1 | INTRODUCTION

Like in Old World camelids, the placenta of the alpaca is epitheliochorial, diffuse and of the non-deciduate type (Arthur, A/Rahim, & Al Hindi, 1985; Brown, 2000; Jones, Skidmore, & Aplin, 2008; Smith, Peter, & Pugh, 1994; Steven, Burton, Sumar, & Nathanielsz, 1980), while it is also characterized as micocolonary (Aba, 2014; Abd-Elnaeim et al., 2003; Brown, 2000; Pearson, Rodriguez, & Tibary, 2014, 2014). It has some similarities with some of the aspects of the placenta found in horses, pigs and bush babies (Iturrizaga et al., 2007; Olivera, Zago, Leiser, Jones, & Bevilacqua, 2003). Different authors describe the volume of allantoic and amniotic fluids as being a low volume (Smith et al., 1994; Tibary, Rodriguez, & Sandoval, 2008; Bravo & Varela, 1993). Only Bravo and Varela (1993) studied the volume of the amniotic and allantoic fluids combined, during 12 different stages of pregnancy. On day 330 of pregnancy, the combined volume of allantois and amnion was 2057 ml. All camelids have a unique extra or fourth foetal membrane, the so-called epidermal membrane, which is derived from the epidermis...
of the foetus. It is translucent and covers the whole foetus and is attached at all mucocutaneous junctions (Figure 1). It is suggested that its function is to lubricate the foetus and thus facilitate its delivery (Aba, 2014; Brown, 2000; Merkt, Böer, Rath, & Schoon, 1988; Smith et al., 1994; Whitehead, 2009).

The placenta is expelled inside out, with the allantoic sac exposed (Tibary, Fite, Anouassi, & Sghiri, 2006). The amnion is closely adhered to either the allantois or the chorion (Morton, 1961; Smith et al., 1994), and the allantochorion has physiological, poorly villous zones along the medial aspect of the uterine horns (Schaefer, Bildfell, Long, & Löhr, 2012).

According to the author, the allantois is adhered to the entire chorionic surface, and the amnion is adhered to the allantois at the level of the pregnant horn. The left horn is always the largest and pregnant horn (Aba, 2014; Brown, 2000; Skidmore, Billah, Binns, Short, & Allen, 1999).

Common findings in the placenta of New World camelids are hippo‐manes in the allantoic cavity and small, firm pustules or plaques at the base of the umbilical cord, on the amniotic membrane (Morton, 1961; Pearson, Rodriguez, & Tibary, 2014, 2014; Rodriguez, Pearson, & Tibary, 2014).

Camelids have a low reproductive efficiency with annual birth rates in South American camelid (SAC) estimated to be 50% (Brown, 2000; Tibary & Anouassi, 2001; Tibary et al., 2006). In SAC, the annual rate of abortion and stillbirth adds up to approximately 10% (Schaefer et al., 2012).

In case of pregnancy loss, abortion, stillbirth or premature birth, the placenta should be properly examined to detect any abnormalities such as incompleteness, placentitis, oedema or any other abnormalities (Pearson, Rodriguez, & Tibary, 2014; Schaefer et al., 2012; Tibary et al., 2006).

Since macroscopic evaluation of the placenta is an essential post‐partum examination, the aim of the present study was to describe reference values regarding the macroscopic properties of normal, full‐term placentas of alpacas and thus be better prepared to evaluate placetas in case of abortion, stillbirth or premature birth.

2 | MATERIALS AND METHODS

2.1 | Animals

All alpaca (Vicugna pacos var. huacaya) mares whose placentas were included in the study were healthy adult females aged two to nine years old, weighing between 60 and 80 kg. All mares (except the one that was two years old) had at least one previous, uneventful parturition with a live‐born, healthy cria. The crias were all born alive and healthy, with normal birth weights (7.7 ± 2.25 kg) (Bravo, Garnica, & Puma, 2009; Bravo & Varela, 1993). The alpaca mares came from four different alpaca farms (three farms with less than ten animals and one bigger farm with around 30 alpacas).

2.2 | Placentas

In total, twelve placentas were collected within 24 hr after parturition and came from normally foaling alpaca mares, giving birth to healthy crias, after a full‐term and uneventful gestation. These placentas were frozen (-18°C) up to the day of examination. All placentas were examined on the same day, after thawing at room temperature. After thawing, one placenta was excluded from the study due to severe decay (Figure 2).

2.3 | Ethics

With the approval from the owners, non‐retained placetas were collected, without handling any live alpacas.

2.4 | Measurements

A series of measurements was performed on each placenta, including the total weight of the placenta, the individual weights of the allantoamnion and chorion, the volume of the allantoamnion and chorion, the surface area of both allantoamnion and chorion and the length of the umbilical cord, the lengths of both pregnant and non‐pregnant horns, the length of the corpus and the distance between the umbilical cord and the corpus.
For weighing the placentas, an electronic scale (Bascules Robbe N.V.®, Type KA-10-150, Nr. 13268/B02) was used. This scale was also used for the determination of the volume of both allantoamnion and chorion. To measure the volume, the different parts of the placenta were submerged into water. The displaced and overflowing water was collected in a collection tray and weighed (Figure 3), as is described by W. Scherle in the 1970s (Atieh, Zeitoun, Abdelsalam, & Al-Sobayil, 2014). The weight of the overflowing water was used as a proxy for the volume, as 1 L of water weighs 1 kg.

**FIGURE 2** All placentas (N = 12) post-thaw, the last placenta (*) being the excluded placenta due to severe decay
The surface area was calculated by using a plexiglass plate (Figure 4), on which squares of ten square centimetres are engraved. By unfolding the allantoamnion and chorion on this plexiglass plate, the surface area could be determined. To measure the chorionic surface area, the chorion was cut open and placed on the plexiglass plate. To measure the allantoamnion, both amnion and allantois were cut open and detached as much as possible, but not completely as the adhesion is quite strong.

A standardized form was created to assess all placentas equally (see Appendix S1).

To measure the (non-)pregnant horn length, the horn was measured from the tip of the horn to the transition to the corpus. The length of the corpus was measured from the cervical star up to the transition to the horns. The distance from the umbilical cord to the corpus was measured from the basis of the umbilicus on the pregnant horn to the transition of the pregnant horn to the corpus, and the umbilical cord length was measured from the start of the umbilicus on the uterine horn up to the tip of the umbilical cord.

### Descriptive analysis

For all parameters, averages and standard deviations were calculated using descriptive analysis, performed with Microsoft® Excel® 2016 (Microsoft Corp.).

### Results

The measurements of all normal placentas are depicted in Table 1.

### 3.1 Weight

The average weight of the placentas was 0.8 ± 0.19 kg with a range of 0.6 kg to 1.1 kg. Since the average weight of the crias was 7.7 ± 2.25 kg, the placental weight was 10.3% of the bodyweight of the crias. The average weights of both allantoamnion and chorion were 0.2 ± 0.07 kg and 0.5 ± 0.13 kg, respectively.

### 3.2 Measurements

The mean umbilical cord length was 8.8 ± 2.84 cm, and the distance from the umbilical cord to the corpus was on average 18.5 ± 6.13 cm. The mean length of the pregnant and non-pregnant horn was 69.4 ± 12.77 cm and 54.5 ± 6.81 cm, respectively, and the length of the corpus was on average 14.6 ± 4.68 cm.

### 3.3 Surface area

On average, the surface area of the allantoamnion and the chorion was 87.6 ± 15.56 dm² and 72.3 ± 9.28 dm², respectively. Thus, the allantoamnion has a surface area that is 17.5% larger than surface area of the chorion.

### 3.4 Volume

The volume of the allantoamnion was on average 0.14 ± 0.079 L, and the mean volume of the chorion was 0.37 ± 0.078 L.

### 3.5 Observations

The chorionic surface of all placentas had a red to burgundy colour and a velvety texture. A well-defined avillous zone was present on the medial side of both uterine horns as well as on the tips of both horns. The allantoamnion was very thin and almost translucent and smooth to the touch. No oedema was visually present between either allantoamnion and chorion or allantois and amnion.

All placentas showed plaques or pustules on the amniotic side of the allantoamnion. The plaques were grouped either only around the
umbilical cord, either around the umbilical cord and the larger blood vessels on the pregnant horn (Figure 5).

Hippomanes were found in four of the placentas. The size was on average 3 × 3 cm and the weight only a few grams.

4 | DISCUSSION

This study is, to the best of our knowledge, the first study that describes the macroscopic dimensions of placentas from alpacas more extensively. The overall mean placental weight in this study (0.8 ± 0.19 kg) was similar to the mean placental weight reported in a previous large study that reported a placental weight of on average 0.876 kg, when crias were born alive and 0.780 kg when crias were born dead (Bravo et al., 2009). This large study, conducted by Bravo et al. (2009), reports a placental weight that is 9.4±1.2% of the cria’s birth weight, which was confirmed in our present study, where the placental weight was 10.3% of the cria’s birth weight. The mean weight of the allantoamnion from the chorion, always releasing a small amount of fluids, and thus, losing some weight.

The mean placental weight that is 9.4±1.2% of the cria’s birth weight, which was confirmed in our present study, where the placental weight was 10.3% of the cria’s birth weight. The mean weight of the allantoamnion from the chorion, always releasing a small amount of fluids, and thus, losing some weight.
The effect of cryopreservation of the placenta should be considered when weighing post-thaw. Cryopreservation is described to lower the post-thawing weight of certain tissues (Bustabad, 1999). Since Bustabad’s study was performed on different types of meat, the author decided to freeze five equine placentas (which were easily available) to measure the weight loss and approach the effect on placentas of alpacas. The weight loss was on average 32% (range 24%–42%). This needs to be considered when measuring weight and thus volume of fresh placentas.

Placental surface area has been described in Wodoh and Majaheem dromedary camels where the surface area of the total placenta (1.78 ± 0.16 m² for Wodoh camels and 2.11 ± 0.15 m² for Majaheem camels) was measured (Atieh et al., 2014), rather than the allantoamnion and chorion separately, as was done in our study. The measurements described by Atieh et al. (2014) cannot be used as comparison, since dromedaries and alpacas are quite different in size, giving rise to major differences in placental size. Morton (1961) documented some placental measurements in three members of the camelid species (dromedary, camel and llama). He described length of the lesser and greater chorionic curve as well as maximum girth, but also umbilical cord lengths. The umbilical cord length was recorded for the Bactrian and Arabian camels, but unfortunately no umbilical cord length was recorded for the llama placenta, since these measurements would have been closest to the umbilical cord length of alpacas. In hindsight, it would be advisable to measure the crown-rump length of the cria, to estimate the gestational age, as well as the widths of the (non-)pregnant horns and the corpus.

Since the placenta is very important for pregnancy success, it is important to recognize a normal placenta, coming from a healthy mother with healthy offspring, to be able to acknowledge when a placenta is abnormal. Placental pathologies are associated with several complications in human and animal pregnancies; notwithstanding, the placenta is too often ignored in cases of embryonic, foetal or perinatal complications (Cross, 2006).

As described by Bravo and Varela (1993) during the last two months of a normal pregnancy, the placental weight does not change much. Interestingly, it is the age of the dam that is reported to have an influence on placental weight, in females having a normal gestation. Dams aged between 6 and 9 years old have increased placental weight in comparison with younger dams or dams older than 10 years old (Bravo et al., 2009). It is described that prolonged gestation in alpacas can be caused by intrauterine growth retardation due to abnormal placentation. Many placentas are described as smaller in these cases or have avillous zones. Most crias will also be smaller than average (Pearson et al., 2014).

The inspection of a placenta following an abortion, stillbirth or premature birth is very valuable to detect both infectious and non-infectious causes. Both the allantoic and chorionic surfaces should be examined to find any abnormalities, after gently cleaning the surfaces with cold water to remove contamination (Pearson, Rodriguez, & Tibary, 2014; Pearson et al., 2014; Tibary et al., 2006).

The chorionic surface should be red and velvety (Morton, 1961; Tibary et al., 2006) and have normal hypovillous areas at the tips of the horns (corresponding to the uterotubal junctions), at the cervical star (on the body or corpus, where there is contact with the cervix) and along the medial aspect of each horn (Pearson et al., 2014, 2014; Schaefer et al., 2012; Tibary et al., 2006). Chorionic inflammation is easily detected as the placenta will be thick and leathery (Tibary et al., 2006).

Placentitis (which is rare in alpacas) might be present when the placenta has focal or diffuse discoloration with brown, white or yellow exudate and should be differentiated from autolysis due to placental retention or storage at room temperature (Pearson et al., 2014, 2014). Webster, Miller, and Vemulapalli (2008) described a placentitis caused by Encephalitozoon cuniculi, which was visible on the placenta as a dark red to pink mottled chorionic surface near the body and covered by thick, viscous plaques (0.2–0.4 cm diameter), the allantois near the umbilical cord being covered with similar exudate.

The umbilicus should be of normal length according to Tibary et al. (2006), which is 8.8 ± 2.84 cm on average, as described in the present study. The umbilicus should also be examined for abnormalities such as excessive twisting, blood clots or signs of inflammation (Pearson et al., 2014, 2014).

In case of stillbirth, abortion or premature birth, the placenta should be visually examined, as well as sent for histopathology, since a large percentage (66.3%) of abortions and stillbirths is still classified as idiopathic. Mineralization and mucinous oedema of the chorioallantoic stroma is often found in normal and aborted placentas, but villous hypoplasia was more often seen in aborted placentas (Schaefer et al., 2012).

In conclusion, the findings described in the present study might be of use in determining if an alpaca placenta has normal dimensions. However, more research is needed on placental dimensions and the visual aspect of a healthy alpaca placenta, but also more macroscopic and histopathological studies are needed on placentas coming from abortions, stillbirths or premature births. This would make macroscopic evaluation of alpaca placentas more accessible to clinicians in the field.

ACKNOWLEDGEMENTS

The authors thank the owners for their cooperation in supplying the placentas and all the necessary information about the alpaca mares and crias.

CONFLICT OF INTEREST

None of the authors have any conflict of interest to declare.

AUTHOR CONTRIBUTIONS

Maya Meesters designed and performed the study, analysed the data and has written the paper. Geert Opsomer has reviewed the paper. Jan Govaere has designed the study and reviewed the paper.

ORCID

Maya Meesters https://orcid.org/0000-0001-9336-517X