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Assessment of growth rate in Purebred Arabian and Barbe Foals

Evaluación de la tasa de crecimiento en potros de raza Pura Sangre Árabe y Barbo

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ABSTRACT

The main objective of this study was to assess the influence of sex, breed, month of birth, and year of birth on the birth weight and postnatal growth performance of foals raised under standardized conditions at the Chaouchaoua National Stud of Tiaret, Algeria. A total of 97 foals (69 Arab and 28 Barb) were included in the study. Only live-born foals that survived beyond six months of age were considered. All animals were reared under the same housing, feeding, and management conditions throughout the study. Data were retrospectively collected from the official birth records of the National Stud Farm for the years 2017 to 2021. The following variables were analysed birth weight (in kg), body weight at first and second weighing, average daily gain between birth and body weight at first weighing, and between body weight at first and second weighing. Weaning dates and weighing dates were also recorded. On average, the two weighing were carried out at approximately six-month intervals, allowing for the estimation of growth rates over distinct phases. Analysis of the data by foal breed revealed a highly significant difference ($P < 0.005$) in birth weight between the two groups. Arab foals had a significantly higher mean birth weight (50.76 ± 5.08 kg) compared to Barb foals (46.82 ± 5.66 kg). This study provides valuable insights into the postnatal growth patterns of foals born at the Chaouchaoua National Stud. These findings confirm that breed significantly influences birth weight and growth rate, with Barb foals outperforming Arab foals in average daily gains.

Key words: Foal growth; birth weight; arabian horse; barb horse; average daily gain.

RESUMEN

El objetivo principal de este estudio fue evaluar la influencia del sexo, la raza, el mes de nacimiento y el año de nacimiento sobre el peso al nacer y el rendimiento de crecimiento posnatal de potros criados en condiciones estandarizadas en el Haras Nacional Chaouchaoua de Tiaret, Argelia. En total se incluyeron 97 potros (69 Árabes y 28 Barbos) en el estudio. Solo se consideraron los potros nacidos vivos que sobrevivieron más allá de los seis meses de edad. Todos los animales fueron criados bajo las mismas condiciones de alojamiento, alimentación y manejo durante el estudio. Los datos se recopilaron retrospectivamente a partir de los registros oficiales de nacimientos del Haras Nacional correspondientes a los años 2017 a 2021. Se analizaron las siguientes variables : peso al nacer (kg), peso corporal en la primera y segunda pesada, ganancia media diaria entre el nacimiento y peso corporal en la primera pesada, y entre peso corporal entre la primera y segunda pesada. También se registraron las fechas de destete y de pesada. En promedio, las dos pesadas se realizaron con un intervalo de aproximadamente seis meses, lo que permitió estimar las tasas de crecimiento en fases distintas. El análisis de los datos según la raza de los potros reveló una diferencia altamente significativa ($P < 0,005$) en el peso al nacer entre los dos grupos. Los potros Árabes presentaron un peso medio al nacer significativamente mayor (50,76 ± 5,08 kg) en comparación con los potros Barbos (46,82 ± 5,66 kg). Este estudio aporta información valiosa sobre los patrones de crecimiento posnatal de potros nacidos en el Haras Nacional Chaouchaoua. Nuestros hallazgos confirman que la raza influye significativamente en el peso al nacer y en la tasa de crecimiento, con los potros Barbos superando a los potros Árabes en las ganancias medias diarias.

Palabras clave: Crecimiento del potro; peso al nacer; caballo árabe; caballo barbo; ganancia diaria media.

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INTRODUCTION

Equine breeding *(Equus caballus*) remains a major component of both economic activity and cultural heritage in many regions worldwide, particularly in North Africa, where horse populations remain relatively high because of long-standing equestrian traditions. In parallel, equine production systems are closely linked to equestrian sports and horse racing, alongside a sustained interest in the preservation and promotion of traditional disciplines such as Fantasia [1].

Seasonal reproductive timing in horses ensures that foals are born under environmental conditions that favour survival, with spring births generally offering advantages over off-season births because of reduced thermoregulatory demands and lower immune stress [2].

Early foal growth is widely recognised as a key indicator of health status, vitality, and future developmental potential. At birth, foal weight represents approximately 8–12 % of the dam's body weight. In Thoroughbred populations, mean birth weight (BW) typically centres around 55 kg, reflecting breed-specific neonatal growth potential and highlighting the importance of BW as an indicator of early development and overall fitness [3 , 4].

Foal body weight usually doubles during the first month of life, and by the time of weaning, at six to seven months of age, it reaches nearly five times its BW. This corresponds to approximately 220–260 kg in saddle horses and 300–400 kg in draft breeds, representing about 45 % of adult body weight [4]. By one year of age, this proportion increases to roughly 65 %, and by two years, foals generally attain 75–80 % of their mature body weight [5].

Growth and development in foals are influenced by a wide range of factors, including weaning age, housing conditions, nutritional management, and climatic conditions. The timing of weaning is particularly critical, as it can markedly affect postnatal growth performance [6 , 7]. In addition, sex-related differences have been reported, with fillies weighing on average 1.2 kg less than colts at birth across multiple regions, including Kentucky, the United Kingdom, and Australia, indicating a consistent effect of sex on foal BW across populations [8].

Furthermore, the season of birth plays a significant role in determining both initial body weight and subsequent growth trajectory. Foals born in spring often exhibit higher growth rates, likely due to more favourable ambient temperatures and improved pasture availability during early development. Maternal parity also influences BW, as primiparous mares tend to produce lighter foals [7 , 8].

Several studies have shown that intrinsic factors, such as breed and dam age, together with extrinsic factors including season of birth and management practices, significantly affect early growth parameters in foals [9]. Foetal size has been reported to decrease when the final phase of gestation coincides with winter months, with neonatal growth during the first three months being correspondingly lower in foals born early in the year compared with those born later in the season [10 , 11]. Moreover, maternal parity affects placental development as well as postnatal growth and metabolism, with foals born to primiparous mares remaining smaller for several months after birth [12].

The primary objective of the present study was to evaluate the influence of sex, breed, month of birth, and year of birth-on-birth weight and postnatal growth performance in foals raised under standardised management conditions at the Chaouchaoua National Stud in Tiaret, Algeria.

MATERIALS AND METHODS

The present study was conducted at the Chaouchaoua National Stud, located in Tiaret Province, Algeria. This stud farm is dedicated to the conservation and genetic improvement of native Algerian horse breeds, including the Arabian, Barb, Arab-Barb, and more recently, the Anglo-Arabian.

The facility includes well-equipped infrastructure for equine breeding, such as stables, a farriery, a Veterinary infirmary, a breeding courtyard, storage buildings for forage and equipment, and fourteen fenced pastures for seasonal grazing.

Data were retrospectively collected from the official birth records of the National Stud Farm for the years 2017 to 2021. However, data from 2019 were not available due to restricted access to the stud during the COVID-19 pandemic, as sanitary measures prevented all entry during that period. A total of 97 foals (69 Arab and 28 Barb) were included in the study.

Only live-born foals that survived beyond six months of age were considered. All animals were reared under the same housing, feeding, and management conditions throughout the study. The mares monitored in this study were between 3 and 15 years of age. However, neither maternal age nor maternal parity was considered in the analysis of their influence on foal BW or postnatal growth.

The data were compiled in Microsoft Excel® spreadsheets and included the following variables: foal identity (name, sex, breed, and date of birth), BW in kg, body weight at first (W1) and second (W2) weighing, average daily gain between birth and W1 (ADG1), and between W1 and W2 (ADG2).

Weaning dates and weighing dates were also recorded. On average, the two weighings were carried out at approximately six-month intervals, allowing for the estimation of growth rates over distinct phases. For foals older than six months, body weight was measured using a barymetric tape. The animal was restrained, and the tape was placed just behind the withers, positioned vertically across the girth line. The weight was read directly from the scale marked on the tape.

Before weaning, foals remained with their dams until six months of age, benefitting from maternal lactation. Weaning was carried out progressively: the mare and foal were first isolated together in a 10 m² stall, then the mare was removed, leaving the foal alone to adapt. When weather conditions allowed, all animals, including lactating mares, had access to grazing paddocks for a few hours daily. Stallions, however, remained in individual boxes to prevent accidental breeding and to preserve breed integrity.

The feeding regime was based primarily on barley and hay. Barley was soaked in water prior to distribution (48 hours (h) in winter, 24 h in summer) to improve digestibility. Feed was

distributed twice daily, with hay provided at 9:00 a.m. and barley at 2:00 p.m. Forage and water were available *ad libitum*. Lactating mares received 6 kg of hay and 5 kg of barley per day (d); pregnant mares were given 5 kg of hay and 4 kg of barley; stallions received 5 kg of hay and 4 kg of barley, with oats occasionally added during the breeding season. Weaned foals initially received 500 g of barley per day, progressively increased to 3 kg by the age of one year. Hay was distributed in group rations, approximately one bale per seven foals.

Between the ages of one and two years, foals were fed 5 kg of hay and 3 kg of barley per d. Pelleted feed was provided as needed, depending on the animals' physiological requirements and the stud's budget. Straw was used as bedding based on availability and need.

Health management included regular deworming and vaccination. Foals received antiparasitic treatment with Milbemycin and were vaccinated against tetanus between 4 and 6 months of age. After weaning, treatments were administered every three months. Vaccination against rabies and equine influenza began at six months of age, followed by a booster one month later, then annual revaccination.

Statistical analysis

This was conducted using IBM SPSS® Statistics version 25. A one-way analysis of variance (ANOVA) was used to assess the effect of four fixed factors, sex (male or female), breed (Arab or Barb), month of birth (January to June), and year of birth (2017, 2018, 2020, 2021) on the growth parameters, an LSD test was performed to compare the differences between categories if a significant difference is observed. Statistical significance was set at $P < 0.05$. When significant differences were detected, groups were distinguished using superscript letters in the tables. Non-significant results were interpreted as $P > 0.05$.

RESULTS AND DISCUSSION

The data obtained is reported in TABLE I for the variation between the two breeds studied. Analysis of the data by foal breed revealed a highly significant difference ($P < 0.005$) in BW between the two groups. Arab foals had a significantly higher mean BW (50.76 ± 5.08 kg) compared to Barb foals (46.82 ± 5.66 kg). However, no significant differences ($P > 0.05$) were observed between the breeds in body weight at W1 and W2, nor in average daily gains (ADG1 and ADG2), although Barb foals exhibited slightly higher mean values in ADG1 (0.69 ± 0.28 kg/d) and ADG2 (0.95 ± 0.40 kg/d) compared to Arab foals (0.56 ± 0.37 kg/d and 0.79 ± 0.53 kg/d, respectively).

Comparisons based on sex (TABLE II) showed no significant differences ($P > 0.05$) for any of the studied variables. Male and female foals exhibited comparable BW (50.51 ± 5.48 kg vs. 48.64 ± 5.47 kg), as well as similar values for body weights at W1 and W2, and for both ADG1 and ADG2.

TABLE I
Mean ± SD values of Birth Weigth, Average Daily Gain of foals variation according to foal breed

Breed	BW (Kg)	W1 (Kg)	W2 (Kg)	ADG 1 (Kg/d)	ADG 2 (Kg/d)
ARABE (n = 69)	50.76 ± 5.08**	187.22 ± 37.51	214.12 ± 44.22	0.56 ± 0.37	0.79 ± 0.53
BARBE (n = 28)	46.82 ± 5.66	180.04 ± 29.56	208.34 ± 33.08	0.69 ± 0.28	0.95 ± 0.40
Total (n=97)	49.62 ± 5.53	185.20 ± 35.45	212.45 ± 41.23	0.60 ± 0.35	0.84 ± 0.50

** Indicates a significant difference ($P < 0.005$) within the same column. (BW: Birth weight; W1: Body weight at first weighing; W2 Body weight at second weighing; ADG1 Average daily gain between birth and W1; ADG2: Average daily gain between W1 and W2)

TABLE II
Mean ± SD values of Birth Weigth, Average Daily Gain of foals variation according to foal sex

BREED	SEXE	BW (Kg)	W1 (Kg)	W2 (Kg)	ADG 1 (Kg/d)	ADG 2 (Kg/d)
Arabe	Male (n = 38)	51.85 ± 4.89	192.53 ± 35.78	218.11 ± 41.34	0.56 ± 0.31	0.79 ± 0.46
	Female (n = 31)	49.42 ± 5.07	180.71 ± 39.13	209.23 ± 47.75	0.57 ± 0.43	0.80 ± 0.61
Barbe	Male (n = 13)	46.59 ± 5.39	181.67 ± 32.73	211.62 ± 31.29	0.71 ± 0.32	0.97 ± 0.43
	Female (n = 15)	47.03 ± 6.07	178.73 ± 27.86	205.50 ± 35.40	0.67 ± 0.26	0.93 ± 0.39
Total	(n = 97)	49.62 ± 5.53	185.20 ± 35.45	212.45 ± 41.23	0.60 ± 0.35	0.84 ± 0.50

(BW: Birth weight; W1: Body weight at first weighing; W2 Body weight at second eighing; ADG1 Average daily gain between birth and W1; ADG2: Average daily gain between W1 and W2)

The month of birth did not significantly influence ($P > 0.05$) the growth performance or BW of the foals, although some numerical variations were noted. Foals born in May recorded the highest mean BW (57.13 ± 9.54 kg), while those born in January showed the highest mean body weight at W2 (228.40 ± 43.27 kg). However, due to limited sample sizes in some months (notably may and june), these differences should be interpreted with caution as shown in TABLE III.

In this work, many significant differences ($P < 0.05$) were observed between years for all variables (BW, W1, W2, ADG1, and ADG2), as indicated in TABLE IV. The foals born in 2020 had the highest BW (52.38 ± 5.66 kg) and final weights (270.75 ± 25.21 kg), but surprisingly exhibited the lowest daily weight gains (ADG1: 0.29 ± 0.03 kg/d; ADG2: 0.37 ± 0.03 kg/d). In contrast, foals born in 2018 showed significantly higher ADG1 (0.93 ± 0.40 kg/d) and ADG2 (1.33 ± 0.56 kg/d) despite having lower W1 and W2 values. The lowest mean BW was recorded in 2021 (44.85 ± 4.83 kg), which also corresponded to significantly lower W1 and ADG2 values.

TABLE III
Mean ± SD values of Birth Weigth, Average Daily Gain of foals variation according to Month of birth

Month of birth	BW (Kg)	W1 (Kg)	W2 (Kg)	ADG 1 (Kg/d)	ADG 2 (Kg/d)
January (n = 21)	47.56 ± 5.26	192.83 ± 39.71	228.40 ± 43.27	0.58 ± 0.32	0.80 ± 0.46
February (n = 26)	49.08 ± 5.66	181.40 ± 31.51	207.65 ± 38.85	0.52 ± 0.23	0.72 ± 0.32
March (n = 33)	49.92 ± 4.84	184.45 ± 35.40	208.23 ± 40.11	0.68 ± 0.38	0.95 ± 0.56
April (n = 13)	51.22 ± 5.20	181.69 ± 42.66	210.42 ± 47.97	0.54 ± 0.49	0.76 ± 0.64
May and June (n = 4)	55.46 ± 2.37	196.50 ± 20.51	208.84 ± 21.45	0.90 ± 0.40	1.23 ± 0.52
Total (n = 97)	49.62 ± 5.53	185.20 ± 35.45	212.45 ± 41.23	0.60 ± 0.35	0.84 ± 0.50

(BW: Birth weight; W1: Body weight at first weighing; W2 Body weight at second weighing; ADG1 Average daily gain between birth and W1; ADG2: Average daily gain between W1 and W2)

The results of this study reveal a significant effect of breed on BW, with Arab foals (50.76 ± 5.08 kg) being significantly heavier at birth than Barb foals (46.82 ± 5.66 kg) ($P < 0.005$). This observation confirms the influence of genetic background on neonatal mass, in line with recent findings showing that breedrelated genetic factors, along with sex and dam age, influence BW and other morphometric traits at birth in Arabian foals in Turkey [13], underlining breed-dependent differences in body mass accumulation.

The higher BW observed in Arab foals may be related to their larger mature size and higher skeletal mass compared to Barbs. This is consistent with recent findings showing that patterns of growth plate closure and skeletal maturity vary among horses, with overall development completed by approximately 2 years of age but with measurable variation in timing and rates among individuals and breeds, supporting the concept that smaller, earlymaturing breeds may differ from larger, slowermaturing types in growth dynamics [14]. Therefore, while Barb foals are often considered more precocious in development due to their smaller adult frame, the Arab breed demonstrates a stronger growth potential from birth, consistent with their more substantial morphological profile.

TABLE IV
Mean ± SD values of Birth Weigth, Average Daily Gain of foals variation according to year of birth

Year of Birth	BW (Kg)	W1 (Kg)	W2 (Kg)	ADG 1 (Kg/d)	ADG 2 (Kg/d)
2017 (n = 24)	51.55 ± 3.62^{ab}	192.17 ± 16.49^{a}	211.42 ± 19.60^{a}	0.68 ± 0.16^{a}	0.93 ± 0.21^{a}
2018 (n = 29)	49.04 ± 5.05^{b}	162.64 ± 11.52^{b}	182.64 ± 18.47^{b}	0.93 ± 0.40^{b}	1.33 ± 0.56^{b}
2020 (n = 24)	52.38 ± 5.66^{ac}	232.42 ± 22.82^{c}	270.75 ± 25.21^{c}	0.29 ± 0.03^{c}	0.37 ± 0.03^{c}
2021 (n = 20)	44.85 ± 4.83^{d}	151.75 ± 18.19^{d}	186.95 ± 22.73^{b}	0.41 ± 0.07^{c}	0.58 ± 0.09^{d}
Total (n = 97)	49.62 ± 5.53	185.20 ± 35.45	212.45 ± 41.23	0.60 ± 0.35	0.84 ± 0.50

^{a,b,c,d} Indicates a significant difference ($P < 0.05$) within the same column. (BW: Birth weight; W1: Body weight at first weighing; W2 Body weight at second weighing; ADG1 Average daily gain between birth and W1; ADG2: Average daily gain between W1 and W2)

Interestingly, despite the higher BW, Arab foals showed lower average daily gains (ADG) during both growth phases compared to Barbs. Specifically, ADG1 (from birth to first weighing) was 0.56 ± 0.37 kg/d for Arabs versus 0.69 ± 0.28 kg/d for Barbs, and ADG2 (between the first and second weighing) was 0.79 ± 0.53 kg/d for Arabs versus 0.95 ± 0.40 kg/d for Barbs. Although these differences were not marked as statistically significant in the current dataset ($P > 0.05$), the tendency suggests that Barb foals, despite their lighter BW, exhibited a faster postnatal growth rate compared to their Arab counterparts.

This pattern may be partly explained by growth efficiency rather than growth capacity alone. The Barb horse, adapted to arid and rugged environments, may exhibit more efficient resource utilization and postnatal growth compensation, especially during the early months. Furthermore, the Kentucky Equine Research Staff [15] report emphasized that ponies and smaller breeds tend to reach a higher proportion of their adult weight and size at a younger age than larger breeds, which continue growing over a longer period. These findings support the idea that Barb foals, representing a smaller-framed native breed, might undergo more accelerated growth in early stages, while Arab foals, as a more mesomorphic and larger-frame breed, sustain a steadier but longer growth curve.

Regarding body weight at W1 and W2, Arab foals maintained slightly higher absolute weights at both checkpoints (W1 = 187.22 kg; W2 = 214.12 kg) compared to Barb foals (W1 = 180.04 kg; W2 = 208.34 kg), although the differences were not statistically significant ($P > 0.05$). This confirms that while Arab foals start heavier and remain heavier overall, Barb foals tend to narrow the weight gap progressively through faster growth, as reflected in their higher ADG values.

These results highlight a dual growth pattern between the two breeds: Arab foals display a higher initial mass and consistent linear growth, while Barb foals compensate for lower BW through enhanced postnatal growth dynamics. This breed-specific growth behaviour has important implications for nutritional strategies, management timing, and genetic selection programs in equine breeding systems.

The analysis of growth performance according to sex showed no statistically significant differences ($P > 0.05$) between male and female foals for any of the measured parameters, including BW, body weight at W1 and W2, and average daily gains (ADG1 and ADG2). These findings are consistent with those of Dias de Castro *et al.* [6], who reported that the influence of sex on

growth is minimal before puberty and becomes more apparent after 12–18 months of age, when male foals tend to surpass females in weight gain and skeletal development.

In this study, although male foals exhibited a slightly higher mean BW (50.51 ± 5.48 kg) than females (48.64 ± 5.47 kg), the difference was not statistically significant. In a longitudinal study of Thoroughbred foals, body weight and linear measures (e.g., wither height) did not differ significantly between males and females through the first year of life when managed under uniform conditions [6].

These results also corroborate previous findings indicating that male foals tend to be heavier at birth than females. For instance, Pagan *et al*. [7] reported average birth weights of 56.5 kg for colts versus 55.3 kg for fillies across Thoroughbred populations in Kentucky, the United Kingdom, and Australia. Similarly, data from Turkish Thoroughbred populations suggest slightly higher average weights for male foals, consistent with the general trend of sex-related differences in neonatal mass [14]. However, in contrast, a high significant difference in body size between sexes, suggesting that such differences may depend on breed, age range, and environmental conditions was described [16].

Although the ADG were nearly identical between sexes in this study (around 0.60 kg/d during the first period and 0.83–0.84 kg/d during the second), females showed a slightly faster growth rate during the later phase. This subtle difference likely reflects the earlier skeletal and muscular maturation observed in fillies compared to colts. Recent research has shown that horses generally reach skeletal maturity by about two years of age, but females tend to mature earlier, with faster closure of growth plates and different bone-turnover patterns [17 , 18 , 19]. As a result, fillies often achieve adult size and proportions sooner than males, which may explain their transient advantage in growth velocity during the second phase.

Taken together, these findings support the hypothesis that sexual dimorphism in equine growth is minimal before puberty and that growth rate and final size diverge gradually thereafter, under the influence of sex hormones and metabolic changes. From a management standpoint, these results underline the importance of monitoring both sexes under similar conditions during the first two years, as the differences in growth remain limited and should not necessitate differentiated rearing practices during this period.

The analysis of foal growth according to the month of birth showed moderate variability in both BW and postnatal weight gains, although these differences were not statistically significant ($P > 0.05$). Nevertheless, some trends can be identified that align with known physiological and environmental influences related to seasonality and forage availability.

Foals born in May and June, although represented by very small sample sizes (n = 3 and n = 1, respectively), displayed the highest BW (57.13 ± 9.54 kg and 53.78 kg) and the most elevated ADG, especially in June (ADG1 = 1.18 kg/d, ADG2 = 1.59 kg/d). These values should be interpreted with caution due to limited statistical power, yet they may reflect the nutritional benefits associated with late gestation occurring during periods of lush spring pasture [20]. Favourable climatic conditions and the abundance of nutrient-rich forage in spring can enhance maternal nutrition, improving fetal growth and promoting better neonatal vitality.

Conversely, foals born earlier in the year, notably in January and February, exhibited lower BW (47.56 ± 5.26 kg and 49.08 ± 5.66 kg, respectively) and relatively slower ADG, particularly in February (ADG1 = 0.52 ± 0.23 kg/d, ADG2 = 0.72 ± 0.32 kg/d). These results may be explained by seasonal limitations in forage quality during the winter months, when mares are typically fed hay and concentrates, which are often lower in digestible nutrients and protein compared to fresh pasture.

This seasonal nutritional constraint has been emphasised by Robles *et al.* [21] who reviewed how reduced availability and quality of forage, particularly during winter in late-gestation mares, may compromise the nutritional support required for optimal fetal development.

Interestingly, foals born in March and April showed intermediate BW (49.92 ± 4.84 kg and 51.22 ± 5.20 kg, respectively) and moderate to high growth rates (ADG1 from 0.54 to 0.68 kg/d), suggesting that mid-gestation during winter followed by early lactation in spring provides relatively balanced conditions for both maternal and neonatal nutrition. This supports the concept that seasonal transitions, such as from late winter to early spring, provide a nutritional window that promotes more stable growth trajectories in foals. These findings are also consistent with Veronesi *et al*. [22], who showed that maternal hormonal profiles change from prefoaling to late pregnancy in response to environmental and nutritional conditions.

Such hormonal adjustments may influence gestation length and fetal development, potentially resulting in earlier parturition or suboptimal growth under adverse seasonal or nutritional circumstances, although no statistically significant differences were observed in this study ($P > 0.05$), the trends across birth months reinforce the idea that seasonal variations in climate and feed availability influence maternal nutrition, which in turn affects BW and early postnatal growth. Therefore, optimal reproductive scheduling and nutritional management of broodmares according to forage cycles could contribute to more uniform and improved growth performance in foals.

The analysis of foal growth according to the year of birth revealed significant interannual variations ($P < 0.05$) in all measured parameters: BW, body weight at W1 and W2, and ADG during both growth periods. These differences can be largely attributed to environmental conditions, particularly climatic variability and its impact on nutritional availability.

Foals born in 2020 had the highest average weights (52.38 ± 5.66 kg at birth, 232.42 ± 22.82 kg at W1, and 270.75 ± 25.21 kg at W2), yet paradoxically exhibited the lowest ADG (ADG1 = 0.29 ± 0.03 kg/d, ADG2 = 0.37 ± 0.03 kg/d). These results suggest that although the foals were born heavier and remained heavier over time, their postnatal growth rate was markedly slower, possibly due to management or nutritional constraints during this specific year.

In contrast, the 2018 cohort displayed significantly lower body weights (BW = 49.04 ± 5.05 kg; W1 = 162.64 ± 11.52 kg; W2 = 182.64 ± 18.47 kg), but had the highest growth velocities (ADG1 = 0.93 ± 0.40 kg/d; ADG2 = 1.33 ± 0.56 kg/d), suggesting compensatory growth potentially triggered by favorable nutritional recovery postnatally. This could reflect the interplay between early environmental adversity and enhanced nutritional support during lactation or pre-weaning phases.

The low BW observed in 2021 foals (44.85 ± 4.83 kg) aligns with significantly lower body weights at W1 and W2 and modest ADG values, confirming an overall subdued growth trajectory for that year. These patterns are consistent with the findings of Meliani *et al.* [3], who reported that periods characterized by reduced rainfall or elevated ambient temperatures are associated with shorter gestation duration in Arabian mares. Such environmental constraints were shown to adversely influence maternal nutritional status and placental nutrient transfer to the fetus, ultimately leading to lower BW.

These findings are also consistent with Silva *et al*. [20], who demonstrated that environmental factors, particularly thermal stress associated with high ambient temperatures and humidity, are negatively correlated with gestation length in Thoroughbred mares. Hotter climatic conditions during late pregnancy were associated with shorter gestation duration, indicating that climate-related stress can influence reproductive timing and may indirectly affect fetal development. In contrast, unfavorable weather patterns, such as those potentially observed in 2021, can reduce forage quality and delay or impair fetal development.

Similarly, the Forage quality and nutrient composition vary markedly with season, harvest time and climatic-soil conditions, such that winter conserved forages often have lower digestibility and higher fibre content compared with fresh spring growth [23].

The interannual variability in forage quality may thus explain some of the year-to-year differences in both BW and growth rates observed in this study. These results suggest that fluctuations in climatic and nutritional conditions across years can strongly influence fetal development and early postnatal growth.

Similar findings were reported by Hacan *et al*. [12], who demonstrated that birth year had a significant effect on foal body measurements at birth, reflecting environmental and management variations. Likewise, Silva *et al*. [24] emphasized that climatic conditions and annual differences in feeding resources are important determinants of gestation length and early-life performance in mares. Collectively, these observations confirm that the year of birth serves as a reliable proxy for environmental and nutritional contexts, reinforcing the importance of adaptive feeding strategies and systematic pasture monitoring to ensure consistent growth performance in equine breeding systems, particularly under increasing climate variability.

CONCLUSION

This study provides valuable insights into the postnatal growth patterns of foals born at the Chaouchaoua National Stud, with particular attention to the effects of breed, sex, birth month, and birth year. These findings confirm that breed significantly influences BW and growth rate, with Barb foals outperforming Arab foals in ADG.

Sex showed no significant effect before puberty, although females demonstrated slightly faster growth—consistent with known precocity in fillies. The influence of the birth year highlighted the impact of environmental and climatic variability, with dry years altering growth trajectories. Month of birth also contributed to fluctuations in weight and growth, likely due to seasonal feed quality. These variations emphasize the multifactorial nature of equine growth and the importance of adapting management strategies.

Optimizing nutritional intake and environmental conditions could enhance developmental outcomes. This study contributes to improving breeding programs and developing evidence-based rearing practices. Future research should explore genetic markers and long-term performance implications of early growth profiles.

Conflict of interest statement

All authors have declared no conflicts of interest.

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