table 1**

AFC of heifer was negatively correlated with each of cow NSC1, CFS1 and DO1 (-0.270, -0.739 and -0.251, respectively, however it was positively correlated with CR1 and SP1 (0.505 and 0.387, respectively (Table 2). In contrast, genetic correlations between AFC and each of cow CFS1, SP1 and DO1 were positive, 0.18, 0.90 and 0.15, respectively (Jagusiak and Zarnecki, 2007).

Moderate positive $r_g$ between CR1 and both AFB, ASB and AFC (0.480, 0.621 and 0.505, respectively, table 2) may suggest that inseminating heifers at older age, may have better ability to conceive, even in later lactations (de Haer et al., 2013). The same trend was observed for the relation between SP1 with each of AFB, ASB and AFC (0.193, 0.339 and 0.387, respectively, Table 2).

**Phenotypic correlations**

Estimates of phenotypic correlation between heifer and cow fertility traits are lower than those of genetic correlations (Table 3). Phenotypic correlations between heifer NSC0 and each of cow fertility traits (NSC1, CR1, CFS1, SP1 and DO1) were lower and near to zero (0.042, -0.041, -0.065, 0.016 and -0.032, respectively, table 3). The same trend was found by Hansen et al., (1983) and Mokhtari et al., (2015).

Phenotypic relationship between heifer CR0 with each of cow NSC1, CR1, CFS1, SP1 and DO1 were -0.040, 0.036, 0.066, -0.018 and 0.031, respectively (Table 3). Phenotypic correlations between heifer CR0 and each of cow CR1, CFS1 and DO1 were 0.05, 0.04 and -0.10, respectively (Abe et al., 2009). Mokhtari et al., (2015) showed that correlations between heifer CR0 with each of cow NSC1, CR1 and DO1 were -0.154, 0.006 and -0.020 respectively.

Estimates of $r_P$ between heifer SP0 with each of cow fertility traits (NSC1, CR1, CFS1, SP1 and DO1) were 0.026, -0.021, -0.022, -0.028 and -0.045, respectively (Table 3). Correlations between heifer SP0 and each of cow NSC1, CFS1, SP1 and DO1 were 0.02, 0.01, 0.02 and 0.03, respectively (Hansen et al., 1983).

Correlations between AFB and each of NSC1, CR1, CFS1, SP1 and DO1 of cow were -0.013, 0.011, 0.038, 0.042 and 0.025, respectively (Table 3). Absolute phenotypic correlations between heifer AFB and each of cow NSC1, CFS1, SP1 and DO1 were small and near to zero, -0.02, 0.02, -0.01 and 0.01, respectively (Hansen et al., 1983). Jagusiak and Zarnecki (2007) found that phenotypic correlations between AFB and each of cow CFS1, SP1 and DO1 were 0.06, 0.54 and 0.03, respectively. Similarly, phenotypic correlations between AFB and each of cow CR1, CFS1 and DO1 were small and near to zero, (Abe et al., 2009). Absolute phenotypic correlations between ASB and cow NSC1, CR1, CFS1, SP1 and DO1 were small and near to zero (-0.013, 0.014, 0.027, 0.016 and -0.013, respectively, table 3). The same trend was reported by Hansen et al., (1983), estimates of phenotypic correlations between ASB and each of cow NSC1, CFS1, SP1 and DO1 were -0.00, 0.02, 0.01 and 0.02, respectively. Jagusiak and Zarnecki (2007) found that phenotypic relationships between ASB and cow fertility traits (CFS1, SP1 and DO1) were 0.06, 0.64 and 0.06, respectively. In the present study, relationship between heifer AFC with each of cow fertility traits (NSC1, CR1, CFS1, SP1 and DO1) were small and near to zero (-0.015, 0.018, 0.029, 0.017 and -0.010, respectively, table 3). Similarly, correlations between AFC and each of cow CFS1, SP1 and DO1 were 0.06, 0.53 and 0.04, respectively (Jagusiak and Zarnecki, 2007).

**Table 3. Phenotypic correlations between heifer and first lactation fertility cow traits.**

| Traits[a] | NSC1 | CR1 | CFS1 | SP1 | DO1 |
|---|---|---|---|---|---|
| NSC0 | 0.042 | -0.041 | -0.065 | 0.016 | -0.032 |
| CR0 | -0.040 | 0.036 | 0.066 | -0.018 | 0.031 |
| SP0 | 0.026 | -0.021 | -0.022 | -0.028 | -0.045 |
| AFB | -0.013 | 0.011 | 0.038 | 0.042 | 0.025 |
| ASB | -0.013 | 0.014 | 0.027 | 0.016 | -0.013 |
| AFC | -0.015 | 0.018 | 0.029 | 0.017 | -0.010 |

**a: abbreviations as described in table 1.**

**Heifer fertility and cow production traits**

**Genetic correlation**

Genetic association between heifer fertility traits and cow production traits (LP1, DMY1, M305 and TMY1) are presented in table 4. Genetic correlations between first lactation LP1 and each of heifer fertility traits (NSC0, AFB, ASB and AFC) were negative (-0.975, -0.824, -0.607 and -0.634, respectively), however it was positive (0.975 and 0.431) with CR0 and SP0 (Table 4), contradicted with low and positive genetic correlation estimates (0.213, 0.215 and 0.251) between first lactation LP1 with each of heifer NSC0, CR0 and SP0, respectively (Tiezzi et al., (2012). Genetic relationship between cow DMY1 and CR0 (Table 4) was negatively correlated (-0.999), however it was positive with each of NSC0, SP0, AFB, ASB and AFC (0.999, 0.997, 0.416, 0.606 and 0.549, respectively).

First lactation M305 was negatively correlated with each of heifer NSC0, SP0, AFB, ASB and AFC (-0.996, -0.989, -0.886, -0.760 and -0.796, respectively), however it was positive (0.997) with heifer CR0 (Table 4). Hansen et al., (1983) found that genetic correlations between first lactation M305 with heifer NSC0, SP0, AFB and ASB were negative and ranged from -0.15 to -0.48. Mokhtari et al., (2015) found that correlations between cow M305 and each of heifer NSC0 and CR0 were 0.210 and -0.414, respectively. TMY1 of first lactation was negatively correlated (-0.984, -0.984, -0.998, -0.973 and -0.984) with each of heifer NSC0, CR0, AFB, ASB and AFC, respectively, while it was positive (0.975) with heifer SP0 (Table 4). Genetic relationships between first lactation TMY1 and each of heifer NSC0, AFB and ASB were negative and ranged from -0.02 to -0.10 (Raheja et al., 1989). Tiezzi et al., (2012) reported that $r_g$ between first lactation TMY1 and each of heifer NSC0, CR0, and SP0 were -0.023, 0.153 and -0.083, respectively.

**Table 4. Genetic correlations between heifer fertility and first lactation production cow traits.**

| Traits[a] | LP1 | DMY1 | M305 | TMY1 |
|---|---|---|---|---|
| NSC0 | -0.975 | 0.999 | -0.996 | -0.984 |
| CR0 | 0.975 | -0.999 | 0.997 | -0.984 |
| SP0 | 0.431 | 0.997 | -0.989 | 0.975 |
| AFB | -0.824 | 0.416 | -0.886 | -0.998 |
| ASB | -0.607 | 0.606 | -0.760 | -0.973 |
| AFC | -0.634 | 0.549 | -0.796 | -0.984 |

**a: abbreviations as described in table 1.**

The estimated negative $r_g$ between NSC0 with each of LP1, M305 and TMY1(-0.975, -0.996 and -0.984, respectively), between CR0 with each of DMY1 and TMY1 (-0.999 and -0.984, respectively), between SP0 with M305 (-

0.989), between AFB with each of LP1, M305 and TMY1 (-0.824, -0.886 and -0.998, respectively), between ASB with each of LP1, M305 and TMY1 (-0.607, -0.760 and -0.973, respectively) and between AFC with each of LP1, M305 and TMY1 (-0.634, -0.796 and -0.984, respectively. The reverse relationships between heifer fertility and most of first lactation production traits may lead to refer that increased yield traits of first lactation may be favorably related to improved fertility as heifer results suggest. So, these negative $r_g$ between heifer fertility traits and most of first lactation production traits indicate that selection for milk yield ignoring fertility will deteriorate heifer fertility as well as cow fertility (Kuhn et al., 2006).

In the present study, negative genetic correlations were ranged from -0.824 to -0.998 between AFB and first lactation production traits, which was stronger in absolute value than ASB (-0.607 to -0.973). These results may indicate that the relationship of AFB with early productive maturity would be stronger than that of ASB (Abe et al., 2009).

Positive favorable $r_g$ between NSC0 with DMY1 (0.999), between CR0 with LP1 and M305 (0.975 and 0.997, respectively), between SP0 with LP1, DMY1 and TMY1 (0.431, 0.997 and 0.975, respectively), between AFB, ASB and AFC with DMY1 (0.416, 0.606 and 0.549, respectively). Positive genetic correlations between CR0 and both LP1 and M305 (0.975 and 0.997) were strongly desirable, however negative genetic correlations between NSC0 with each of LP1, M305 and TMY1 (-0.975, -0.996 and -0.984, respectively), and between CR0 with each of DMY1 and TMY1 (-0.999 and -0.984, respectively) were unfavorable. Genetic relationships between heifer fertility and first lactation production traits of cows were medium to high ranged from -0.999 to 0.999 (Table 4), indicating that high-producing females are not predisposed to be genetically infertile, but other factors associated with high production moderately affect reproductive efficiency.

**Phenotypic correlation**

Estimates of $r_p$ between heifer fertility and cow production traits were smaller than those of genetic correlations (Table 5). Phenotypic correlations between first lactation LP1 with heifer traits (NSC0, CR0, SP0, AFB, ASB, and AFC) were small and near to zero (0.076, -0.065, 0.071, -0.015, 0.040 and 0.049, respectively, table 5). Relationship between cow DMY1 with each of heifer NSC0, CR0, SP0, AFB, ASB, and AFC were small and near to zero (0.044, -0.044, 0.051, 0.052, 0.070 and 0.067, respectively, table 5).

First lactation M305 was phenotypically correlated with each of heifer NSC0, CR0, SP0, AFB, ASB, and AFC (0.065, -.056, 0.067, -0.059, -0.013 and -0.002, respectively, table 5). Phenotypic correlations between first lactation M305 and each of heifer NSC0, SP0, AFB and ASB were small and near to zero, 0.02, -0.00, -0.01 and -0.00, respectively (Hansen et al., 1983). Also, Abe et. al., (2009) found that phenotypic correlations between M305 and each of heifer CR0, AFB and ASB were -0.06, 0.00, and 0.12, respectively.

First lactation TMY1 was phenotypically correlated with each of heifer NSC0, CR0, SP0, AFB, ASB, and AFC (-0.969, 0.060, 0.970, -0.061, -0.016 and -0.006, respectively, table 5). Phenotypic correlations between TMY1 and each of NSC0, AFB and ASB were small, 0.03, -0.13 and -0.12, respectively (Raheja et al., 1989). Also, Jagusiak (2006) found that correlations between TMY1 and each of heifer CR0, AFB and ASB were small (-0.02, 0.05 and 0.10, respectively).

Phenotypic correlation between heifer traits and all productive traits in first lactation were low and near to zero (Table 5), except between NSC0 and TMY1 (-0.969) and between SP0 and TMY1 (0.970) which indicate that late heifer pregnancy (long SP0) increased TMY1 in first lactation.

**Table 5. Phenotypic correlations between heifer fertility and first lactation production cow traits.**

| Traits[a] | LP1 | DMY1 | M305 | TMY1 |
|---|---|---|---|---|
| NSC0 | 0.076 | 0.044 | 0.065 | -0.969 |
| CR0 | -0.065 | -0.044 | -0.056 | 0.060 |
| SP0 | 0.071 | 0.051 | 0.067 | 0.970 |
| AFB | -0.015 | 0.052 | -0.059 | -0.061 |
| ASB | 0.040 | 0.070 | -0.013 | -0.016 |
| AFC | 0.049 | 0.067 | -0.002 | -0.006 |

**a: abbreviations as described in table 1.**

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# علاقة خصوبة العجلات بصفات الموسم الأول فى ماشية الفريزيان فى مصر

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## الملخص

تهدف هذه الدراسة لفحص العلاقة الوراثية والمظهرية بين صفات الخصوبة فى العجلات مع الصفات التناسل والإنتاجية للموسم الأول فى أبقار الفريزيان فى مصر. تم استخدام بيانات 2914 حيوان خلال الفترة من عام 1979 وحتى 2013 من محطتى سخا والقرضا. تم إستخدام نموذج الحيوان متعدد الصفات فى تحليل هذه الصفات. تم التحصل على أعلى معامل إرتباط وراثى مطلق بين كل من NSC0, CR1 (0.827)، بين CR0, CR1 (-0.763)، بين SP0, NSC1 (-0.793) وبين كل من AFB, AFC مع CFS1 (-0.728 و -0.739). كل معاملات الإرتباط المظهرى بين الصفات التناسلية للعجلات ومثيلاتها فى الموسم الأول كانت صغيرة وقريبة من الصفر. تتراوحت قيم معامل الإرتباط الوراثى بين الصفات التناسلية للعجلات والصفات الإنتاجية لأبقار الموسم الأول بين -0.999 و 0.999. كان أعلى معامل إرتباط وراثى بين DMY1 وكل من NSC0, CR0 , SP0 (0.999، -0.999 و 0.997 )، على التوالى، وبين صفة M305 ونفس الصفات الثلاث (-0.996، 0.997و -0.989) ،على التوالى وبين صفة TMY1 وكلا من الصفات NSC0, CR0, SP0, AFB, ASB,AFC كالآتى -0.984، -0.984، 0.975، -0.998و -0.973، و -0.984، على التوالى. كانت معاملات الإرتباط المظهرى بين صفات الخصوبة للعجلات والصفات الإنتاجية فى الموسم الأول أقل من مثيلاتها الوراثية فيما عدا ما بين TMY1 وكلا من NSC0 و SP0 (-0.969 و 0.970).