Longevity and life reproductive efficiency in Arabian broodmares

Iliana Sabeva†, A. Apostolov

Agricultural Institute, Shumen, Bulgaria

SUMMARY

The objective of this article was to establish the variance, the phenotypic and genetic parameters of longevity and the traits characterizing life reproductive efficiency in Arabian broodmares as well as the relation between these traits and some anatomical and constitutional peculiarities of the body. The information dataset included information about the breeding activity of all Arabian broodmares acted at the National Kabiuk Stud after introduction of the breed in the country. The analyses of variance were done by means of mixed model methodology. The influence of inbreeding rate, basic body indices, assessments of exterior and quality of movements were estimated by their regression effect. The basic sources of phenotypic variance were the broodmares' sires and broodmares' massiveness regarding the longevity (R_{xy}=0.28) and the number of born alive (R_{xy}=0.14). The phenotypic variety due to the differences between lines, families and inbreeding regarding the life fertility and between lines regarding the index of foals born alive was studied.

Medium heritability of the longevity and low inheritable determination of the life fertility and the number of born alive were established. The index of foals born alive (h^2= 0.27) had the biggest part of the additive variance from the reproductive traits. The genetic correlations between the above mentioned index and the other studied straits were significantly high to be considered as one of the basic parameters characterizing the life reproductive efficiency in Arabian horses. The trait – number of foals born alive can be a reliable criterion for conducting indirect selection for longevity (r_g=0.92). The index of foals born alive and massiveness can be used for prediction of life fertility, longevity and number of foals born alive.

Keywords: Arabian horse, genetic parameters, life reproductive efficiency longevity.

† Corresponding author e-mail: iliana_sabeva@abv.bg

INTRODUCTION

The length of productive life is a trait, which strongly affects the profitability of selection. Its parameters are used to plan the selection intensity and to calculate the economic efficiency of the implementation of certain breeding program. The research results of a number of scientists in the sphere of animal breeding show that the lifespan and longevity have considerable genetic variance which ensures ecological plasticity of breeds and reveals the possibilities of applying indirect selection. Magnitude of heritability estimates mainly depends on species, breed and methods of calculation. Consensus about proper methods of estimation of longevity genetic parameters and animals' breeding value does not exist in literature. For example genetic determination of sow length of productive life from survival analysis ranged between 0.11 and 0.31, as from linear models – between 0.05 and 0.10 (Yazdi et al. 2000 a, b, Serenius and Stalder 2004). Dekkers' (1993) results showed that true heritability of caw survival may be lower than already recoded in scientific articles low estimates. Guo et al. (2001) analysed data with different censoring rates by mixed model methodology. According their results heritability decrease with increasing censoring rates. Using linear censored models Mekkawy et al. (2009) established moderate heritability at 0.27 for ewes' longevity. Burns et al. (2006) found low inheritance of length of productive racing life (h^2=0.12) using uncensored data set with Irish thoroughbred horses. Mantovani et al. (2007) reported about survival of 10.4 years and heritability at 0.07 for Italian Heavy Draught mares. Ricard and Blouin (2011) estimated heritability at 0.10 for longevity measured as duration of competitive life in French jumping horses with 22 % right-censored records. Low additive variance for number of breeding seasons (0.10) and number of weaned foals (0.16) with Polish Arabian mares was ascertained by Budzynski et al. (1994).

The phenotypic variance of longevity depends on many factors. Wallin et al. (2000) investigated causes of culling and death in Swedish warm-blood and cold-blood horses. They found statistically proved differences between breeds, sex and type of using. Due to the minimum physical stress, compared with competing horses, the warm-blood broodmares had length of life between 18.3 and 18.6 years, as probability of death increased at age of 7 and after 16. Effects of genealogical lines, herd and individual inbreeding on productive life were found for East-Bulgarian Riding broodmares (Sabeva, 1997). The analysis of the period of reproductive utilization with Arabian broodmares in Bialka and Michalow studs had shown the influence of dam lines (Chimel and Sobczuk, 2006 a, b). Significant variance due to the origin of mares' sires, inbreeding and morphological traits judgment score was ascertained by Mantovani et al. (2007) for Italian Heavy Draught mares.

The duration of productive life in horse breeding is very often determined by the animals' lifespan and for this reason the natural selection and its interaction with the artificial one have strong influence on the formation of phenotypic and genetic structure of populations. Broodmares are a seasonal-polycyclic animal which means that they have strongly expressed sensibility to climatic changes. When broodmares are used for reproduction for a long time (15 – 18 years) the cumulative reproductive efficiency depends to a great extent on the long-term adaptive abilities of organism. According to Zdravkov and Dragnev (1997) there are not completed working mechanisms for the adaptation, but only genetically determined prerequisites for their manifestation. Compared with other horse breeds, Arabians possess longer lifespan and higher fertility. Often, they keep good body condition and reproductive abilities after 20 years of age. Budzynski et al. (1994) notified of 11.29 breeding seasons and 7.67 numbers of foals for Arabian mares in Poland. Budzynski et al. (2001) did not found explicit dependencies between low degrees of inbreeding and basic reproductive traits of Arabian mares. The fertility rate recently presented in the literature usually exceeded 69 – 80 % and depends on adopted system of management and culling (Budzynski et al. 1994, Özdemir and Ogan 1999, Chilek 2009, et al.).

Scientific articles concerning broodmare longevity in relation with life reproductive efficiency and type traits take together are still rare. Budzynski et al. (2000) found that the Champion and Reserve Champion mares were used in breeding significantly longer, but gave birth to the same number of foals as other ones. The important role of plenty reproductive, exterior and anatomical traits as early predictors of longevity is well examined with sows and caws (Grindflek and Sehested 1996, Yazdi et al. 2000 b, Diaz et al. 2002, Rodriguez-Zas et al. 2003, Strapak et al. 2005, Tarres et al. 2006, Čanji et al. 2008, et al.).

The objective of this article was to establish the variance and the genetic parameters of longevity and the traits characterizing the life reproductive efficiency in Arabian broodmares as well as the relation between these traits and some anatomical and constitutional peculiarities of the body.

Material and Methods

The set of data used in this study included information about longevity and life reproduction efficiency in Arabian broodmares, acted at the National Stud Kabiuk after introduction of the breed in 1976 (N=58). The broodmares were representatives of 7 families and originated from 16 stallions from 5 genealogical lines. Longevity was measured as length of productive life. Length of productive life was defined as the number of years between month and year of the stud entrance, and month and year of leaving the breeding herd. Any editing restrictions or censoring of data was not imposed. The life reproduction efficiency was calculated by the number of foals born alive and by expressed in percentage indices of fertility and of born foals as follows:

$$fertility\ (\%) = \frac{number\ of\ born\ foals + number\ of\ abortions}{longevity} x100$$

$$born\ foals\ (\%) = \left[1 + \frac{number\ of\ born\ foals}{longevity}\right] x\ 100$$

The analyses of variance were done by mixed model methodology. The preliminary procedures for specifying the operational models showed that the body measurements: height at withers, body length, chest depth, chest width, chest girth, cannon girth and the type estimations did not influence the variety of the studied traits and did not contribute to an increase in the calculation precision. The influence of inbreeding rate, basic body indices, estimations of exterior and quality of movements were estimated by their regression effect. The measurement scale of traits with high coefficients of variation was transformed by log or $\sqrt{\ }$ (Falconer, 1989). The individual inbreeding coefficients were calculated by Wright's formula (1921) including to sixth generation of pedigrees. The body indices were presented as percent proportions of the cannon girth to height at withers for the bone development; of the chest girth to height at withers for the massiveness and of the chest width to chest depth for the chest development.

RESULTS AND DISCUSSION

The parameters of general trait statistics, the structure of the used models and the significance of the studied factors are given in Table 1. The average longevity was 9.17 years and the average number of born foals – 6.40. The transformation of the scale of measurements decreased the variation coefficients up to 27.16 % for the longevity and up to 28.39 % for the number of born foals. The differences between the sires' genetic potential were the basic source of statistically proved variation for both traits. The months of birth did not influence the phenotypic variance and their inclusion in the structure of models did not contribute to higher accuracy. The influence of massiveness as one of the main traits of type was significant with degree of probability $P \leq 0.05$. Measured in real values, the regression effect of the massiveness was 0.28 for the longevity and 0.14 for the number of born foals. The relation between chest index and born foals was negative (-0.12), due probably of some culling peculiarities where too big value of chest width is not desirable in race disciplines. Leading broodmares' sires regard to the productive life were the following stallions: Neapol ($BLUP_{log}$=0.79), Aswan ($BLUP_{log}$=0.34), Eliot ($BLUP_{log}$=0.14) and Zlatar ($BLUP_{log}$=0.22).

Table 1: Means, standard deviations and Anova of the examined traits

Longevity x = 9.17; s.d. = 4.77 CV = 51.98 %	Yi-r = μ + Sire*+ Line + Family+ Inbreeding (C) + Bone development index (C) + Massiveness*(C) + Chest index (C) + Exterior (C) + Gaits (C) + Ei-r R= 0.77 mean (log) = 0.96; s.d. = 0.26; CV = 27,16 %
Number of born foals x = 6.40; s.d. = 3.70 CV = 57.92 %	Yi-r = μ + Sire*+ Line + Family + Inbreeding (C) + Bone development index (C) + Massiveness*(C) + Chest index* (C) + Exterior (C) + Gaits (C) + Ei-r R= 0.80 mean (sqrt) = 2.53; s.d. = 0.71; CV = 28,39 %
Fertility index x = 75.74; s.d. = 13.04 CV = 17.70 %	Yi-r = μ + Sire+ Line* + Family*+ Month of birth** + Inbreeding* (C) + Bone development (C) + Massiveness*(C) + Chest index* (C) + Exterior (C) + Ei-r R= 0.89
Index of born foals x =169.89; s.d. = 17.61 CV = 8.52 %	Yi-r = μ + Sire+ Line* + Family + Month of birth* + Inbreeding (C) + Bone development (C) + Massiveness(C) + Chest index (C) + Exterior (C) + Ei-r R= 0.87

C – Covariate; Levels of significance: *P ≤ 0.05, **P≤ 0.01, ***P≤ 0.001.

The fertility during the investigated period was 75.74 % with variation of 17.70 %. Sources of specific variance were the lineal and family belonging, months of birth and degree of inbreeding (Table 1). The significance of group effects and of inbreeding comes from the manner of selection in Arabian horses. For hundreds of years on end the consolidation of traits is carried out by crossing lines and families using inbreeding. The best fertility was established for broodmares belonged to the following lines: Kuhailan Afas ($BLUE_{log}$=0.20), Amurath ($BLUE_{log}$=0.18) and Skowronek ($BLUE_{log}$=0.14); and from the families of Emese ($BLUE_{log}$=0.13), Szweykowska ($BLUE_{log}$=0.12) and Sahara ($BLUE_{log}$=0.02). The regression coefficient between the inbreeding and fertility rate was negative (-3.61), although closed mating was not applied at the Kabiuk Stud. The highest cumulative fertility was established for broodmares born in October ($BLUE_{log}$=0.16) and November ($BLUE_{log}$=0.10). They constitute 32.7 % of the total number of broodmares included in the analyses. The influence of the month of birth most probably is due to the peculiarities of moderate continental climate and the seasonal pasture in the Republic of Bulgaria. Summer pasture coincides with the last pregnancy months of broodmares, which contributes to good prenatal development of fetus and higher milk yield during the first lactation months. These circumstances determine better body development of foals born in autumn.

The estimates of the sub-levels of factors show presence of positive regressions between the fertility and the indices of bone development (R_{xy}=0.14), massiveness (R_{xy}=0.02) and chest development (R_{xy}=0.01). Although in this case the influence of the traits characterizing the body configuration and soundness is not statistically proved, it is possible with larger sets of data their effects to be more clearly outlined.

The index of born foals gives an alternative scale for measuring the trait – total number of born alive. This scale without transformation meets the requirements for analyzing quantitative traits (Table 1). The factors lineal belonging of sires and month of birth of broodmares significantly influenced the phenotypic variety of the index. The index of bone development examined as covariate tend to have substantial, but non-statistically proven regression effect (R_{xy}=16.61). Estimates over the population average were established for the lines of Skowronek (BLUE=25.80), Kuhailan Afas (BLUE=23.97) and Amurath (BLUE=23.09), and the broodmares born in September (BLUE=30.99), October (BLUE=20.81), and February (BLUE=1.16).

Table 2: Heritability (on the diagonal), phenotypic (below the diagonal) and genotypic (above the diagonal) correlations between examined traits

rp \ rg	Longevity	Number of born alive	Fertility index	Index of born foals
Longevity	0.44	0.90	0.54	0.71
Number of born alive	0.92	0.08	0.39	0.67
Fertility index	0.14	0.22	0.11	0.79
Index of born foals	0.08	0.74	0.77	0.27

The heritability estimate of longevity was 0.44 and of the number of foals born alive 0.08 (Table 2). The phenotypic and genetic correlations between them were r_g= 0.92 and r_p=0.90 respectively. Low phenotypic and high genetic correlations between the longevity and the indices of fertility and born foals were estimated It should be mention that the estimation of heritability of broodmares' longevity measured as length of productive life in small population may be a little bit overestimated, because of the small size of progeny groups. But long selection built up genetically homogeneous groups and it is normal to expect harder transfer of the inheritance qualities inside the groups. The presence of statistically proved genetic effect (table 1) and decreasing of non additive variance after modification of the scale of measurements can also lead to higher heritability. Besides, system of management and culling in old studs is rather conservative over the time, which induces less rate of environmental variance. Nearly the same heritability (0.45) was established for longevity of East Bulgarian Riding broodmares bred in the same stud where problem with size of progeny groups did not exist (Sabeva, 1997). Over 13 years have been acted 32.75 % from Arabian broodmares and 31.31 % from the East Bulgarians'. So, in some cases with standardized manner of breeding and management for long time ensuring less survival risk, medium heritability of broodmares' length of productive live can be acceptable, as the main reason for extremely low inheritance of competitive life is the great influence of external and environmental factors.

The inheritable determination of life fertility was 0.11 and the phenotypic correlations with the other traits were low. The genetic correlation between the same trait and the index of born foals was 0.79. The genetic correlation between the fertility and the number of foals born alive was of average high value (r_g=0.39). The index of born foals (h^2=0.27) had the biggest part of the additively conditioned variance compared with other reproductive traits. The genetic correlations between the abovementioned index and the other studied straits were significantly high to be considered as one of the basic parameters characterizing the life reproductive efficiency in Arabian horses. The values of the calculated genetic correlations show that the number of foals born alive and the index of born foals can be reliable criteria for conducting indirect selection for longevity. For the same reasons the index of born foals can be a good predictor of the life fertility and number of foals born alive.

Results of this study are closed to the reported ones from polish scientist regarding to the means of the examined traits, presence of genealogical effects and heritability estimates of number of born alive and fertility. Such similarity sourced from the circumstance that Kabiuks' breeding herd was created mainly on the base of imported from Michalow stud mares and stallions.

CONCLUSIONS

Average high heritability of the longevity and low inheritable determination of the life fertility and the number of alive born alive were estimated.

The trait – number of foals born alive can be a reliable criterion for conducting of indirect selection for longevity. The index of born foals and massiveness can be used for prediction of the life fertility, longevity and number of foals born alive.

REFERENCES

Budzyn´ski, M., Chmiel, K., Kamieniak, J., Urban´ski, J., 1994 – Heritability and variability of reproductive features in pure-bred Arabian horses. Advances in Agricultural Sciences, vol. 3 (1): 3-6.

Budzyn´ski, M., Chmiel, K., 2000 – Comparison of reproductive efficiency of purebred Arabian mares - winners of Polish national champion or reserve champion titles - with their peers. Annales Universitatis Mariae Curie-Sklodowska, Sectio EE Zootechnica, vol. 18: 105-109.

Budzyn´ski, M., Kamieniak, J., Sapuła, M., Sołtys, L., Budzyn´ska, M., Krupa, W., Stefaniuk, A., 2001 – Causation relations between the level of reproductive indexes and the inbred of Arabian mares. Annales Universitatis Mariae Curie-Sklodowska. Sectio EE Zootechnica, vol. 19: 153-159.

Burns Eleanor M., Richard M. Enns and Dorian J. Garrick., 2006 – The effect of simulated censored data on estimates of heritability of longevity in the Thoroughbred racing industry. Genet. Mol. Res., 5 (1): 7-15.

Čanji V., P. Strapák, E. Strapáková, P. Juhás., 2008 – Effect of conformation traits on longevity of cows of Slovak Simmental breed. Slovak J. Anim. Sci., 41, (2): 83 – 90.

Cilek, S., 2009 – The survey of reproductive success in Arabian horse breeding from 1976-2007 at Anadolu State farm in Turkey. Journal of Animal and Veterinary Advances, vol. 8 (2): 389-396.

Chmiel, K., Sobczuk, D., 2006a – The analysis of reproductive utilization of purebred Arabian broodmares at Białka Stud. Annales Universitatis Mariae Curie-Skłodowska, Sectio EE Zootechnica, vol. 24: 243-247.

Chmiel, K., Sobczuk, D., 2006b – The analysis of reproductive utilization of purebred Arabian broodmares at Michałów Stud. Annales Universitatis Mariae Curie-Skłodowska, Sectio EE Zootechnica, vol. 24: 235-241.

Dekkers, J. C. M., 1993 – Theoretical basis for genetic parameters of herd life and effects on response to selection. J. Dairy Sci., 76: 1433–1443.

Diaz, C., Z. Chirinos, A. Moreno and M. J. Carabano., 2002 – Preliminary analysis of functional longevity in the Avilen a Negra Iberica beef cattle breed. Communication no. 02-65 in Proc. 7-th World Congr. Genet. Appl. Livest. Prod., Montpellier, France.

Falconer, D. S., 1989 – Introduction to Quantitative Genetic. 3-th edition, Longman, pp. 438.

Grindflek, E. and E. Sehested., 1996 – Conformation and longevity in Norwegian pigs. Proceedings of the Nordiska Jordbruksforskares Forening Seminar 265–Longevity of Sows, Research Centre Foulum, Denmark, pg. 77-83.

Guo, S. F., D. Gianola, R. Rekaya and T. Short., 2001 – Bayesian analysis of lifetime performance and prolificacy in Landrace sow using linear mixed model with censoring. Livest. Prod. Sci., 72: 243-252.

Mantovani, R., B. Contiero, A. Sartori, C. Stoppa, G. Pigozzi., 2007 – Phenotypic study on longevity in Italian Heavy Draught mares. 58-th Annual Meeting of the EAAP, Dublin, Ireland.

Mekkawy, W., R. Roehe, R. M. Lewis, M. H. Davies, L. Bunger, G. Simm and W. Haresign., 2009 – Genetic relationship between longevity and objectively or subjectively assessed performance traits in sheep using linear censored models. J. Anim. Sci., 87: 3482–3489.

Özdemir, B., Ogan, M., 1999 – The reproductive performance, viability and body measurements of purebred Arabian Horses raised in Sultansuyu State Farm. Veteriner Fakültesi Dergisi, Uludağ Üniversitesi, vol. 18 (3): 51-61.

Ricard, A., C. Blouin., 2011 – Genetic analysis of the longevity of French sport horses in jumping competition. J. Anim. Sci., (E-pup ahead of print), Abstract.

Rodriguez-Zas, S. L., B. R. Southey, R. V. Knox, J. F. Connor., 2003 – Bioeconomic evaluation of sow longevity and profitability. J. Anim. Sci., 81: 2915–2922.

Sabeva, I., 1997 – Selection aspects of longevity of broodmares from the East-Bulgarian breed. Bulgarian J. of Anim. Sci., 5-6:115-118. (Bg)

Serenius, T., and K. J. Stalder., 2004 – Genetics of length of productive life and lifetime prolificacy in the Finnish Landrace and Large White pig populations. J. Anim. Sci., 82: 3111–3117.

Tarres J., J. P. Bidanel, A. Hofer and V. Ducroc., 2006 – Analysis of longevity and exterior traits on Large White sows in Switzerland. J. Anim. Sci. 84: 2914–2924.

Strapak, P., Candrak, J., Aumann, J. 2005 – Relationship between longevity and selected production, reproduction and type traits. In Czech J. Anim. Sci., vol. 50, no. 1: 1-6.

Wallin Lena, Erling Strandberg, Jan Philipsson, Goran Dalin., 2000 – Estimates of longevity and causes of culling and death in Swedish warmblood and coldblood horses. Livest. Prod. Sci., 63: 275-289.

Yazdi, M. H., L. Rydhmer, E. Ringmar-Cederberg, N. Lundeheim, and K. Johansson., 2000 a – Genetic study of longevity in Swedish Landrace sows. Livest. Prod. Sci., 63: 255–264.

Yazdi, M. H., L. Rydhmer, E. Ringmar-Cederberg, N. Lundeheim, and K. Johansson., 2000 b – Survival of Landrace and Yorkshire sows in relation to osteochondrosis: A genetic study. J. Anim. Sci., 71: 1–9.

Zdravkov, G., H. Dragnev, 1977 – Ecology of farm animals. Zemizdat, Sofia, pp. 216. (Bg)