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Pregnancy Length, Offspring Weight and Birth Outcomes in Alpaca (*Vicugna pacos*): An International Survey

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ABSTRACT

Alpaca gestation lasts approximately 11.5 months, but significant variation exists, and contributing factors are poorly described. This study aimed to conduct an international survey to assess pregnancy length (PL), based on geographical location. When available, the survey collected data on embryo transfer, dam and sire identity, maternal age, offspring sex, and time of birth. These variables were analyzed for their potential effects on PL, cria weight (CW), and parturition complications such as dystocia. Data from 7049 worldwide pregnancies were analyzed. The global median PL was 346 days (range: 270–428; coefficient of variation: 3.37%), with 50% of pregnancies between 339 and 353 days. Median birth time was 11:30 AM (range 0:30 AM–11:30PM). Northern hemisphere had longer PL ($p < 0.0001$, 345.9–346.7 vs 344.3–345.1 days, $n = 7049$), that depended on the country ($p < 0.0001$). Fetal sex had no impact, but embryo transfer slightly tended to increase PL ($p = 0.0918$). While effect of the dam had no influence, the sire and the maternal age did ($p < 0.0001$; $p = 0.0039$). No correlation was found between PL and CW, though season and maternal age influenced both in the northern hemisphere ($p < 0.0001$ for both). Maternal age also affected CW ($p < 0.0001$). Dystocia rates were not affected by CW, but longer PL slightly tended to increase dystocia risk ($p = 0.0798$). This survey confirms the median pregnancy length of 346 days and suggests explanations for the wide variability in PL and CW, as sire, dam age, season, and location.

1 | Introduction

Alpaca (*Vicugna pacos)* is a domesticated Bactrians, like camels or llamas. It belongs to the artiodactyls order and the tylopods sub-order, which includes the species with pads on their two toes. Alpacas originate from Peru, where they were primarily bred for the quality of their fibre. Today, they are also kept as pets, used in animal-assisted therapy or employed for eco-grazing in Europe, North America or Oceania.

As observed in other Bactrians, ovulation in female alpacas is induced by mating (Riveros et al. 2010; Vaughan and Tibary 2006). Alpacas can mate and give birth throughout the year (Smith et al. 1994), but female receptivity decreases and matings become shorter and less frequent during spring in the Southern Hemisphere (Pollard et al. 1995). In New Zealand, lower pregnancy rates are reported in spring (59.1%) compared to autumn (66.4%) (Davis et al. 1997). The breeding season in the Southern Hemisphere begins in November and ends in April, aligning

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with the improved quality of pasture necessary for milk production and offspring development (San-Martin et al. 1968).

The average duration of alpaca pregnancy is around 11.5 months (343 days), though extreme variations have been reported (Whitehead 2009a, 2009b), with lengths ranging between 316 and 367 in Australia (Vaughan et al. 2003; Vaughan and Tibary 2006), and between 320 and 400 days in Northern America (Tibary, Rodriguez, and Sandoval 2008). Such variability in pregnancy length (PL) has also been observed in dromedaries (Nagy and Juhasz 2019) and equids (Davies Morel et al. 2002; Ewert et al. 2018; Kuhl et al. 2015; Valera et al. 2006). While some factors influencing PL are known in these species, they remain poorly described in alpacas. One study from New-Zealand reported that pregnancies ending in spring were 12.5 days longer than those ending in autumn (Davis et al. 1997), indicating a seasonal effect on PL. Other factors known to modulate equine PL like fetal sex, age of the dam, and sire (Ewert et al. 2018; Kuhl et al. 2015; Rodrigues et al. 2020; Valera et al. 2006) have not yet been studied in alpacas. Alpacas also seem to prefer giving birth during sunny days. In their natural environment (South America), 93.5% of births occur between 7 A.M. and 1 P.M., with no deliveries observed at night (Vaughan and Tibary 2006). This suggests that external stimuli may influence the onset of parturition, as seen in horses, where stress can delay foaling (Nagel et al. 2020).

On the other hand, the relationship between PL and the offspring (named cria) weight at birth (CW) remains unclear. Offsprings born in autumn have been reported to weigh 1 kg more than those born in spring, with an average weight of 7.7 kg in a Peruvian report (Bravo et al. 2009) and of 8.3 kg in a Chilian study (Burton et al. 2003). The birth weight of crias is significantly higher if the dam is older than 12 years, when compared to dams aged 2 to 5 years (Bravo et al. 2009). Other factors potentially influencing CW, like sire, sex, embryo transfer are yet to be identified. The CW could also increase the risk of dystocia, particularly due to feto-maternal disproportion, and the rate of stillbirth. While such complications are rare in alpacas—with fewer than 5% of births requiring human intervention (Tibary, Rodriguez, and Sandoval 2008; Tibary, Rodriguez, Walker, and Anouassi 2008) - identifying predisposing factors could help in better monitoring high risk pregnancies.

Using a survey collecting worldwide data from alpacas' breeders, this study aims to describe the geographical, seasonal, gestational, maternal and paternal factors associated with PL and CW. The effects of the PL and CW on dystocia and stillbirth were also investigated.

2 | Material and Methods

2.1 | Design and Diffusion of the Survey

Promotion of the survey was made using worldwide specialised groups dedicated to alpaca breeders on social networks. Breeders were invited to express their interest in participating in a study on PL in alpacas. In case of interest, the breeders were then contacted to determine if their retrospective data documented sufficient items. If they were unable to provide the localization of the farm, dates of last mating and parturition, the survey was not sent to them. When such data were available in the breeder's records, additional questions on general breeding practices—such as mating procedures or pregnancy diagnosis policies- were also investigated and the link leading to the survey was sent by email.

On a worksheet, breeders were instructed to complete one line per pregnancy that occurred in their farm, since the year 2000. Besides the breeding farm, its country, last mating and parturition dates (4 main questions), the survey also collected secondary data, when available: CW at birth, whether the pregnancy resulted from embryo transfer (ET) or not, name (identity) of the dam to determine a maternal effect on PL or CW and her age to determine an effect of maternal age on PL or CW, name (identity) of the sire to determine a paternal effect on PL or CW, offspring sex, dystocia (including C-section, when applicable), and neonatal viability. The approximative time of birth ($\pm$1 h) was also asked, when available (for a total of 9 optional questions). When these data were not available, breeders could select a box 'absence of data'. The complete file sent to the breeders is available as additional material.

2.2 | Statistics

Statistical analyses were performed using Graphpad Prism (version 9.0 for Mac OSX, Graphpad Inc., San Diego, USA), and statistical significance was established at $p < 0.05$, whereas $p < 0.1$ was reported as a statistical trend. Normal distribution of data was assessed with *the Kolmogorov-Smirnov test*. When data were distributed normally, Welch corrected t-test or one-way Brown-Forsythe ANOVA models were used. *Mann–Whitney* or *Kruskal-Wallis tests* were used for non-normally distributed data. Results are expressed as mean ± standard deviation or as median with minimum and maximum values if they are not normally distributed. Chi-square test was used to assess associations between discontinuous data.

Lack of convergence was observed for a general mixed-model effect including all parameters:

$$\begin{aligned} &\text{PL} \sim \text{Intercept} + \text{Hemisphere} + \text{Country} + \text{Breeder} + \text{Month of Birth} \\ &+ \text{Fetal Sex} + \text{Embryo Transfer} + \text{Paternal effect (Name of the Sire)} \\ &+ \text{Maternal Effect (Name of the Dam)} + \text{Mother Age.} \end{aligned}$$

This can be explained by the lack of answers to the optional questions described above and by the association (collinearity) between parameters such as country, breeder and hemisphere. Thus, several Least Squares Multilinear Regressions models were performed to determine the primary effects influencing PL:

- PL ~ Intercept + Hemisphere + Month of birth + Fetal Sex;
- PL ~ Intercept + Country + Month of birth + Fetal Sex;
- PL ~ Intercept + Paternal effect (Name of the Sire) + Maternal effect (Name of the Dam);
- PL ~ Intercept + Father + Fetal Sex;
- PL ~ Intercept + Mother Age + Fetal Sex.

Individual models were then performed to confirm the main factors identified by these models and to use post-tests to spot the differences between groups. *Mann–Whitney test* was used to compare PL between hemispheres. Kruskal-Wallis test with Dunn's post-test was applied to assess PL differences across countries and months of birth. A Mann–Whitney test was performed to observe the difference in PL for the offspring sex and ET effects. Of the males documented, only those siring more than ten offsprings were included in the analysis of paternal effects with a one-way Brown-Fortsythe ANOVA. Maternal effect was studied on dams with more than 7 pregnancies recorded in this study using *Kruskal-Wallis test with Dunn's post-test*. The mothers were also split into 2 categories according to their age: below or equal to 6 years ($\leq$6 y) or above 6 years (> 6 y). As ten individual models (including those addressing PL effect on dystocia and stillbirth) were used to investigate the effects on PL, Bonferroni correction was applied, and threshold of significance was adjusted to a q value of 0.005. The lunar cycle was investigated by dividing the births into two groups (less than 50% of moon light and more than 50% of moon light) and using a *Chi-square test* to compare them with a random distribution.

Cria weight at birth was recorded, but because of small data numbers in some subgroups (e.g., southern hemisphere), the general model did not converge, and only one Least Squares Multilinear Regressions was performed to determine the main effects influencing CW in the Northern Hemisphere: CW ~ Intercept + Mother Age + Fetal Sex. Differences in CW were investigated across months of birth in both hemispheres using *Kruskal-Wallis tests*. The effect of dam age and embryo transfer were analysed using the *Mann–Whitney test*. As six individual models (including those addressing CW effect on dystocia and stillbirth) were used to investigate the effects on CW, Bonferroni correction was applied, and threshold of significance was adjusted to a q value of 0.0083.

When available, data on birth type, eutocia or dystocia (defined as the necessity of human intervention), were recorded, as well as a C-section. Fetal viability at birth and potential stillbirth were also recorded, when available. Differences in PL and CW were investigated for eutocia, dystocia, C-section and stillbirth using Least Squares Multilinear Regressions (PL ~ Intercept + Fetal Sex + Dystocia + C-Section + Stillbirth; CW ~ Intercept + Fetal Sex + Dystocia + C-Section + Stillbirth). A difference in CW between dystocia and eutocia groups was further investigated with the *Mann–Whitney test*. In case of dystocia, an additional sub-question was addressed to determine the cause. Differences in PL and CW between stillbirth and viable offsprings were investigated using the *Mann–Whitney test*.

3 | Results

3.1 | Survey Answer and Breeders' Description

Ninety-seven breeders expressed interest in this study, however only 48 (50.52%) provided the minimum required information for inclusion. The selected breeders contributed 7049 pregnancy records between 2002 and 2024, spanning both hemispheres. The geographical distribution of the answers to this survey is summarised in Table 1.

Most breeders assessed female sexual receptivity and managed matings in 20 square meters paddocks by introducing the male to the female, as previously described (Pollard et al. 1995), with some breeders assisting the male with penis intromission. Breeders used the “spit-off” method consisting in introducing the male in the presence of the female in the paddock every 7 days over a 21 to 60-day period. Female rejection behaviour -spitting or kicking 7 days after mating was considered as a sign that ovulation occurred, and a second reject at day 14 was taken as confirmation of corpus luteum activity. This method allowed breeders to precisely record the mating dates. A transabdominal ultrasonography was performed after two or 3 months to confirm pregnancy in most breeding farms.

TABLE 1 | Geographical repartitions of breeding farms and pregnancies.

Northern Hemisphere			Southern Hemisphere		
Country	**Farm number**	**Reported pregnancies number**	**Country**	**Farm number**	**Reported pregnancies number**
Germany	2	461	Australia	6	2410
Belgium	5	225	New-Zealand	2	162
Finland	1	110			
France	5	390			
Ireland	1	70			
Netherlands	1	366			
U.K.	14	2984			
U.S.A.	5	146			
Austria	1	16			
Canada	4	600			
Estonia	1	60			

3.2 | Pregnancy Length

The worldwide median pregnancy length was 346 days (Range: 270–428, coefficient of variation: 3.37%, without information about the offspring survival for the pregnancy lasting 270 days). Half of the pregnancies lasted between 339 to 353 days. The median time of birth documented for 405 pregnancies was 11:30 A.M. (Range: 12:30 A.M.—11:30 P.M.; $n = 405$), with no significant difference between northern and southern hemispheres.

Fetal sex was reported for 6815 pregnancies and had no effect on PL. Neither hemisphere nor dam age influenced the observed sex ratio of 0.986 males per female. No twin pregnancy was reported. Embryo transfer was performed in 129 pregnancies and showed a tendency ($p = 0.0918$) to increase the gestation length compared to natural conceptions reported in the form ($n = 1725$). The father showed an effect on PL ($p < 0.0001$; $n = 2708$), with differences of up to 16 days in PL observed between the 68 sires included, whereas no maternal effect was observed with the 76 dams included ($n = 627$). Age of the mother was recorded for only 3224 pregnancies, and older dams (> 6 y) had a median PL 1 day shorter than the younger ($p = 0.0039$).

Pregnancy length was slightly longer in the northern hemisphere (346 days) compared to the southern hemisphere (345 days; $p < 0.0001$). In the northern hemisphere, births have been recorded throughout the year, with the majority (63.61%) occurring in northern summer, between June and August. Pregnancy length was increased ($p < 0.0001$) when birth occurred during the late spring months (see Figure 1) and also varied ($p < 0.0001$) between different countries in the northern hemisphere. In the southern hemisphere, 60.4% of births occurred during the summer months—December, January, and February. A significant effect of the parturition month on the pregnancy length was observed (Figure 1; $p < 0.0001$). The effect of the lunar cycle was also investigated on 2535 records, but no significant difference was observed between periods of low and high moon light ($n = 2535$).

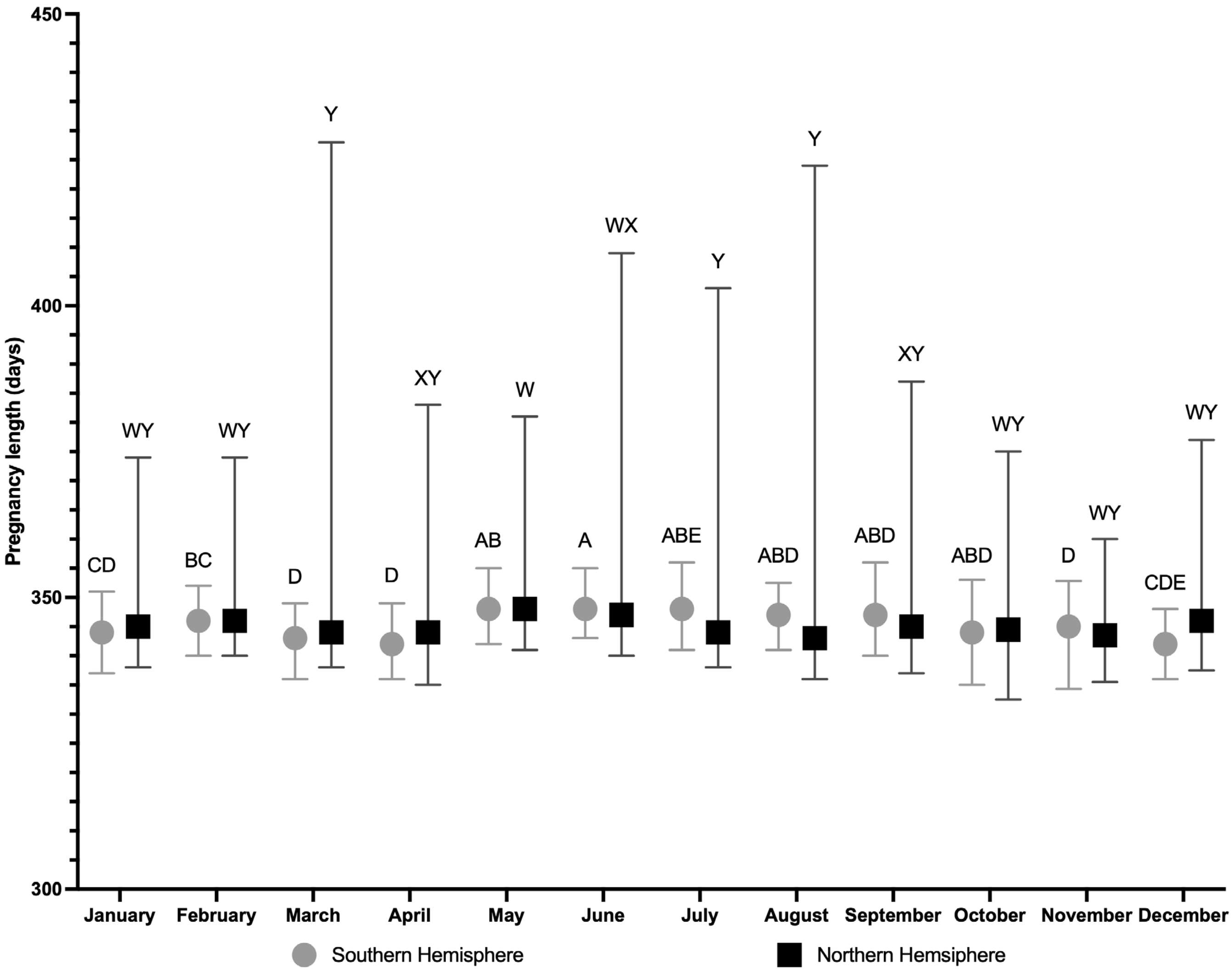

FIGURE 1 | Pregnancy Length (in days) according to the month of birth in the Northern and Southern Hemisphere. Dots or squares represent the median of pregnancy length (in days) in respectively southern and northern hemisphere. Whiskers represents quartile 25 and 75 of pregnancy length. Values of southern hemisphere with different letters(A, B, C, D) are statistically different ($p < 0.05$). Values of northern hemisphere with different letters(W, X, Y, Z) are statistically different ($p < 0.05$).

3.3 | Weight of the Crias

The weight of 2708 alive and stillborn crias was recorded, with a median of 7.6 kg (range:3.0–17.7 kg) and 75% weighed less than 8.4 kg. The lightest surviving offspring reported weight was 4.4 kg. Newborn males tended ($p = 0.0168$, q-value = 0.0083) to be heavier (median = 7.6 kg) than females (7.5 kg). No correlation was observed between PL and CW. However, dam age had a significant effect on CW ($p < 0.0001$) with dams younger than 6 years giving birth to heavier offsprings (7.8 kg) compared to those older than 6 years (7.4 kg). No effect of ET was observed on CW. In the northern hemisphere, month of birth influenced CW ($p < 0.0001$), with the heaviest offsprings observed during summer, in July, August and September (Figure 2). The number of CW records from the southern hemisphere was too low to perform a comparable statistical analysis.

3.4 | Birth Complications

Assistance from the breeder or the veterinary surgeon was required in 63 births of the 860 parturitions documented (7.33%). Of these 63 cases, four dystocia led to a C-section (6.35%), yielding an overall C-section rate of 0.8%. Reported causes of dystocia were abnormal fetal presentation, position or posture, uterine inertia or torsion, feto-maternal disproportion or fetal abnormalities. No difference was observed in CW between dystocia and eutocia groups, whereas dystocia tended to be observed more frequently in longer pregnancies ($p = 0.0798$ q-value = 0.005, 349 days vs. 347 days for eutocia). Fetal sex was not associated with dystocia incidence.

Stillbirths were reported in 4.27% of cases, with 71 stillborn offsprings among the 1663 records that included viability information. There was no difference in stillborn rates between hemispheres. There was no significant difference in CW between stillborn and live offsprings. However, PL was significantly shorter in stillbirths (median 339 days) compared to live births (median 346 days; $p = 0.0069$, q-value = 0.0083). The incidence of stillbirth did not differ between younger (< 6 years) and older (> 6 years) dams.

4 | Discussion

To the best of our knowledge, this is the first survey to compile such a large number of alpacas pregnancy records, including pregnancy length, offspring weight and birth complications. The observed median PL (346 days) was slightly longer than reported in previous studies, which were based on smaller sample sizes and conducted in Peru with 341,6 days or Australia with 343 days (San-Martin et al. 1968; Vaughan et al. 2003; Vaughan and Tibary 2006). Half of the PL reported fell within the 339 to 353 days range, but observed extremes (270 to 428 days) were wider than in previous studies, which were not mentioning if extreme situations were taken into account (325 to 358 and 316 to 367) (San-Martin et al. 1968; Vaughan et al. 2003; Vaughan and Tibary 2006). Several factors highlighted below, such as season, geographical localisation, sire, age of the dam, explains a part of this variation. Misclassification of some abortions as very short pregnancies by breeders might however explain the unusually short PL observed in some of the reported gestations, as the offspring survival was not reported in these cases. The coefficient of variation based on our survey data is 3.37%, which is consistent with previous studies that included only 34 pregnancies

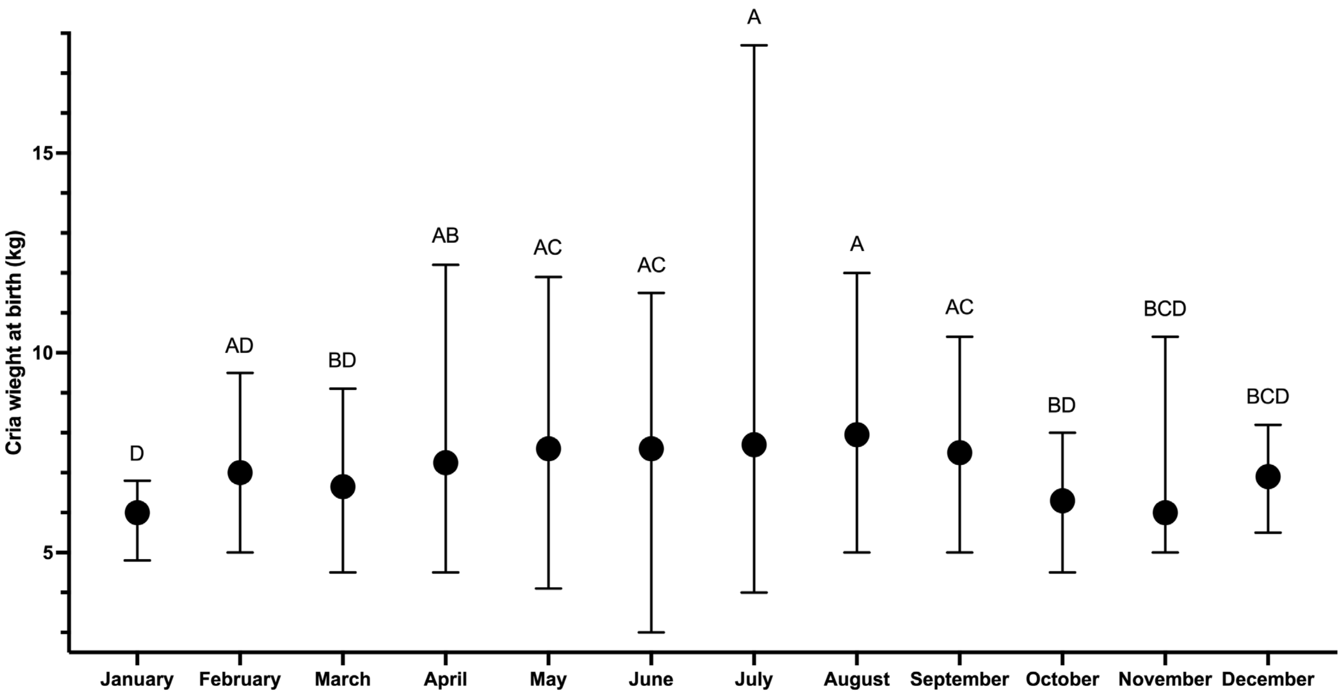

FIGURE 2 | Cria Weight at birth (in kg) according to the month of birth in the Northern Hemisphere. Dots or squares represent the median of cria weight (in kg) in Northern Hemisphere. Whiskers represents quartile 25 and 75 of offspring weight. Values with different letters$^{(A, B, C, D)}$ are statistically different ($p < 0.05$).

(Vaughan et al. 2013). Variation of PL in alpacas is higher than in dogs, cats, rabbits, pigs, sheep and camels (1.4% to 3.2%) (Heck et al. 2018) and only horses are currently known to have similar PL variation, from 2.84% to 3.3% for Arab and Spanish thoroughbreds, respectively (Valera et al. 2006).

Our data do not show any influence of fetal sex on PL, which is consistent with a previous study including 162 alpaca gestations (Davis et al. 1997), and with observations of 4248 dromedaries pregnancies (Nagy and Juhasz 2019). Camelids seem to differ from horses, where a male fetus can extend the pregnancy by up to 7 days (Ewert et al. 2018; Kuhl et al. 2015; Valera et al. 2006; Wilsher and Allen 2003), which could be explained by the specific equine feto-placental endocrine interaction (Conley 2016; Conley and Ball 2019; Ledeck et al. 2022). The male-to-female ratio documented in this survey contrasts with the 51.5% male ratio reported in dromedaries. Neither hemisphere nor dam age showed an influence on sex ratio, in contrast to horses, where sex ratio has been shown to vary with mare's age (Santos et al. 2015).

Data collected in this survey also tended to show a two-day increase in PL after ET, in contrast to findings in cows (King et al. 1985; Lopes et al. 2020) where no such effect was observed. If these data are confirmed in alpacas, the recipient's endometrium reception of the embryonic could be delayed in case of ET, as this signal appears to be mediated by embryonic estradiol production in llamas (Rossetto et al. 2023). Data from this survey showed that mothers older than 6 years have a one-day shorter PL than younger ones, unlike what happens in mares, where PL increases with age (Ewert et al. 2018; Rodrigues et al. 2020). This discrepancy warrants further investigation into the placental and uterine development and degeneration associated with aging (Beythien et al. 2017; Bravo et al. 2009; Haneda et al. 2021; Wilsher and Allen 2003). In our dataset of 76 dams with more than seven registered pregnancies, no maternal effect (maternal identity) on PL was spotted, whereas there was a sire effect (identity of the father), with substantial differences observed in PL medians between males. Similar paternal effects have also been reported in dromedaries (Nagy and Juhasz 2019) and for the breed of the sire in cattle (Fouz et al. 2013; Inoue et al. 2017), but remains discussed in the horse with some studies pointing a stallion effect (Rodrigues et al. 2020; Satue et al. 2011) and others not (Aoki et al. 2013; Davies Morel et al. 2002; Ferreira et al. 2016). The effect of the male on placental endocrine activity, fetal development, and onset of parturition deserves further investigation and comparison between new world camelids and other species.

Geographical location influenced PL in alpacas not only between hemispheres, but also within the same hemisphere, with differences observed even among northwestern European countries sharing similar photoperiod and climate. This country effect on PL probably relies on breeding farms practices and specificities (e.g.,: altitude, food complementation, housing during the winter…), but should be further investigated, as these data were not available in our survey, as a limitation. According to our data, the month of birth and the season influence the PL in both hemispheres. Early autumn in the southern hemisphere (February, March and April) is associated with a three to five-day shorter pregnancy than in September (early spring). Similarly, up to 12 days of PL difference was observed in New Zealand between births of fall and spring (Davis et al. 1997). Pregnancies in the northern hemisphere were shorter when birth was observed in autumn when compared to spring and summer, as observed in horses, where pregnancy is longer when foaling occurs in March when compared to July (Malinska et al. 2019; Rodrigues et al. 2020). Additional blue LED light on one mare's eye during pregnancy has been showed to decrease PL (Lutzer et al. 2022): this partially explains this effect in horses and should be investigated in alpacas.

Additionally, our survey also showed that CW at birth increased during the northern hemisphere summer and declined in autumn and spring, whereas PL peaked earlier, in May, further supporting the lack of correlation between PL and CW in alpacas. These findings are also further in line with reports of lighter dromedary calves being born during winter (Nagy and Juhasz 2019). The role of melatonin should be further investigated in alpacas, as it is secreted during the night and known to be involved in fetal growth. Melatonin receptors have been identified in the foetuses of seasonal species such as sheep and elk (Rowell and Shipka 2009; Torres-Farfan et al. 2008), suggesting a potential regulatory function worth exploring in this context.

Photoperiod and specifically daylight appears critical for the onset of parturition in alpacas (Knight et al. 1995). The median time of birth observed in this survey was 11:30 A.M. in both hemisphere, and mainly occurring between 10:00 A.M. and 1:00 P.M. In a previous Australian study, including lower numbers of alpacas (Vaughan et al. 2003; Vaughan and Tibary 2006), earlier median parturition time was reported (9:00 A.M.). However, breeding management practices, as housing mothers inside before birth, could also have influenced our findings. In dromedaries, most of births also occurred during the day, between 2:00 and 3:00 P.M. (Nagy and Juhasz 2019). Since camelids do not lick their offspring or consume the placenta, giving birth during the middle of the day appears to be critical for the offspring to dry its coat, locate the udder, and potentially move away from the birth site (Bravo et al. 1994; Bravo et al. 2009). Previous studies in alpacas have reported that the early onset of parturition is triggered by the onset of the darkness rather than by sunset itself (Knight et al. 1995), and housing the late pregnant alpacas inside could interfere on this parameter. It has also been suggested that camelids can delay parturition under adverse conditions (Aba et al. 1998). Supporting this, some alpacas' breeders in our survey reported births occurring just after rainy morning or even following a brief shower. A similar ability to delay the onset of parturition has been observed in mares (Ferreira-Dias et al. 2013), although in the equine, stress appears to play a more significant role than the photoperiod or weather (Nagel et al. 2020). Investigating the endocrine (especially melatonin) profiles of prepartum alpacas could help determine whether stress, weather or photoperiod are involved in this response.

There is a common belief that the moon could influence the increase in births in several species. This hypothesis has been extensively studied in humans, and the results show a lack of influence (Marco-Gracia 2019; Arliss et al. 2005). However, a recent study conducted in Japan (Yonezawa et al. 2016), used retrospective data from 428 calvings in Holstein cattle over a three-year period. The results showed that spontaneous calvings increased uniformly from the new moon to the full moon and then decreased in the same way thereafter. Our study in alpacas however failed to show significant difference between periods of high and low lunar illumination.

The median offspring weight reported in our survey was consistent with previous findings from Peru (Bravo et al. 2009). Similarly, the trend for a difference in CW between male and female offsprings aligns with earlier results (Davis et al. 1997). Our data also indicated that CW decreased with older mothers, which corresponds with our findings on PL. This is however in contradiction with previous reports suggesting that CW was increasing with the dam's age (Bravo et al. 2009). Further studies under controlled conditions are needed to confirm or refute this observation.

Offspring weight and fetal sex ratio did not differ between eutocic or dystocic parturitions, supporting the low incidence of feto-maternal disproportion compared to abnormalities in fetal presentation, position or posture (Anderson and Whitehead 2009). Our survey also indicated a tendency for dystocia to occur following longer pregnancies that should be further confirmed, highlighting the need for further investigation into the mechanisms regulating the onset of parturition in alpacas, with a particular emphasis on myometrial activity. In our survey, the overall rate of dystocia was 7.3%, markedly higher than the 1.6% reported in a Southern American study involving 1660 births (Anderson and Whitehead 2009). This discrepancy may be attributed to the broader definition of dystocia that had to be used in this survey dedicated to breeders—as any birth requiring human intervention—which could include cases where breeders intervened prematurely due to stress or inexperience. The veterinary reports were unfortunately unavailable for each case of dystocia and breeders' records were the only information available, as a limitation of the study. The incidence of C-section was very low (0.46%), consistent with North American reports describing that this procedure is performed in less than 5% of camelids births (Tibary, Rodriguez, and Sandoval 2008).

Stillbirths accounted for 2.7% of cases in our survey, compared to 6% reported in the literature (Bravo et al. 1994; Bravo et al. 2009). Offspring weight did not differ between live and stillborn births, contrasting findings in dromedaries, where stillborn calves are typically lighter (Nagy and Juhasz 2019). However, CW was only recorded for 10 of the stillborn cases in our survey, limiting the strength of this comparison. Our data also showed shorter PL in stillborn cases compared to live births. A similar pattern has been observed in dromedaries (Nagy and Juhasz 2019), where shortened gestation was linked to fetal stress triggering parturition, but this could reflect misclassification by breeders-confusing stillbirths with abortion.

5 | Limitations of the Study

This study is based on survey data and therefore relies on the accuracy of breeder records. Participants were however selected based on the documented quality of their record-keeping prior to inclusion, what could induce a second bias: the good student effect. The dataset received for this study is coming from the best managed alpacas' breeding farms, inducing some biais, e.g., the high rate of human intervention during birth, leading to a high rate of dystocia. Thus, some categories—such as dystocia vs. eutocia, or stillbirths vs. abortion, depending on the breeder's experience, but not on veterinary reports—should be carefully interpreted as they may introduce a degree of misclassification. Some additional data about breeding farm specificities and management, such as altitude, food complementation, housing during the winter or housing of the ready to give birth dam should be collected in the future to give new insights to the upcoming studies investigating alpacas' pregnancy. Some continents are also underrepresented, such as Asia and Southern America, what is regrettable for alpacas, where they are originating from: answers from these countries were very scarce and data were leaking, limiting their use in the present report. Additionally, different scales used to measure the offspring weight may have introduced minor measurement bias, although this was considered negligible.

6 | Conclusions

This international survey, based on over 7000 alpaca pregnancies, confirms a median pregnancy length of 346 days in alpacas and underscores the wide variability in gestation length and offspring birth weight, while offering suggestions for the primary contributing factors: sire effect, dam age, season, and geographic location. Some other factors like altitude, nutrition and housing should however be further investigated. Unlike other domestic species, the absence of fetal sex influence on gestation duration or birth weight suggests species-specific endocrine dynamics in camelids. The consistent timing of parturition during hours of daylight further indicates a strong environmental sensitivity, particularly to photoperiod, aligning alpacas more closely with other photoperiod-responsive species like equids.

These findings open valuable avenues for improving reproductive management in alpaca herds through a more tailored approach, considering individual and environmental characteristics. Future investigations should delve deeper into the sire effect on gestational development, the uterine changes associated with maternal aging, and the endocrine mechanisms that regulate parturition onset. By revealing the complex interplay of physiological and environmental factors governing alpaca reproduction, this study lays the groundwork for advancing evidence-based practices in camelid husbandry.

Author Contributions

Jérôme Ponthier: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, software, supervision, writing original draft, writing review and editing. **Marc Lambert:** conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, writing original draft, writing review and editing. **Sophie Egyptien:** methodology, writing review and editing. **Alexandra Salciccia:** methodology, writing review and editing. **Joy Ledeck:** methodology, writing review and editing. **Stéfan Deleuze:** methodology, writing review and editing. **Vincent Frisée:** data curation, formal analysis, validation, methodology, writing original draft, writing review and editing. **Geoffroy de la Rebière:** formal analysis, investigation, methodology, writing review and editing.

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Ethics Statement

The study is a survey, not leading to animal manipulations. All alpacas' breeders consented for their data to be used in this report, and data were anonymized by the principal investigator directly after reception by replacing the name of the breeding farm with a number.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that supports the findings of this study are available in the Supporting Information of this article.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** Supporting Information