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Characterization of Friesian Heifer Fertility under Egyptian Conditions

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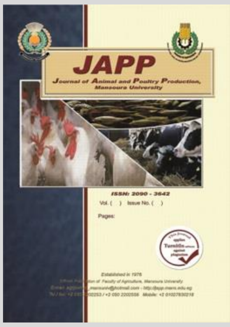

ABSTRACT

Data from 3081 reproductive records of Friesian heifers covering the period from 1979 to 2013 belongs to Sakha and El-Karada experimental farms - Kafr-El-Sheikh Governorate, Animal Production Research Institute, Ministry of Agriculture, Egypt were analyzed. A multitrait animal model was used to estimate genetic parameters, genetic and phenotypic changes for age at first breeding (AFB), age at successful breeding (ASB), age at first calving (AFC), number of services per conception (NSC) and service period (SP). Heritabilities of AFB, ASB, AFC, NSC and SP were 0.15, 0.12, 0.11, 0.02 and 0.01, respectively. Genetic correlations between AFB, ASB and AFC were high and ranged from 0.97 to 0.99, however the phenotypic correlations were ranged from 0.78 to 0.99. Genetic correlations between NSC and both AFB, ASB and AFC were -0.12 to 0.16, however the corresponding phenotypic correlations were ranged from -0.04 to 0.46. The genetic correlations between SP and both AFB, ASB and AFC were ranged from 0.58 to 0.79, however that corresponding estimates of phenotypic correlations were ranged from 0.01 to 0.56. The genetic and phenotypic correlations between NSC and SP were 0.72 and 0.94, respectively. A linear regression analysis of estimated breeding values on year of birth of heifers showed favorable genetic improvement of all fertility traits, however the reverse phenotypic trend was observed for AFB, ASB and AFC.

Keywords: Characterization - Friesian heifer – Fertility - Genetic, phenotypic trend

INTRODUCTION

Continuous increasing milk yield by selection has induced a decrease in reproductive performance due to antagonistic genetic relationship between milk yield and fertility traits (Pryce and Veerkamp, 2001, Lin *et al*., 2008, Guo *et al*., 2014). The inclusion of fertility in the breeding goal is necessary to optimize the result of genetic improvement of dairy cattle (Buaban *et al*., 2015). Fogh *et al*., (2004) concluded that the deteriorating genetic trend for Holstein is showing the importance of including fertility in a total merit index so the genetic trend can be at least hold constant.

Although there are large numbers of publications on cow fertility, very little has been published about virgin heifer fertility (Hansen *et al*., 1983, Raheja *et al*., 1989, Kuhn, *et al*., 2006, Hagiya *et al*., 2013). Hahn (1969) found higher heritabilities of fertility for heifers than cows and submitted that selection for heifer fertility may be of greater benefit than selection for cow fertility. However, virgin heifer traits are measured relatively early in life, and therefore they should be included in dairy cattle breeding program to improve the efficiency of fertility (Buaban *et al*., 2015).

The objective of this study was to characterize Egyptian Friesian (virgin) heifer fertility. In addition to a basic description of the data that has been received, this characterization included two general aspects. The first part involved assessment of factors affecting heifer fertility. Identification of such factors is needed for modeling purposes and can also be useful for management as well as mating programs. The second part of this characterization was to estimate heritablities, genetic and phenotypic correlations for various fertility traits as well as the genetic and phenotypic trends to assist in national genetic programs for the selection of fertility traits in the future.

MATERIALS AND METHODS

A total of 3081 reproductive records of Friesian heifers covering the period from 1979 to 2013 were used.Heifers in this study belongs to two experimental farms, Sakha and El-Karada – Kafr-El-Sheikh Governorate, belonging to Animal Production Research Institute, Ministry of Agriculture, Egypt. Heifers were inseminated by professional artificial insemination technicians at 18-22 months of age (about 350 kg body weight), using frozen semen. For mating that were less than 6 day a part, only the later mating was kept. A maximum of 5 services per heifer was imposed; services beyond 5 were excluded. Pregnancy was detected by rectal palpation 60 days after the last service. Calves were left with their dams for suckling during the first three days after birth and thereafter were housed in calf-boxes and bucket-fed on milk and /or milk replacer till weaning at 90-100 kg in weight (about 3-3.5 months of age). After weaning and up to six months of age, calves of the same age were group-housed in pens provided with yards for exercise. At six months of age, male calves were separated from female and housed in open sheds up to sexual maturity.

In the two farms, animals (Heifers and cows) were kept under similar feeding system. During summer and autumn months (from June to the end of November), all animals were fed concentrates and corn silage, and during the winter and spring months (from December to May) the

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animals were supplied with Egyptian clover (*Trifolium alexandrinum*). In addition, rice straw was available all the year round. Feed was supplied to heifers according to their live weight, while cows were feed according to their live weight, production and pregnancy status. Free clean water and mineral mixture were available at all times.

Fertility traits under study were age at first breeding (AFB), age at successful breeding (ASB), age at first calving (AFC), number of services per conception (NSC) and days from first to last service (service period, SP). Criteria for data editing included: (1) heifers with correct pedigree, all heifers with missing sire or dam were discarded; (2) the ranges for AFB, ASB, AFC, NSC and SP were 11-32 mo., 11-32 mo., 20-42 mo., 1-5 and 15-200 d. The records that included abortion were eliminated from heifer's data set. The structure of the data analyzed is shown in table 1.

Table 1. Structure of the fertility data set for Friesian dairy heifers.

Item	Data
No. of sires	66
No. of dams	427
No. of Service sires	127
No. of base animals	622
No. of non-base animals	3081

Preliminary statistical analysis were performed for identifying non-genetic effects to be included in the final model using MIXED procedure of SAS software (SAS, 2011). The applied model was as follows:

$$Y_{ijkl} = F_i + R_j + M_k + FR_{ij} + RM_{jk} + e_{ijkl} \quad (1)$$

Where: Y_{ijkl} was the individual observation, F_i was the fixed effect of farm, R_j was the fixed effect of year of first service, M_k was the fixed effect of month of first service, FR_{ij} was the fixed effect of farm by year of first service, RM_{jk} was the fixed effect of year by month of first service and e_{ijkl} was random residual term.

All non-significant interactions were removed from the model (1).

Genetic parameters as heritability, genetic and phenotypic variation and genetic and phenotypic correlations were estimated using VCE6 program (Groeneveld *et al*., 2010). A linear animal model was applied as follows:

$$Y1_{ijklm} = F_i + R_j + M_k + FR_{ij} + RM_{jk} + a_l + e_{ijklm} \quad (2)$$

$$Y2_{ijklmn} = F_i + R_j + M_k + FR_{ij} + RM_{jk} + a_l + ss_m + e_{ijklmn} \quad (3)$$

Where: $Y1_{ijklm}$ was the individual observation on AFB, ASB and AFC traits, and $Y2_{ijklmn}$ was the individual observation on NSC and SP, a_l was the random additive genetic effect of animal, ss_m was the random effect of service sire, and the remaining effects as described in model (1).

For animal effect pedigree data was included. Multivariate EBV were estimated by PEST program (Groeneveld *et al*., 2001) fitting an animal model and using genetic parameters obtained as described above.

The genetic trend was estimated as the linear regression of means of estimated breeding values on year of birth for all traits. Phenotypic trend was estimated by regressing phenotypic values on year of birth. Genetic and phenotypic trends were estimated by SAS (2011).

RESTULTS AND DISCUSSION

Descriptive statistics for heifer fertility traits are presented in table 2. The mean estimate of AFB in the present study (21.7 mo.) was nearly the same (22.9 mo.) as reported by Buaban *et al*., (2015), however it was higher than 16.2, 16.7, 17.3 and 17.3 mo., as reported by deHaer *et al*., (2013), Jamrozik *et al*., (2005), Abe *et al*., (2009) and Guo *et al*., (2014), respectively. The longer AFB in Egyptian dairy Friesian heifers could be due to the managerial condition, particularly feeding level. It is generally recognized that dairy heifers in tropical areas have a lower growth rate than those in temperate areas (Vaccaro and Rivero, 1985). The estimated mean value of ASB was 23.2 mo., which was higher than 18.1, 18.2, 20.0 and 20.7 as reported by Abe *et al*., (2009), Jagusiak (2005), Raheja *et al*., (1989) and Hansen *et al*., (1983), respectively. AFC mean value in the present study was 32.2 mo. which was nearly the same (32.9 mo.) as reported by Buaban *et al*., (2015), however it was higher than 31.22, 27.4, 28.0, 29 and 27.2 mo. as published by Khattab and Sultan (1991), Jagusiak (2005), Berry *et al*., (2007) , Janzekovic *et al*., (2009) and Salem and Hammoud (2016). The average value of NSC in the present study (2.07service) which was nearly the same (2.0) as reported by Salem and Hammoud (2016) with another herd of Friesian in Egypt and was higher than 1.31, 1.57 and 1.56 service (Mokhtari *et al*., 2015, Buaban *et al*., 2015 and Tiezzi *et al*., 2012, respectively) in virgin heifer. The estimated mean value for SP in virgin Friesian heifers was 43.9 d. which was greater than 18.1, 26.8, 33.0 and 35.6 d. as reported by Muuttoranta *et al*., (2019), Buaban *et al*., (2015), deHaer *et al*., (2013) and Tiezzi *et al*., (2012), respectively.

Coefficients of phenotypic variation (CV_p) for NSC and SP (Table 2) were 70.04 and 65.97 which were higher than the estimates of 61.1 and 43.4,respectively, reported by Salem and Hammoud (2016) with another herd of Friesian cwos in Egypt and which were higher than the estimates of AFB, ASB and AFC (17.05, 18.18 and 13.57, respectively). Raheja *et al*., (1989) reported that estimate of CV_p were 17.25, 17.93 and 52.89 for AFB, ASB and NSC, respectively. Additive genetic variation (CV_a) in the present study were lower than those of CV_p for AFB, ASB , AFC, NSC and SP (6.38, 6.08, 4.47, 8.35 and 6.81, respectively). These estimates were higher than 3.73, 3.89 for AFB and ASB, respectively, however it was lower than 9.39 for NSC as reported by Raheja *et al*., (1989).

Table 2. Descriptive statistics for heifer fertility traits.

Trait[a]	No. Records	Mean	S.D.[b]	C.V.$_p$[b]	C.V.$_a$[b]	Min.	Max.
AFB (mo.)	3081	21.7	3.70	17.05	6.38	13	32
ASB (mo.)	3081	23.2	4.21	18.18	6.08	14	32
AFC (mo.)	3081	32.2	4.37	13.57	4.47	22	42
NSC	3081	2.07	1.45	70.04	8.35	1	5
SP (d)	1410	43.9	63.20	65.97	6.81	15	200

a: AFB= age at first breeding; ASB= age at successful breeding; AFC= age at first calving; NSC= number of services per conception; and SP= service period.

b: S.D.= standard deviation, C.V.$_p$ = phenotypic coefficient of variability, and C.V.$_a$= additive genetic variation.

Variance and heritability estimates of heifer fertility traits are given in table 3. Estimated heritability of AFB was 0.145, which was higher than 0.100, 0.107 and 0.128 as reported by Guo *et al*., (2014), Eghbalsaied (2011) and Abe *et al*., (2009), respectively, however it was lower than estimates of 0.324, 0.227 and 0.26, reported by Jagusiak

(2005), deHaer *et al*., (2013), and Buaban *et al*., (2015), respectively. The heritability of ASB was estimated to be 0.115, which was nearly the same (0.120) as reported by Abe *et al*., (2009), and lower than estimates of 0.16 and 0.321 reported by Hansen *et al*., (1983) and Jagusiak (2005), respectively. Hansen *et al*., (1983) reported that 0.16 estimate of heritability for ASB suggests that reasonable response could be expected from selection, since this trait may be related to genetic differences in rate of maturity. Heritability of 0.111 for AFC was lower than 0.39, 0.296, and 0.25 that reported by Khattab and Sultan (1991), Jagusiak (2005) and Buaban *et al*., (2015), respectively. Direct heritability estimate of NSC was 0.015, which was slightly higher than 0.012 and 0.006 reported by Mokhtari *et al*., (2015) and Salem And Hammoud (2016),, however it was lower than 0.02 and 0.026 reported by Buaban *et al*., (2015) and Tiezzi *et al*., (2012), respectively. The direct heritability estimate of SP was 0.011, which was nearly the same as 0.01 reported by Buaban *et al*., (2015), however it was lower than 0.014, 0.016, 0.016, 0.017 and 0.012 reported by Lin *et al*., (2008), Fogh *et al*., (2004), deHaer *et al*., (2013), Tiezzi *et al*., (2012) and Muuttoranta *et al*., (2019), respectively.

Table 3. Variance component and genetic parameters[b] for heifer fertility traits,

Trait[a]	σ^2_a	σ^2_s	σ^2_e	h^2	s^2
AFB	1.9142 (0.114)	-----	11.22 (0.254)	0.146 (0.009)	-----
ASB	1.9930 (0.188)	------	15.38 (0.326)	0.115 (0.011)	------
AFC	2.0697 (0.208)	------	16.63 (0.321)	0.111 (0.011)	-----
NSC	0.0299 (0.014)	0.002 (0.003)	2.00 (0.043)	0.015 (0.007)	0.001 (0.003)
SP	42.5320 (21.44)	14.72 (11.24)	3854.21 (105.86)	0.011 (0.005)	0.004 (0.002)

a: the abbreviations as described in table 1.
b: σ^2_a = direct additive genetic variance, σ^2_s = sire-service variance, σ^2_e = residual variance, h^2 = direct heritability, s^2 = ratio of sire-service variances.

Table 4 has correlations among measures of heifer fertility traits. Genetic correlations (r_g) of AFB with each of ASB and AFC were 0.979 and 0.974, respectively, however between ASB and AFC was nearly the unity (0.999). The high genetic correlation between AFB and ASB indicates to the high degree of the same additive genes influence both of these measures of heifer fertility traits or that these traits may be different measures of the same trait (Raheja *et al*., 1989). Also, high genetic correlation between ASB and AFC (0.999) indicated that ASB could be used in genetic evaluation instead of AFC if the AFC data are incomplete for some reasons, e.g. heifers culled due to abortion. Phenotypic correlations (r_p) between AFB and each of ASB and AFC were lower than the corresponding estimates of r_g (0.791 and 0.780, respectively), however r_p estimate between ASB and AFC was 0.985. Many authors concluded that AFB and ASB were closely genetically and phenotypically related. Hanasen *et al*., (1983) reported that r_g and r_p between AFB and ASB were 0.97 and 0.67, respectively. Raheja *et al*., (1989) also reported high estimates of r_g and r_p between AFB and ASB (0.76 and 0.81, respectively). Estimates of r_g and r_p between AFB and ASB were 0.99 and 0.82, respectively (Abe *et al*., 2009). Buaban *et al*., (2015) reported that r_g and r_p estimates between AFB and AFC were 1.0 and 0.94, respectively.

Table 4. Genetic (above diagonal) and phenotypic correlations (below diagonal) for heifer fertility traits.

Trait[a]	AFB	ASB	AFC	NSC	SP
AFB	------	0.979	0.974	-0.123	0.580
ASB	0.791	------	0.999	0.119	0.768
AFC	0.780	0.985	------	0.160	0.795
NSC	-0.044	0.458	0.451	------	0.723
SP	0.014	0.561	0.561	0.939	------

a: the abbreviations as described in table 1.

Estimates of r_g and r_p between NSC and AFB were low and negative (-0.123 and -0.044, respectively), however it was low and positive between NSC and each of ASB and AFC (0.119 and 0.160, respectively) for r_g and were medium and positive between the same traits for r_p (0.458 and 0.451, respectively). Raheja *et al*., (1989) reported that genetic correlations between NSC and each of AFB and ASB were -0.08 and 0.17, respectively however the corresponding r_p estimates between the same traits were -0.04 and 0.30, respectively. Also, Buaban *et al*., (2015) found that r_g between NSC and AFB was -0.19. AFB in the present study was negatively correlated with NSC in both genetic and phenotypic correlations, which mean that when heifer breeding was started at young ages, it takes a lot of number of services to be pregnant. Hansen *et al*., (1983) found that phenotypically, AFB was negatively related with numerous measures of fertility, and concluded that perhaps fertility was hindered when heifer breeding was initiated at young ages. Estimates of r_g between SP and each of AFB, ASB and AFC traits ranged from 0.580 to 0.795, however the corresponding estimates of r_p between the same traits ranged from 0.014 to 0.561 (Table 4). Buaban *et al*., (2015) reported that r_g estimates between SP and each of AFB and AFC were -0.31and -0.02, respectively, however the corresponding r_p estimates were -0.08 and 0.29, respectively for the same traits. Estimates of r_g and r_p between NSC and SP were 0.723 and 0.939, respectively (Table 4). Buaban *et al*., (2015) reported that r_g and r_p estimates between NSC and SP were 0.85 and 0.73, respectively. The same authors concluded that high genetic correlations between fertility traits even though the lowest heritability of these traits, they could be used as one of the best indicators for heifer fertility and could be complemented by other traits that are genetically considered as different traits in terms of a fertility index.

The overall genetic trend in fertility traits of heifers were as desired negative and significant in almost traits, indicating a genetic improvement in heifer fertility traits (Figure 1). The regression coefficients of mean breeding values for AFB, ASB and AFC decreased during the study period at the rate of -0.01, -0.01 and -0.002 mo/yr (Table 5), respectively.

Table 5. Genetic and phenotypic trends for heifer fertility traits.

Trait[a]	Genetic Trend	Sig.	Phenotypic Trend	Sig.
AFB	9.7x - 0.005	0.01	9.2x + 0.006	NS
ASB	11.9x - 0.006	0.02	8.5x + 0.02	0.05
AFC	4.3x - 0.002	NS	1.3x + 0.02	NS
NSC	10.5x - 0.005	0.001	16.1x – 0.007	0.01
SP	-416.7x - 0.21	0.0001	-549.6x - 0.29	0.02

a: the abbreviations as described in table 1.

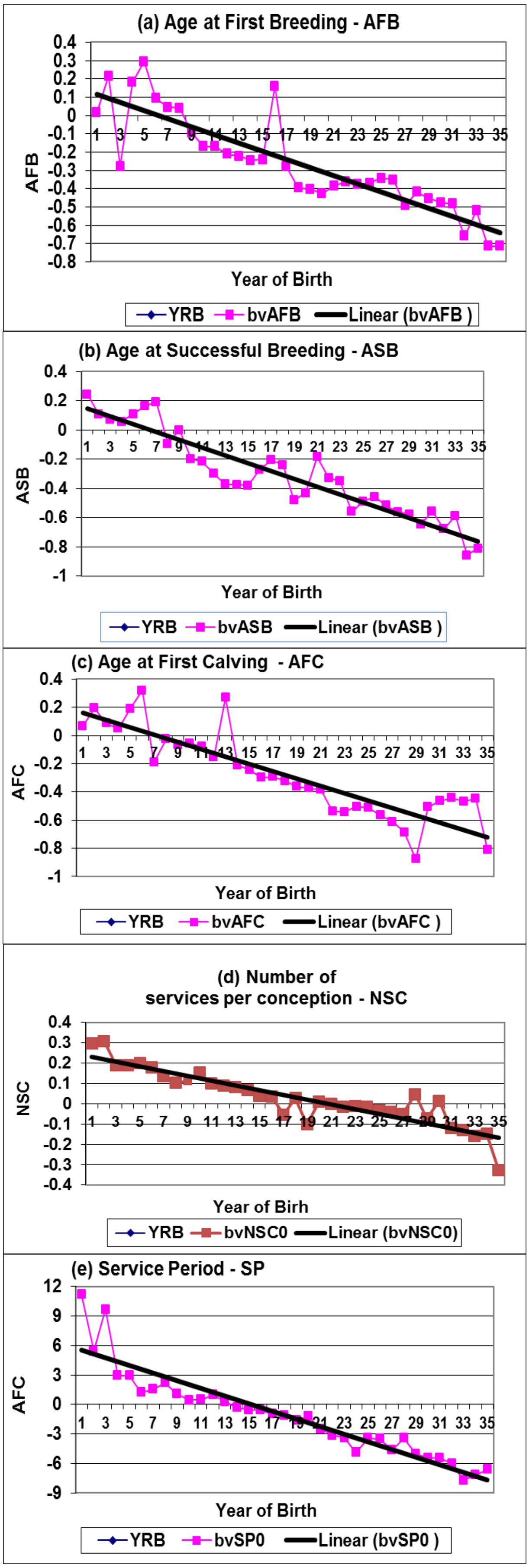

Figure 1. Genetic trends for (a) AFB, (b) ASB, (c) AFC, (d) NSC,and (e) SP.

The same trend was also observed for NSC and SP, the regression coefficients of mean breeding values decreased at the rate of -0.01 service/yr and -0.21 d/y for NSC and SP, respectively. The corresponding phenotypic trends were positive in AFB, ASB and AFC, however it were negative in NSC and SP (Figure 2). The regression coefficients of mean phenotypic values for AFB, ASB and AFC increased during the study period at the rate of 0.01, 0.02 and 0.02 mo/yr, however it were decreased at the rate of -0.01 service/yr and -0.29 d/yr for NSC and SP, respectively (Table 5).

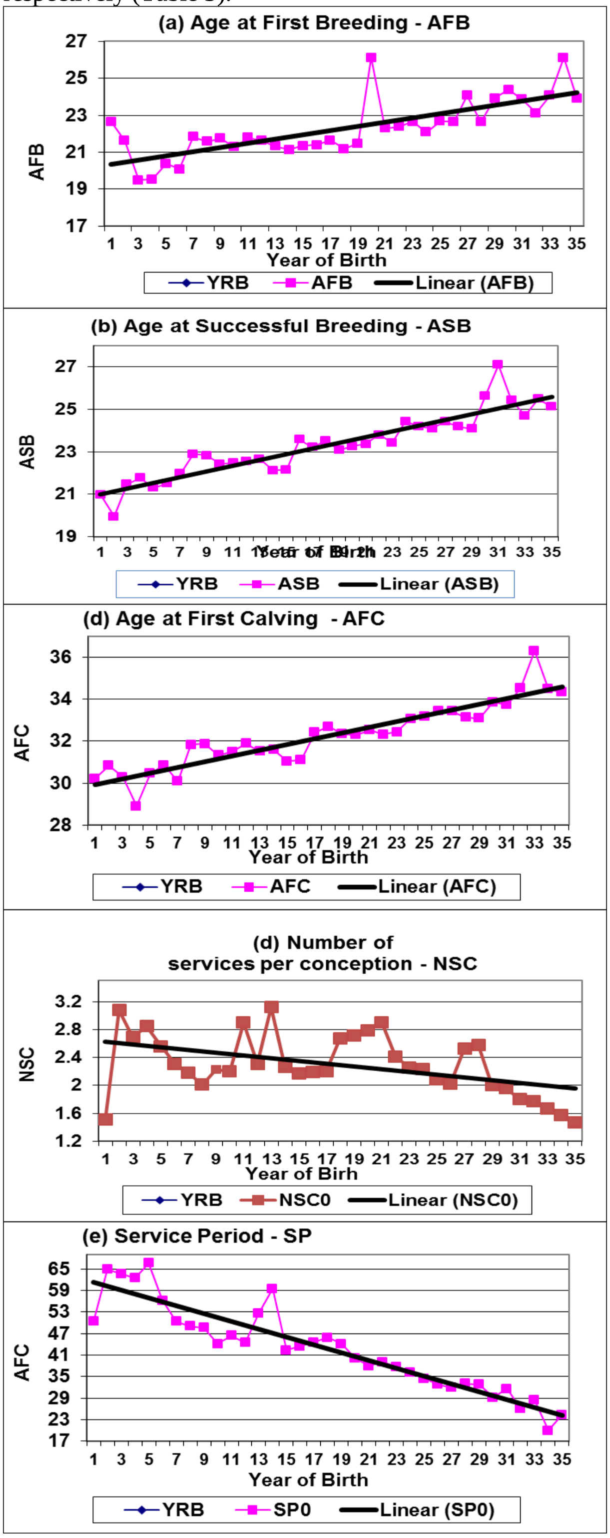

Figure 2. Phenotypic trends for (a) AFB, (b) ASB, (c) AFC, (d) NSC,and (e) SP.

The favorable negative genetic trends for all fertility traits in heifers were a result of good selection program, however the unfavorable positive phenotypic trend for AFB, ASB and AFC may be attributed to un correct culling policy, low nutritional level applied and low management practices through the study period.

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توصيف خصوبة العجلات الفريزيان تحت الظروف المصرية

سميح محمد زاهد و أناس عبد السلام أبو العنين بدر
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تم تحليل سجلات التناسل لسجلات ٣٠٨١ عجلة فريزيان خلال الفترة من ١٩٧٩ وحتى ٢٠١٣ فى محطتى سخا والفرضا - محافظة كفر الشيخ والتابعتين لمعهد بحوث الإنتاج الحيوانى – وزارة الزراعة، مصر. إستخدم نموذج الحيوان متعدد الصفات لتقدير المقاييس الوراثية وكذلك التحسين الوراثى والمظهرى لصفات العمر عند أول تلقيحة (AFB) ، العمر عند التلقيحة المخصبة (ASB) ، العمر عند أول ولادة (AFC) ، عدد التلقيحات اللازمة للإخصاب (NSC) و فترة التلقيح (SP).كانت قيم المكافئ الوراثى (h^2) للصفات SP, NSC, AFC, ASB, AFB هى٠,١٥، ٠,١٢، ٠,١١ ، ٠,٠٢ و ٠,٠١ على التوالى . كانت الإرتباطات الوراثية بين AFB, ASB و AFC عالية وتتراح من ٠,٩٧ إلى ٠,٩٩، بينما تراوحت الإرتباطات المظهرية من ٠,٧٨ إلى ٠,٩٩. كانت قيم الإرتباط الوراثى بين صفة NSC وكلا من AFC, ASB, AFB تتراوح بين -٠,١٢ إلى ٠،١٦ بينما تراوحت قيم الإرتباط المظهرى لنفس الصفات بين – ٠,٠٤إلى ٠,٤٦. كانت قيم الإرتباط الوراثى بين صفة SP وكلا من AFC, ASB, AFB تتراوح بين ٠,٥٨ إلى ٠,٧٩ بينما تراوحت قيم الإرتباط المظهرى لنفس الصفات بين ٠,٠١إلى ٠,٥٦. كانت قيم الإرتباط الوراثى والمظهرى بين SP, NSC هى ٠,٧٢. و ٠,٩٤، على التوالى. أظهر تحليل الإنحدار الخطى لتقديرات القيم التربوية على سنة الميلاد للعجلات تحسين وراثى مرغوب فيه لصفات الخصوبة ، بينما كان التحسن المظهرى فى الإتجاه العكسى لصفات AFC, ASB, AFB .