

# Genetic, phenotypic, and environmental trends towards improving birth and weaning weights of Syrian buffalo calves

M. Elsayed<sup>a</sup>, A.Q. Al-Momani<sup>b</sup>, M.J. Amin<sup>c</sup> and K.A. Al-Najjar<sup>b\*</sup>

<sup>a</sup>Animal Production Dept., Fac. Agric., Ain Shams University, Egypt, P.O. Box 68, Hadayek Shoubra 11241, Cairo, Egypt. <sup>b</sup>Animal Production and protection Dept., Jerash University, Jordan. <sup>c</sup>Animal Wealth Dept., General Commission for Scientific, Agricultural Research, Syria.

\*Corresponding author: khnjj2011@yahoo.com

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## Abstract

This study was carried out at Shatiha station in Hama, which belongs to the Syrian Ministry of Agriculture. Data were collected during the period from 2008 to 2018. This study aimed to evaluate birth weight (BWT) and weaning weight (WWT) of buffalo calves under the Syrian condition and to monitor genetic, environmental, and phenotypic changes of BWT and WWT. 501 records were analyzed by GLM procedure to study the effect of non-genetic factors such as year of calving, calf sex, parity, the interaction between a year of calving and calf sex, and cow-buffalo weight at calving on BWT and WWT. The least-squares means (LSM) of BWT and WWT were  $32.79 \pm 2.09$  kg and  $82.45 \pm 1.69$  kg, respectively. Parity, (year of calving  $\times$  calf sex) and cow-buffalo weight at calving had significant effects, while a year of calving and calf sex had non-significant effects on BWT. On the other hand, calf sex, parity, and (year of calving  $\times$  calf sex) had significant effects, while a year of calving and cow-buffalo weight at calving had non-significant effects on WWT. The annual average breeding value of calves predicated from MTDFREML was regressed on years of birth for BWT and WWT, to monitor any genetic change during the studied period. The result showed that annual genetic, environmental, and phenotypic changes were  $(0.002 \pm 0.001$  and  $0.004 \pm 0.003)$  kg/year,  $(0.179 \pm 0.106$  and  $0.126 \pm 0.100)$  and  $(0.069 \pm 0.060$  and  $-0.103 \pm 0.061)$  kg/year for BWT and WWT, respectively. The heritability of BWT was 0.19 and 0.02 for WWT. The genetic correlation between BWT and WWT in the present study was high (0.93). The phenotypic and environmental correlations were lower than the genetic correlation (0.28 and 0.25), respectively. The results indicated that buffalo calves might need better management under rearing conditions in Syria. Also, an effective selection program did not exist during this studied period to improve BWT and WWT. Therefore, the selection is recommended. Genetic parameters indicated the potential for an increased rate of genetic change with full implementation of genetic improvement programs.

**Keywords:** Buffalo; calves; body weights; trend; heritability; Syria.

## Introduction

Buffalo (*Bubalus bubalis*) population in the world is around 168 million head; more than 95% of buffalo are in Asia (Borghese, 2005). Water buffalo includes two subspecies the River and the Swamp (Borghese 2011). The total buffalo population in Syria is about 8000 heads (FAO, 2018.). The countryside of Hama is known for breeding water buffaloes, Swamp type (Fig 1), because of the availability of water ponds, and lakes that are considered ideal pastures for buffaloes, especially on the Orontes River, which passes through the fertile area.

The breeding of buffalo was considered a source of livelihood for breeders and many families that depend on this animal's milk and meat. Also, buffalo is used as a working animal (draft animals) at wetlands where cows cannot live. Locals consider buffalo's milk and meat tastier than cows, despite the high price compared to cow's milk. Besides, the buffalo breeding depends on turning crops to food unlike the rest of the livestock, such as cattle, sheep, and goats, and relies on grazing in all seasons to secure the animal's food, while in the winter season it needs concentrating feeds such as "silage" and "hay" for feeding. In addition, the buffalo's strong body structure and resistance to diseases have made it important for livestock in Syria, especially in the countryside of Hama. Besides, buffalo calves could grow well and produce lower fat meat when compared to cattle calves (Clark, 2017).

Years of continuous battles in the region have led to shrinking the buffalo pastures and raising the cost of their rearing, in addition to the displacement of most of the area's population from the Hama countryside with their herds of buffaloes. So good management can be increased under the intensive system, genetic improvement, and productivity. Since then it has been necessary to assess the productivity of the herd already in a Shatiha research station, allowing more knowledge of its capabilities.

The study of the environmental factors and genetic trend in a population is of significant importance to monitor the selection for a given trait since it corresponds to the observed changes in the average breeding values of animals during the selection process (Potocnik et al 2007, Sharma et al 2016). Defining the genetic trend helps to monitor the efficiency of improvement strategies. The present study was planned to 1) monitor genetic, environmental, and phenotypic changes of birth weight (BWT) and weaning weight (WWT); 2) investigate the effect of some non-genetic factors on the two studied traits and; 3) estimate the genetic parameters of Syrian buffalo calves at some remarkable stages (birth and weaning) under the semi-intensive conditions.

## Material and methods

### Data

This study was conducted at Shatiha station for the Syrian buffalo. This station is located about 73 km northwest of Hama city in Syria, which had an annual rainfall of about 253.9 mm. A total data of 501 records of Syria buffalo calves were collected during 2008-2018. Each record included ID for a calf, sire, dam, calves' birth (BWT), and weaning weight/kg (WWT), in addition to a year of calving, calf sex, parity, and a dam's weight at calving.

### Herd management

Animals were kept in semi-open yards and they were housed in concrete barns at night and during the bad weather in the winter. Adult animals were allowed to graze on pastures grasses all-day within the fence station. The amounts of commercial concentrates and roughages (barley and wheat straws, vetch, fodder beet, barley, peeled cotton straw, wheat bran, hay, and corn) were provided twice a day which ranged from around 3 to 6 kg according to the animal's physiological position. Water was available all time. All adult females were naturally mated with selected bullocks according to their reproductive efficiency taking into account no kinship. Each bull was designated about 30-40 females and was allowed to mate when a female has in estrus.

The buffaloes were infected with internal and external parasitic diseases and were treated with anti-parasites as needed. Adult females were raised for producing milk and offspring, where females' calves were kept as a replacement and surplus males were sold to breeders. A pregnant female was removed in an individual barn at calving allowing it to take care of her calf for a week. After calving, calves had taken colostrum as fast as possible, then suckled their dams up to weaning at 90 days old, and identifying ear tag was used for all calves. The newborn was fed an amount of milk equivalent to 10% of the weight of the newborn through artificial feeding, and after the first month of birth, the newborn was fed in addition to milk in an amount of 200-300 g of concentrated feed until the time of weaning at the age of three months. The newborn calves were gradually accustomed to feeding green herbs, starter concentrate fodders, and hay during the first month of age, so reducing the amount of milk the newborn calves take from their dams, as they were breastfeeding the remainder after milking and were continued until their dam reject them. The females were milked in the milking room and in the presence of their calf, where the udder was washed and checked before the milking cups were installed, and concentrated feed was provided during milking. Milking was done in two periods in the morning and evening.

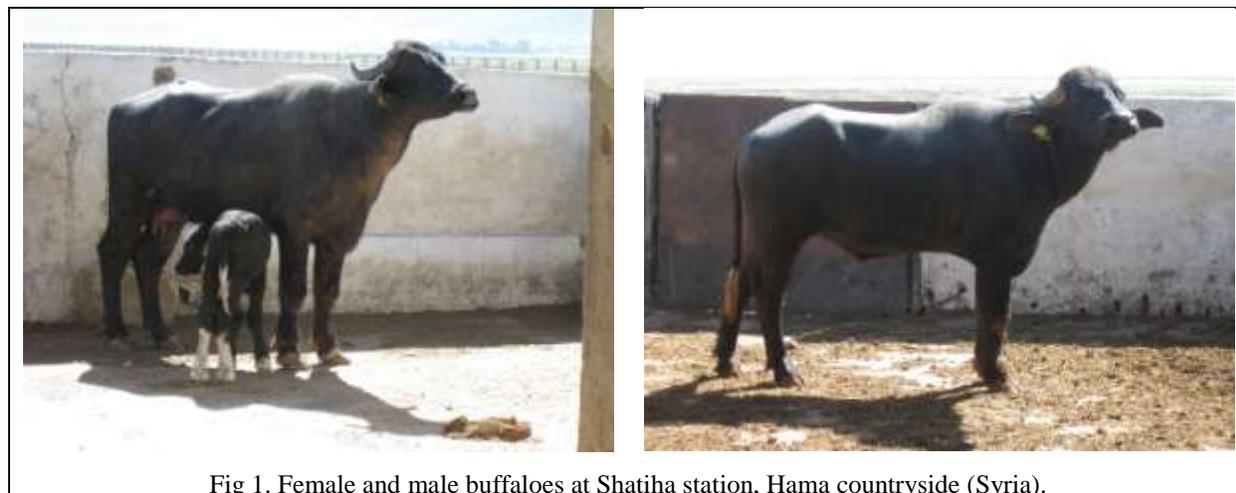


Fig 1. Female and male buffaloes at Shatiha station, Hama countryside (Syria).

### Statistical analysis.

Data were analyzed using SAS (2012) program to determine non-genetic factors that affect the calves' at birth and weaning weights, according to the following model:

$$Y_{ijkl} = \mu + YC_i + SEX_j + PR_k + (YC \times SEX)_{ij} + b(X_{ijkl} - \bar{X}) + e_{ijkl}, \quad \text{Model 1}$$

Where,  $Y_{ijkl}$  = weight at birth or at weaning -90 days of the  $ijkl$ <sup>th</sup> record,  $\mu$  = grand mean,  $YC_i$  = effect of the  $i^{\text{th}}$  year of calving coded as  $i = 1, 2, \dots$  and 11 of the years 2008-2018, respectively,  $SEX_j$  = effect of the  $j^{\text{th}}$  sex of calf coded as  $j = 1$  and  $2$  of male and female, respectively,  $PR_k$  = effect of the  $k^{\text{th}}$  parity coded as  $k = 1, 2$  and  $10+$ , respectively,  $(YC \times SEX)_{ij}$  = the interaction of the calving year and calf sex, respectively,  $B$  = linear partial regression coefficient of the weights at birth or weaning of calves on the dam's weight at calving,  $X_{ijkl}$  = the  $l^{\text{th}}$  dam's weight at calving -kg,  $\bar{X}$  is the grand mean of the dam's weight at calving, and  $e_{ijkl}$  = the random error term associated with the  $Y_{ijkl}$  observation with zero mean and variance  $I \sigma^2 e$ . Duncan multiple range tests were used to detect the differences among means of effects (Duncan, 1955).

A multiple trait animal model program (MTDFREML) of Boldman et al (1993) was used, as a multiple traits analysis to predict the breeding values of birth and weaning for each calf and to estimate genetic parameters for the two traits considering all available pedigree information generated from their ancestors according to the following model:

$$Y = XB + Z_a a + Z_c c + e, \quad \text{Model 2,}$$

Where,

$Y$  = the vector of observation of birth and weaning weights -kg,  $X$  = the incidence matrix for fixed effects,  $B$  = the vector of a grand means and fixed effects of year of calving (11 classes), calf sex (2 classes), parity (10 classes), and a dam's weight at calving,

$Z_a, Z_c$  = the incidence matrix for random effects,  $a$  = the vector of direct genetic effects of a calf,  $c$  = the vector of permanent environmental effects of a calf and  $e$  = a vector of random errors normally and independently distributed with zero mean and variance  $I \sigma^2 e$ .

Genetic trends were estimated by regression of average estimated breeding values on a year of birth. The phenotypic trend was calculated as the linear regression of the adjusted means for given bodyweight on the years of birth (Bakir and Kaygisiz, 2009). The environmental trend was calculated as the linear regression of the year solution for given bodyweight on the years of birth.

## Results and discussion

### Non-genetic factors

Table (2) presents grand means and least-square means with their standard errors for bodyweights at birth (BWT) and weaning (WWT) according to the analysis of variance for non-genetic factors affecting these traits. For the birth weight trait, the effects of all studied non-genetic factors were significant ( $P < 0.05$ ) except the effect of  $YC$  where it was not significant ( $P > 0.05$ ) as shown in Table (1). Besides, the same results were noticed for weaning weight trait except that the effect of weight at calving was not significant ( $P > 0.05$ ).

**Table 1.** Analysis of variance for body weights at birth (BWT) and weaning (WWT) of Syrian buffalo calves in the present study.

S.O.V.	BWT			WWT		
	DF	MS	Pr> F	DF	MS	P> F
YC	10	17.730	0.4592	10	17.997	0.1020
SEX	1	93.525	0.0234	1	545.007	<.0001
PR	9	42.203	0.0140	9	25.723	0.0159
(YC)×(SEX)	10	49.717	0.0027	10	73.153	<.0001
WC	1	733.052	<.0001	1	12.448	0.2924
Residual	464	18.077		425	11.200	

YC: year of calving, SEX: sex of calf, PR: parity, (YC)×(SEX): the interaction between year of calving and sex of calf, WC: dam's weight at calving, BWT: body weights at birth, WWT: body weights at weaning.

The birth weight was affected ( $P<0.05$ ) by all studied non-genetic factors except for YC ( $P>0.05$ ). Besides, the weaning weight was similarly affected by the same factors except for weight at calving as shown in Table (1). Table (2) indicates that increased body weight is associated with lower variation in terms of standard errors. This means that birth weight had a difference over weaning weight by all of the non-genetic factors studied.

The estimated Lsmeans for BWT in this study was  $32.79\pm 2.09$  close to the estimated value of Marai et al (2001) (32.44) and less than Shahin et al (2010) (33.50) and Akhtar et al (2012) ( $35.86\pm 4.30$  kg) and more than Kantharaja et al (2018) ( $30.87\pm 1.13$ ).

The estimated Lsmeans for BWT in this study was  $32.79\pm 2.09$  close to the estimated value of Marai et al (2001), and less than Shahin et al (2010) and Akhtar et al (2012), and more than Kantharaja et al (2018), their estimates were (32.44), (33.50), (35.86), and (30.87) kg, respectively. The weaning weight grand means of the present study was  $82.45\pm 1.69$  kg. This estimate was low compared to the estimate resulted in the study of Marai et al (2001) maybe because of the difference in weaning age, but higher than the study of Thiruvankadan et al (2009), Akhtar et al (2012), Kantharaja et al (2018) and Shahin et al (2010). Their estimates were (124.3), (63.1), (66.12), and (77.28) kg, respectively.

The effect of year of calving was reported that non-significantly affect body weights in Syrian buffalo calves in the present study. This result might reflect the level of feeding, management, and environmental conditions in which the buffaloes flock was maintained. The level of feeding and management did not vary according to the ability and efficiency of the farm manager, husbandry system as well as the method and intensity of culling. It means that there was deterioration in the management system, poor environmental conditions, and lack of a good breeding system in the herd. As mentioned before, Table 1 shows that the influence of calf sex was found to be significant on weight at birth ( $P<0.05$ ) and highly significant effect on weaning weight ( $P<0.01$ ). Table (2) presents that males were heavier at the two studied ages ( $33.72\pm 0.31$  for BWT and  $84.61\pm 0.26$  for WWT) than the females ( $32.83\pm 0.32$  for BWT and  $82.36\pm 0.25$  for WWT). The increase in body weight probably arises from the increasing differences in the endocrine system between males and females (Swenson and Reece, 1990). Basu and Rao (1979), NDRI (1982), and Kumaravel et al (2004) also reported the significant influence of sex of the calf on birth weight. The study of Kantharaja et al (2018) reported the non-significant effect of sex and lower estimates of Lsmeans of males and females than the present study (male and female BWT were  $31.83\pm 1.09$  and  $29.92\pm 1.17$ , respectively; male and female WWT were  $72.44\pm 3.35$  and  $77.59\pm 3.75$ , respectively). Thiruvankadan et al (2009) reported that the adjusted birth weights of male and female calves were  $33.0\pm 0.49$  and  $31.9\pm 0.27$  kg, respectively, with a value of  $32.4\pm 0.30$  kg. Also, these estimates were close to the estimates of the present study. Usmani et al (1987) reported that birth weight averaged  $38.2\pm 0.2$  kg and bull calves were heavier at birth than heifer calves (39.0 vs. 37.5 kg) as resulted in the present study.

Parity had a highly significant effect on birth and weaning weights (Table 1). The birth weight observed in the first parity was significantly lower ( $31.28\pm 0.47$  first parity) than those observed in later parities ( $34.35\pm 0.55$ ). Generally, birth weight increased as parities progressed, maybe because of the increase of the dam's ability to care for the fetus. This increasing trend is not noticeable in weaning weight, where it could be noticed that although there is a significant effect of the parity on weaning weight, there is no specific trend of increase or decrease. The effect of weight at calving (WC) was significant on birth weight ( $P<0.05$ ), where it was not significant on weaning weight ( $P>0.05$ ). Usmani et al (1987) also reported that calf birth weight increased with the bodyweight of the dam at calving. The same result was noticed in the present study, heavier dams produced heavier calves.

The study of Thiruvankadan et al (2009) revealed that non-genetic factors such as sex of the calf and parity of the dam might be considered when performing an evaluation of calves based on growth traits. The same study

reported that the effect of parity on the production performances has been demonstrated for the commercial exploitation of this breed for meat purposes.

#### *Genetic, environmental and phenotypic trends*

Table (3) shows that the direct genetic trends from linear regression were 0.002, 0.004 kg per year for BWT and WWT, respectively ( $P>0.05$ ). The genetic trends were positive but very low and almost close to zero for the two studied traits. This result indicates that there was no significant genetic improvement in this period of the present study. The study of Mendes Machado et al (2007) reported that the genetic and phenotypic trends of BWT and WWT were 0.006 and -0.03 kg per year, respectively. Non-significant genetic trends indicate that effective selection may not have taken place for the buffalo herd over the years (Rather et al 2019). The phenotypic trends of the two traits (BWT and WWT) were 0.06 kg/year and -0.103 kg/year, respectively. The negative phenotypic trend of WWT indicated that the environment should be improved.

**Table 2.** Means and their standard errors (SE) for body weights at birth (BWT) and weaning (WWT) according to year of calving, sex and parity.

Factors	BWT		WWT	
	No.	Mean±SE	No.	Mean±SE
Grand Mean	496	32.79±2.09	457	82.45±1.69
Year of calving	2008	33.19 <sup>ab</sup> ±0.68	43	84.23 <sup>ab</sup> ±0.54
	2009	32.71 <sup>ab</sup> ±0.67	48	83.35 <sup>ab</sup> ±0.52
	2010	31.99 <sup>ab</sup> ±0.72	41	83.25 <sup>ab</sup> ±0.57
	2011	34.32 <sup>ab</sup> ±0.67	54	84.79 <sup>a</sup> ±0.53
	2012	32.94 <sup>abc</sup> ±0.65	48	83.80 <sup>ab</sup> ±0.51
	2013	33.59 <sup>ab</sup> ±0.72	36	83.12 <sup>ab</sup> ±0.58
	2014	34.07 <sup>a</sup> ±0.69	42	83.48 <sup>ab</sup> ±0.55
	2015	33.42 <sup>c</sup> ±0.70	32	83.22 <sup>bc</sup> ±0.62
	2016	32.97 <sup>abc</sup> ±0.63	34	83.62 <sup>ab</sup> ±0.60
	2017	33.12 <sup>bc</sup> ±0.67	35	81.97 <sup>c</sup> ±0.60
2018	33.66 <sup>ab</sup> ±0.64	44	83.53 <sup>ab</sup> ±0.52	
Sex	Male	33.72 <sup>a</sup> ±0.31	226	84.61 <sup>a</sup> ±0.26
	Female	32.83 <sup>a</sup> ±0.32	231	82.36 <sup>b</sup> ±0.25
Parity	1 <sup>st</sup>	31.28 <sup>c</sup> ±0.47	112	82.37 <sup>bc</sup> ±0.40
	2 <sup>nd</sup>	31.78 <sup>de</sup> ±0.50	73	83.70 <sup>abc</sup> ±0.42
	3 <sup>rd</sup>	33.09 <sup>cd</sup> ±0.59	50	83.47 <sup>abc</sup> ±0.49
	4 <sup>th</sup>	32.78 <sup>bcd</sup> ±0.71	37	83.37 <sup>abc</sup> ±0.57
	5 <sup>th</sup>	34.22 <sup>abc</sup> ±0.89	23	84.55 <sup>ab</sup> ±0.73
	6 <sup>th</sup>	33.58 <sup>abc</sup> ±0.81	28	82.63 <sup>bc</sup> ±0.68
	7 <sup>th</sup>	33.24 <sup>bc</sup> ±0.80	26	85.08 <sup>a</sup> ±0.69
	8 <sup>th</sup>	33.87 <sup>abc</sup> ±0.97	19	82.45 <sup>c</sup> ±0.80
	9 <sup>th</sup>	34.58 <sup>a</sup> ±1.14	15	84.24 <sup>a</sup> ±0.90
	10 <sup>th</sup> +	34.35 <sup>ab</sup> ±0.55	74	83.00 <sup>bc</sup> ±0.43

Having at least one identical letter means that there was no significant difference between the two means ( $P>0.05$ ). The regression coefficient on weight at calving: for BWT= 0.0238 ±0.0037 and WWT= 0.0032±0.0030, coefficient of Var. for BWT = 12.96 and WWT = 4.02. BWT: body weights at birth, WWT: body weights at weaning, No.: Number of observations.

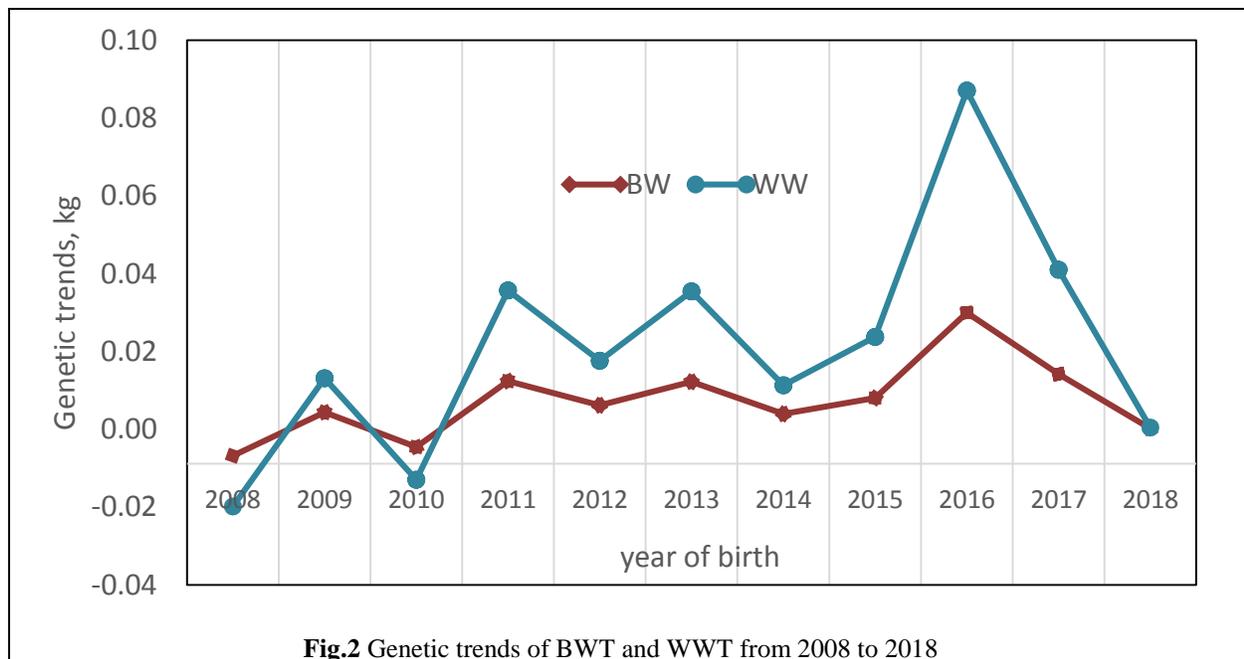
**Table 3.** Genetic, environmental and phenotypic trends for body weights (kg) at birth, BWT and weaning WWT.

Traits		Regression coefficient ± SE	P> t
Birth weight	Genetic	0.002 ± 0.001	0.1145
	Environment	0.179 ± 0.106	0.1325
	Phenotypic	0.060 ± 0.069	0.3587
Weaning weight	Genetic	0.004 ± 0.003	0.1229
	Environment	0.126 ± 0.100	0.2462
	Phenotypic	-0.103 ± 0.061	0.1284

P>|t|: the p-value is the measure of the strength of the evidence against the null hypothesis.

In general, the genetic and phenotypic trends of the two studied traits showed very few changes and were almost constant over the years examined (Table 3) which may indicate that these traits were not responded to any selection procedures or there was no selection plan for this herd. Constant BWT and WWT over the years examined can be considered a sign of adapting buffalo calves to severe weather conditions and lack of feed (El-wakil and Elsayed, 2013). Environmental trends of the two traits were of higher magnitude (Table 3) than genetic and phenotypic ones. Environmental trends for the BWT and WWT traits were positive (0.179 and 0.126, respectively with  $P>0.05$ ). The phenotypic trend was positive (0.06) for BWT. The positive phenotypic trend can be attributed to high environmental effects (Rather et al 2019). While it was negative (-0.103) and not significant ( $P>0.05$ ) for WWT indicating that there was deterioration in environmental conditions.

Figs. (2-4) show the genetic, environmental, and, phenotypic trends of BWT and WWT from 2008 to 2018. Generally, genetic trends of the two traits exhibited substantial irregular fluctuations among the examined years, which might indicate that there was no genetic improvement plan. There is a very slight upward genetic trend until 2016 in both traits, and then a sudden drop occurred (Fig. 2), perhaps due to the effect of the war in Syria. Fig. 2 shows that the curve of the genetic trend for WWT appeared to have sharper fluctuations than that of the BWT over the examined years which might reflect the inconsistent management system and exhibited the environmental influence on this trait (El-wakil and Elsayed, 2013).



The studied bodyweights showed non-significant fluctuations of environmental trends over the years examined without a clear direction (Fig. 3). This confirms the instability of environmental conditions and the absence of a good management system. The same trend was observed for the phenotypic trend for the two traits. These results confirm the need for a recording system and genetic improvement through the selection and improving the environmental conditions of the buffalo herds in Syria. These results confirm the need to improve the environmental conditions of the studied buffalo herd and the need for a recording system and genetic improvement through selection.

#### Genetic parameters

Table (4) Shows heritability estimates, genetic, environmental, and phenotypic variances of BWT and WWT and genetic, phenotypic, and environmental correlations of the two studied traits. From Table (4), the heritability of BWT was 0.19 and 0.02 for WWT. The study of Intaratham et al (2008) reported higher estimates of heritability for BWT and WWT (0.24 and 0.27, respectively). Besides, the study of Karima Shahin et al (2010) reported high estimates of heritability for the two traits (0.49 and 0.69 for BWT and weight at 9 weeks of age, respectively). Where the estimate of heritability is for BWT in the study of Salem et al (2020) was 0.06 and 0.41 for WWT. The differences between these estimates may be attributed to different breeds of buffaloes.

The estimate of heritability for BWT in the present study indicates that good prospects for improvement of this live performance trait through selection if these animals are uniformly managed and fed. The small estimate of WWT heritability may be attributed to genotype-environmental interactions and other factors. Maybe, a low estimate of heritability for this trait suggested that most of the observed variation in this trait was due to temporary environmental conditions and management (Shahin et al (2010)). The same authors suggested that good management and feeding lead to much improvement for this trait.



Fig. 3. Environmental trends of BWT and WWT from 2008 to 2018.

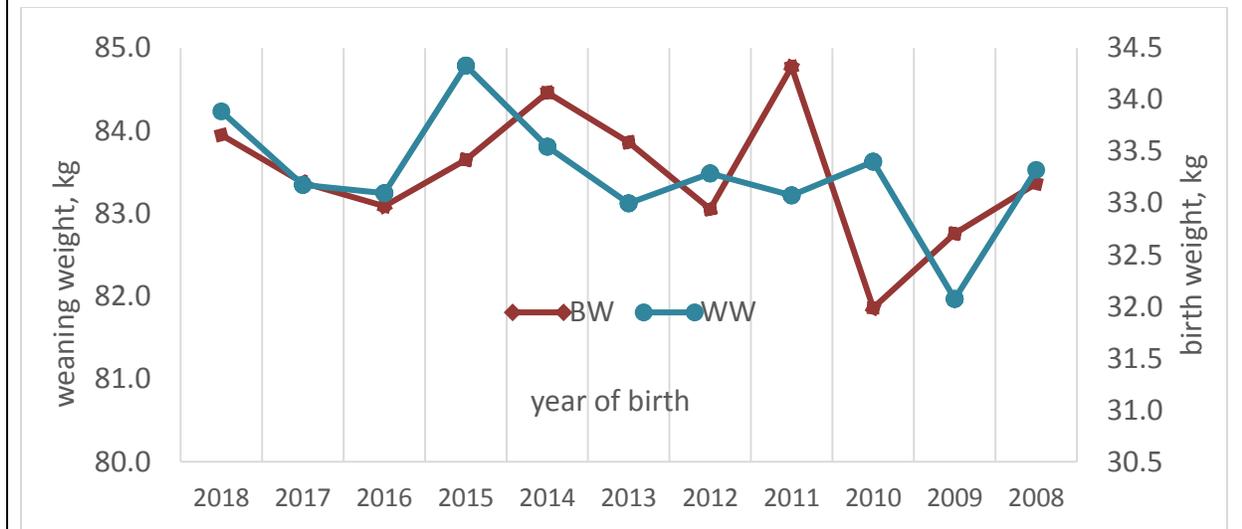


Fig. 4 phenotypic trends of BWT and WWT from 2008 to 2018

Table 4. Heritability estimates, genetic, environmental and phenotypic variances of BWT and WWT and genetic, phenotypic and environmental correlations of the two studied traits.

Trait	$h^2$	$\sigma^2_G$	$\sigma^2_E$	$\sigma^2_P$	$r_G$	$r_P$	$r_E$
BWT	0.190	3.790	16.300	20.090	0.930	0.280	0.250
WWT	0.024	0.340	13.650	13.990			

$h^2$ : Heritability,  $\sigma^2_G$ : genetic variances,  $\sigma^2_E$ : environmental variances,  $\sigma^2_P$ : phenotypic variances,  $r_G$ : genetic correlations,  $r_P$ : phenotypic correlations,  $r_E$ : environmental correlations.

In adverse of Salem et al (2020) but as reported in Shahin et al (2010) the genetic correlation between BWT and WWT in the present study was high (0.93). It means that any genetic improvement in one of these traits will improve the other. The phenotypic and environmental correlations were lower than the genetic correlation. The magnitude of genetic correlation indicates that many of the genes that control birth weight also control weaning weight in the same direction. The positive genetic association between the two studied traits suggested that selection to increase BWT would also cause some increase in WWT (Shahin et al 2010).

### Conclusion

The non-genetic factors might be considered when performing an evaluation of buffalo calves based on growth traits. Non-significant trends and very low estimates indicated that effective selection may not have taken place for this herd over the years. Therefore, the selection is recommended. Genetic parameters indicated the potential for an increase rate of genetic change with full implementation of genetic improvement programs. Breeders can use BWT to improve WWT in this herd through indirect selection according to the high genetic correlation between the two traits.

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