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Elephant Gestation: Insights Into Idiopathic Abortions and Stillbirth

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ABSTRACT

The declining African and Asian elephant populations emphasize the importance of a backup population. Successful reproduction in captivity plays a key role in maintaining such a genetically diverse ex situ population but is challenged by reproductive loss in the form of abortions and stillbirths. The elephants' biphasic prolactin pattern led us to predict a higher incidence of abortions during the time of reduced prolactin concentrations. Therefore, this study focuses on the identification of months during elephant gestation which are prone to loss of pregnancy. A metric was developed to identify the fetal age of aborted calves based on the fetal mass using a regression model. Data on idiopathic abortions in captive and wild elephants collected from zoos, tourist camps, semi-captive, and free-ranging populations since 1974 were analyzed, revealing a significantly higher prevalence of abortions during the 15th and 17th month of gestation. Additionally, the prevalence of stillbirths in the 22nd month of gestation between 2000 and 2023 was assessed. Although stillbirths showed a declining trend over time, the average prevalence between 2019 and 2023 was still 2.8%. Consequently, the 15th, 17th, and 22nd month of gestation were identified as stages prone to pregnancy loss. These findings underscore the necessity of researching risk factors and preventative measures for pregnancy loss in these 3 months, especially exploring a possible link with prolactin during the 15th and 17th month of gestation. The identification of stages prone to fetal loss is a key step towards enhancing elephant reproductive success and welfare.

1 | Introduction

The African elephant (*Loxodonta africana*) and the Asian elephant (*Elephas maximus*) face significant threats to their populations (Mumby et al. 2013; van de Water and Matteson 2018; Padalia et al. 2019). As a result, both species show decreasing population trends in the wild and are listed as endangered on the IUCN Red List (Williams et al. 2020; Gobush et al. 2021). Therefore, a well-managed and closely monitored ex situ backup population is of critical importance. In 2006, the International Species Information System reported a total of 831 captive elephants, consisting of 336 African and 495 Asian elephants residing in 194 zoological institutions (Rees 2009). To keep this ex situ population healthy and viable, reproduction and genetic diversity are key.

Species with a long lifespan, such as the elephant, typically have a slow reproduction rate, making the success rate of each reproductive effort of utmost importance (Wu et al. 2021). For the African and Asian elephants respectively, reproductive characteristics which are indicative of slow reproduction are a high age of primiparity (average 14.1 vs. 13.4 years), a long inter-calving interval (average 4.5 vs. 4.2 years), and the longest gestation of all mammalian species (640–673 vs. 623–729 days) (Hildebrandt et al. 2007; Wittemyer et al. 2013; Crawley et al. 2020).

Reproductive success is threatened by multiple forms of reproductive failure during pregnancy, including abortion, and stillbirth. An abortion is the loss of a calf between the eighth and 21st month of gestation. The abortion rate is 7.5% and 3.2% in captive African and Asian elephants, respectively (Hartley and Stanley 2016). Abortions can be caused by either infectious (i.e., viruses, bacteria, or parasites) or noninfectious agents. Salmonella (*Salmonella typhimurium*) has been described as a causative infectious agent for abortion in elephants (Emanuelson and Kinzley 2000). Noninfectious agents are rarely diagnosed, resulting in many abortions listed as idiopathic. Possible causes of these idiopathic abortions might be stress, hormonal dysfunction, malfunction of the corpus luteum, trauma, chromosome abnormalities, or toxins. Considering the significant number of abortions diagnosed as idiopathic, it is imperative to investigate their underlying causes. A case reported by Yamamoto et al. (2012) highlighted an instance where an elephant experienced abortion at 17 months of gestation. While the initial peak of immunoreactive prolactin of the biphasic prolactin pattern was noted around the 9th to 10th month of gestation, the absence of a second peak in this particular case was an important finding and may be related with the abortion. This prompted us to explore whether more abortions occur during the period of lower prolactin concentrations, specifically between 15 and 17 months of gestation. Given the pivotal role of prolactin in maintaining pregnancy in various species (Duckworth et al. 1993; Chen et al. 2002) and the observed biphasic pattern in the elephant, there may be a correlation with abortions during this timeframe. Therefore, it becomes crucial to define the period during which the prevalence of idiopathic abortions is highest.

Stillbirth is the loss of a calf shortly before parturition or during parturition and is thus defined as the birth of a lifeless fetus. Stillbirth rates are significantly higher for primiparous elephants. Chances of stillbirth decrease for the second calf and increase again with maternal age for subsequent calves, especially after age 35 (Mar et al. 2012). Stillbirth is often correlated with dystocia (Hartley and Stanley 2016) but can also have an infectious component. For example, the cowpox virus (*Poxviridae*) has been reported to cause stillbirth in elephants (Wisser et al. 2001). To identify the magnitude of reproductive loss due to stillbirths, we investigated its prevalence since 2000.

Here, we have analyzed data kept on elephant pregnancies in different institutes around the world, to identify which months are more prone to reproductive loss. To determine the age of the aborted fetuses, we established a metric to calculate the fetal age based on its mass. Pinpointing the months prone to reproductive loss is a key step toward improving reproductive success in elephants.

2 | Materials and Methods

2.1 | Data Collection Fetal Loss

Observational data on abortions in elephants were collected from zoos, tourist camps, semi-captive, and free-ranging populations around the world. A total of 35 idiopathic abortions were recorded since 1974. Eleven of them were excluded due to insufficient data to estimate fetal age. The 24 remaining cases of abortions were categorized based on the fetal age. To investigate stillbirths, we used the elephant.se database to collect retrospective data in captive elephants between 2000 and 2023 ($n = 79$). In seven cases, a tentative cause of the stillbirth was mentioned without diagnostic confirmation. These cases were therefore still categorized as idiopathic and incorporated into this study.

2.2 | Estimation of Fetal Age at the Time of Abortion

We determined the age of aborted calves based on the insemination or mating date. If not available, hormone patterns or measurements of bone lengths from computed tomography scans or back lengths compared to the size of the mother or other aborted calves were used to identify the fetal age. In addition, we established a metric to calculate fetal age based on fetal mass using data published by Allen et al. (2005) and additional data by Hildebrandt et al. (2007). A total of 66 data points from these two publications were included, with fetal ages varying between 2.0 and 21.3 months.

2.3 | Data Analysis

All analyses were conducted using R version 4.2.1 (R Core Team 2022) using Rstudio IDE (Posit Team 2023). The fetal age determination formula was established using a log–log regression model. Months with significantly more abortions were determined using an unpaired T test.

3 | Results

3.1 | Age Estimation Metric

Following a regression analysis, we established the following metric to calculate the fetal age at time of abortion ($r^2 = 0.982$, $F_{1,64} = 3495$, $p < 0.001$, between 2 and 21.3 months of gestation):

$$\text{Fetal age} = 8.34 \times \text{Mass}^{0.181},$$

where the fetal age is in months and the fetal mass in kg.

3.2 | Abortions

More than half of the abortions (13/24 or 54.2%) took place during Months 15 and 17 of gestation (Figure 1). In each group of elephants (Asian and African, captive and wild) abortions occurred in at least one of these 2 months of gestation.

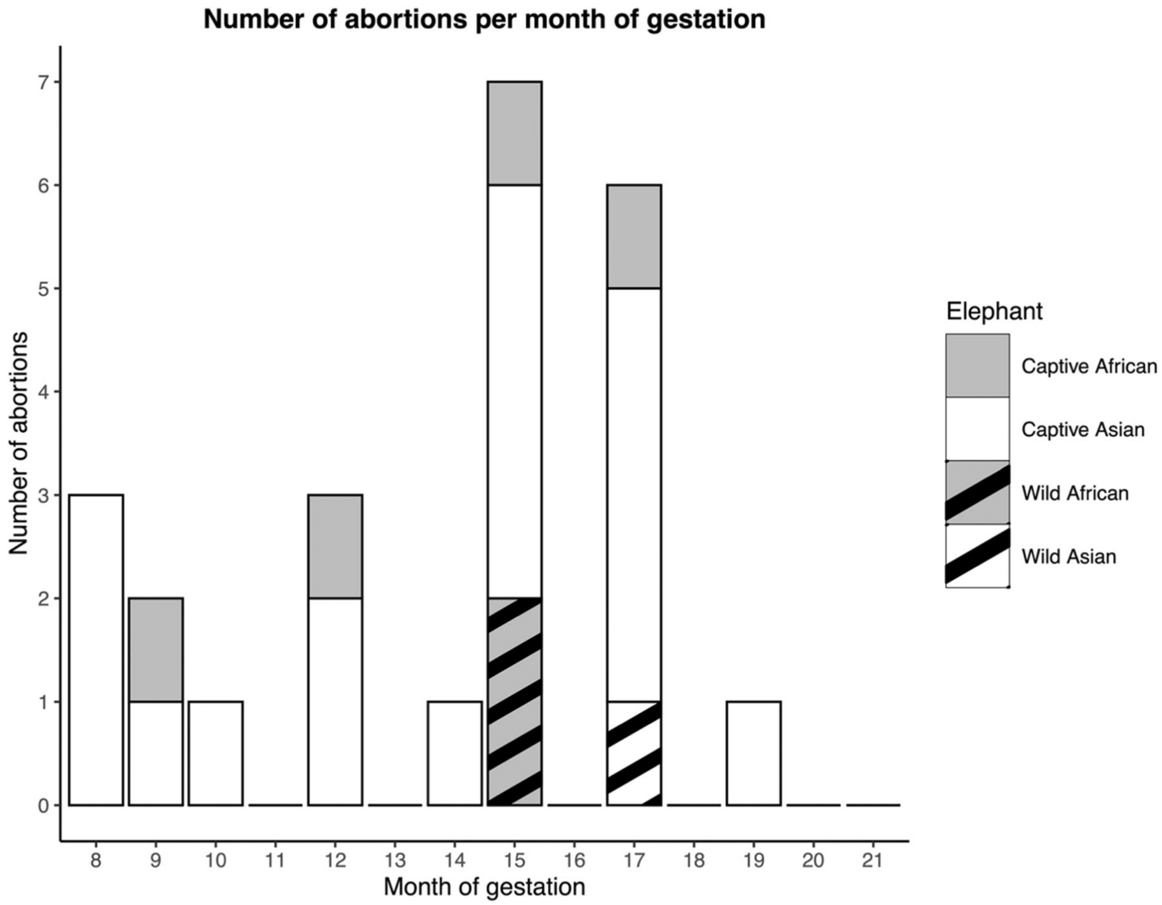

FIGURE 1 | Stacked bar plot displaying the number of abortions per month of gestation. The bars have a different pattern based on the type of elephant that aborted, that is, captive African, captive Asian, wild African, or wild Asian.

The number of abortions in Months 15 and 17 was significantly higher compared to the number of abortions in the other months ($p < 0.001$).

3.3 | Stillbirths

Of the 1366 recorded births between 2000 and 2023, 79 (5.8%) ended in stillbirth. Of these stillbirths, 26 occurred in African elephants and 53 in Asian elephants, with a prevalence of 9.8% and 4.8%, respectively. Of the dams that experienced stillbirth, 21 were captive-born, 35 were wild-caught, and 23 had an unknown history, resulting in a prevalence of 5.6%, 8.1%, and 4.1% for these three groups, respectively. The prevalence of stillbirths per year is presented in Figure 2.

Although the trend shows a decline in the percentage of stillbirths since 2000, the average percentage of stillbirths over the past 5 years (2019–2023) is still 2.8%.

4 | Discussion

This study revealed a significantly higher prevalence of abortions during the 15th and 17th month of gestation in elephants. Furthermore, there was a substantial percentage of stillbirths, although a declining trend is present over the last 2 decades. Consequently, it is imperative to designate the 15th, 17th, and 22nd months as stages prone to fetal loss.

Identified cases of abortions in wild populations were limited, but all three fetuses found in the wild were classified as either 15 or 17 months old, which may again be indicative for the importance of reproductive loss during this period. It should be considered, however, that the chances of finding a dead calf in the wild are slim, as elephants will go to a quiet place to abort or give birth. In addition, most elephants give birth during the night or in the early morning (Hermes et al. 2008; Dale 2009). The presence of many predators and scavengers additionally impairs the chances of an aborted calf being found.

Although a direct link between stress and abortions or stillbirths has not been proven in elephants, research in many other species shows a clear correlation (Joachim et al. 2003; Gilchrist 2006; Jafari et al. 2017; Bartoš et al. 2021). Changes in group structure and construction noise are for instance known causes of stress in elephants (Jakob-Hoff et al. 2019; Glaeser et al. 2020). Wild-caught elephants have higher stress levels in a captive environment compared to captive-born ones (Kumar et al. 2019; Lahdenperä et al. 2019) and habituation to this captive environment is not self-evident (Fischer and Romero 2019). In our study, the prevalence of stillbirths in wild-caught elephants was higher compared to the prevalence in captive-born elephants, as well,

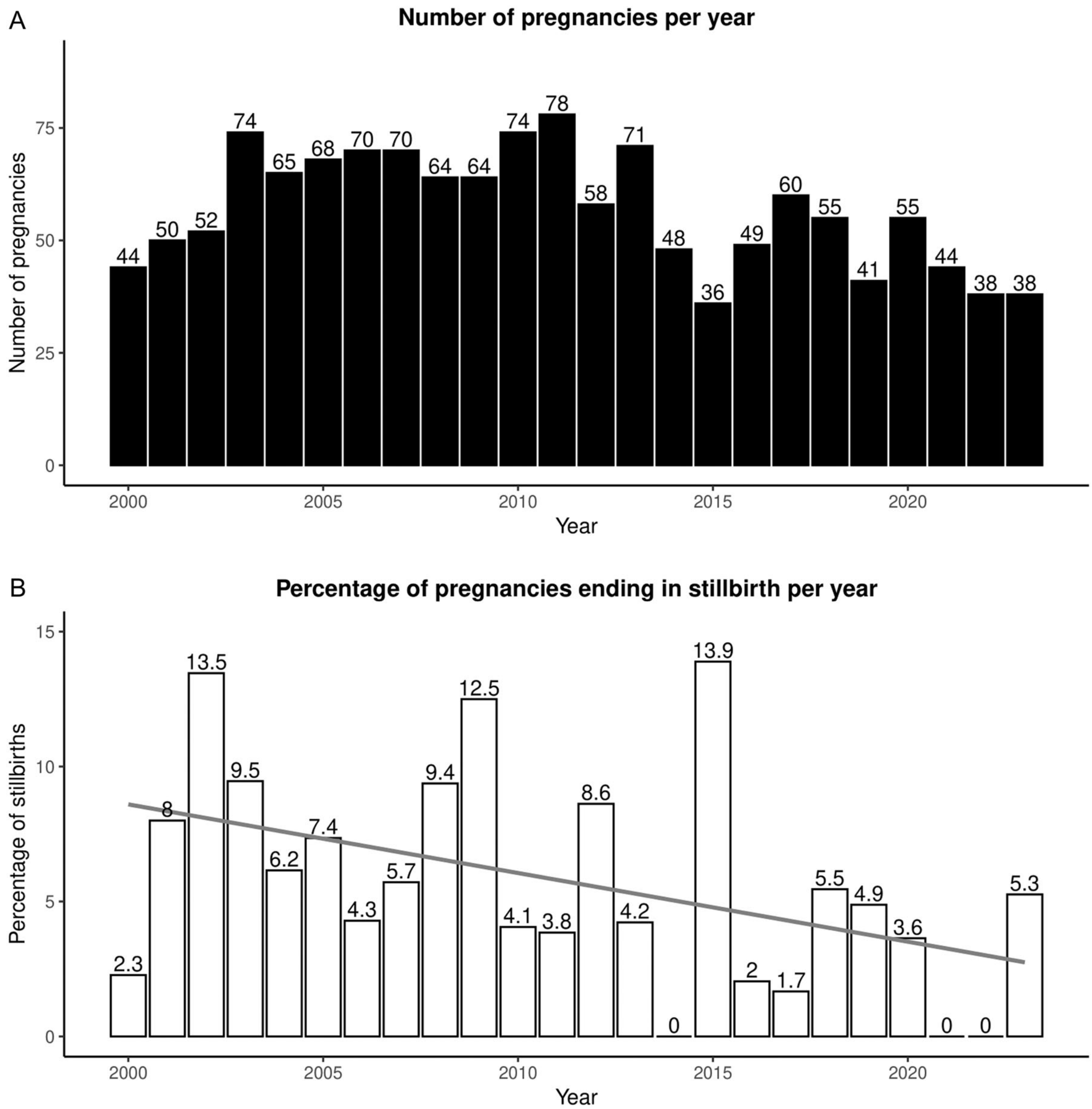

FIGURE 2 | (A) barplot showing the number of pregnancies per year since 2000. (B) barplot showing the percentage of pregnancies ending in stillbirth per year since 2000. The line represents the trend.

supporting the suggestion of a possible link between stress and abortions.

As expected, the defined months prone to fetal loss coincide with a period of low prolactin concentration during Months 15–17 in elephant gestation (Yamamoto et al. 2012). In many mammals, prolactin plays a role in maintaining pregnancy due to its luteotropic effect (Duckworth et al. 1993; Chen et al. 2002). In elephants, prolactin may exert a luteotropic effect as well (Lueders et al. 2018). Although elephants with a successful gestation experience this biphasic pattern too (Yamamoto et al. 2012), a connection with abortion may exist. Therefore, a possible relation between prolactin and/or stress as a cause of reproductive loss merits further investigation.

In conclusion, this study sheds light on the stages of gestation in elephants prone to fetal loss, being the 15th, 17th, and 22nd month. These findings form a key step in evaluating reproductive loss in elephants, bringing us a step closer to enhancing reproductive outcomes and welfare. As a next course of action, we therefore propose a study aimed at comparing PRL levels in pregnancies that conclude with successful delivery and those that terminate in abortion.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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