Duración del parto en ovejas y sus consecuencias sobre las características comportamentales en la relación madre-cría

Mariel Regueiro Rodríguez

Doctorado en Ciencias Agrarias

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Para Agustín, Andrés y Camila,
que me alegran el alma con sus locuras

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TABLA DE CONTENIDO

página

RESUMEN

La mortalidad de corderos en las primeras 72 horas de vida impacta en gran medida a la cría ovina, sobre todo en condiciones extensivas, resulta en pérdidas económicas y afecta el bienestar animal. Los partos donde la fase de expulsión fetal (fase II) se prolonga, pueden influir al comportamiento materno; debido al período prolongado de hipoxia durante el parto puede afectarse también el comportamiento del neonato. Existe escasa información acerca del tiempo necesario de la fase de expulsión fetal, para que se produzcan estos cambios en el comportamiento materno, o para que la hipoxia resultante de un parto prolongado, pueda revertirse o provoque secuelas que afecten la viabilidad del cordero. Las alteraciones en el comportamiento, evitarán que se logre un correcto vínculo madre-cría. En este trabajo de tesis se buscó investigar sobre el tiempo requerido para que la duración de la fase de expulsión fetal tenga consecuencias sobre los factores comportamentales tanto de la madre como de la cría. Para una temprana detección de la hipoxia fetal, se evaluó la eficacia de una herramienta no invasiva y de fácil uso, el oxímetro de pulso, comparándolo con gasometría venosa. La prolongada duración del parto afectó el comportamiento tanto de las madres como de los corderos, lo que alteró el vínculo madre-cría, con un mayor porcentaje de abandono de corderos. Una correlación lineal entre la duración del parto y el mal comportamiento materno se observó en ovejas primíparas, pero no así en las multíparas. El oxímetro de pulso logró detectar aquellos corderos con bajo porcentaje de oxigenación al nacer, por lo que podría utilizarse para establecer medidas terapéuticas o de manejo que mejoren la sobrevivencia. Una disminución en el período de expulsión fetal mediante asistencia programada al parto resultó en una mejora tanto en el comportamiento materno como en el vigor de los corderos en ovejas primerizas, lo que permitió establecer un vínculo madre-cría apropiado y mejorar potencialmente la sobrevivencia neonatal.

Palabras clave: duración del parto, ovejas primíparas, comportamiento materno, hipoxia, oximetría

DURATION OF PARTURITION IN EWES AND ITS CONSEQUENCES ON BEHAVIOURAL TRAITS IN MOTHER-LAMB BOND

SUMMARY

Lamb mortality within the first 72 hours of life greatly affects sheep breeding, especially in extensive rearing, resulting in important economic losses and involving animal welfare. Prolonged fetal expulsion phase can influence maternal behaviour, and the extended period of hypoxia during birth can also affect the behaviour of the neonate. Limited information exists regarding the necessary duration of the fetal expulsion phase for these changes in maternal behaviour to occur or for the resulting hypoxia from prolonged delivery to either be reversed or cause sequelae that affect lamb viability. Behavioural disturbances of both the mother and the neonate prevent establishing a proper mother-lamb bond. This thesis aims to investigate the required time for the duration of the fetal expulsion phase to have consequences on both maternal and offspring behaviour. For early detection of foetal hypoxia, the effectiveness of a non-invasive and easy-to-use tool, a pulse oximeter, was evaluated and compared with venous blood gas analysis. The prolonged duration of parturition affected the behaviour of both dams and lambs, disrupting the mother-lamb bond and leading to a higher percentage of abandonment. A linear correlation between the duration of delivery and poor maternal behaviour was observed in primiparous ewes, but not in multiparous ones. The pulse oximeter successfully detected lambs with low oxygenation at birth, which would allow to establish therapeutic or management measures to improve survival. Reducing the duration of the foetal expulsion phase through programmed parturition assistance improved maternal behaviour and lamb vigour in primiparous ewes, enabling the establishment of an appropriate mother-lamb bond and potentially enhancing neonatal survival.

Keywords: duration of parturition, primiparous ewes, maternal behaviour, hypoxia, oximetry

1. INTRODUCCIÓN

En Uruguay, al igual que ha ocurrido en el ámbito mundial, las existencias ovinas han presentado durante las últimas décadas una marcada reducción. Se ha originado un cambio en la composición del stock, lo que ha resultado en una majada nacional que tiene al proceso de cría de los corderos en franco crecimiento (Montossi et al., 2005).

La producción ovina bajo sistemas intensivos o semiextensivos ha alcanzado niveles satisfactorios gracias a mejoras en la alimentación, manejo sanitario y avances en estrategias de reproducción (De Arriba y Sánchez-Andrés, 2014). Sin embargo, en la cría extensiva no se observa la misma tendencia debido, en parte, a la alta mortalidad de corderos durante y después del parto, la cual ha permanecido persistentemente invariable durante los últimos 40 años (Flinn et al., 2020a, Dwyer et al., 2016).

Según las existencias actuales de ovejas de cría (DIEA, 2022) y cifras de señalada que rondan el 70 %, en Uruguay mueren en promedio entre 800.000 y 1 millón de corderos al año, lo que conlleva pérdidas económicas derivadas no sólo de la muerte de animales, sino también de la mayor utilización de forraje y menor producción de lana de la oveja gestante (Bruce et al., 2021, Azzarini y Fernández Abella, 2004). Además, la mortalidad de corderos no sólo implica pérdidas económicas, sino que involucra también otro aspecto importante como lo es el bienestar animal, ya que muchos corderos padecen hambre y frío durante horas o incluso días antes de morir (Banchero, 2003).

La mayoría de las muertes neonatales ocurren durante las primeras 72 horas de vida (Holmøy et al., 2017, Dutra et al., 2007, Hinch et al., 1985, Dalton et al., 1980), y en condiciones de campo, la inanición, junto con la exposición a condiciones climáticas adversas, se identifican como los principales determinantes de las muertes (Dwyer, 2003). No obstante, en sistemas de cría extensiva se observan dos factores principales que predisponen a la mortalidad neonatal: lesiones del sistema nervioso central (SNC) como consecuencia de hipoxia fetal intraparto y el desarrollo de un vínculo madre-cría débil o nulo (Dwyer et al., 2016, Dutra et al., 2007). Ambos factores se presentan como consecuencias directas de una duración prolongada del

parto (Dutra y Banchero, 2011, Dwyer, 2008) que probablemente conducen a la causa determinante de la muerte: el complejo inanición-exposición (Novak y Poindron, 2006). La comprensión y abordaje tanto de las secuelas comportamentales de hipoxia fetal como de la interacción madre-cría son aspectos fundamentales para mejorar la supervivencia y el bienestar de los recién nacidos en estos sistemas de cría.

Un parto prolongado puede afectar la supervivencia del recién nacido, tanto en ovejas (Bruce et al., 2021, Jacobson et al., 2020, Dutra y Banchero, 2011, Dutra et al., 2007) como en diversas especies, incluyendo humanos (Martínez-Burnes et al., 2021, Nam y Sukon, 2021), como resultado del daño al SNC producido por la hipoxia sufrida durante el nacimiento. Aunque en algunos casos las consecuencias de dichas lesiones pueden ser leves, si el período de falta de oxigenación se prolonga, las secuelas pueden resultar de tal magnitud que, incluso si los corderos logran sobrevivir al proceso de parto, existe la posibilidad de que mueran en los días posteriores como consecuencia del daño producido (Dutra et al., 2007).

Además de las consecuencias que un parto dificultoso puede tener sobre el neonato, su supervivencia dependerá en gran medida del establecimiento temprano de un vínculo con su madre (Dwyer, 2014). Los primeros minutos posparto son fundamentales para el reconocimiento mutuo y cualquier factor que lo altere tendrá un impacto en esta relación (Nowak y Poindron, 2006). La fase de expulsión fetal (fase II del parto), aunque suele ser la más breve del proceso, en partos distócicos puede generar consecuencias perjudiciales en el comportamiento materno (Dwyer et al., 2016, Alexander, 1988). A pesar de que el dolor es una medida subjetiva y difícil de evaluar en los animales (Fitzpatrick et al., 2006, Stasiak et al., 2003), en numerosas especies el parto es considerado el evento más doloroso que las hembras pueden experimentar (Martínez-Burnes et al., 2021, Ison et al., 2018). El mal comportamiento materno, como resultado de una prolongada duración de la expulsión fetal, puede generar el rechazo parcial o total del cordero (abandono) (Banchero, 2004, Alexander, 1960). En sistemas de cría extensiva, y considerando especies precociales como las ovejas, este comportamiento determina que en un tiempo relativamente corto el recién nacido no logre sobrevivir (Nowak, 1996).

Si bien la nutrición durante la gestación, la edad de la madre, el tamaño de camada y las diferencias individuales son algunos de los factores que influyen tanto en el comportamiento materno como en el del cordero durante el período neonatal, todos ellos tienen incidencia directa sobre la duración del parto (Dwyer, 2008b, Dwyer et al., 2003).

Varios trabajos han indicado que la duración de la fase de expulsión fetal tiene un efecto relevante sobre el comportamiento en ovejas primíparas (Dwyer et al., 2016, Mora-Medina et al., 2016, Darwish y Ashmawy, 2011). El dolor experimentado durante esta fase suele afectar de forma particular el comportamiento posterior de las madres en esta categoría (Dwyer, 2008a). Sin embargo, los estudios que señalan la prolongada duración del parto como factor determinante de cambios en el comportamiento tanto de la madre como del cordero mencionan una espera de un período de dos horas antes de asistir los partos (Olivera-Muzante et al., 2022, Dutra y Banchero, 2011, Banchero et al., 2010, Dwyer, 2003, Dwyer et al., 1996). Esto deja un período ventana, del cual existe escasa información acerca de cuanto es el tiempo necesario para que se produzcan cambios comportamentales una vez iniciada la fase de expulsión. ¿Es necesario que transcurran dos horas desde el inicio de la expulsión fetal para que se manifieste un mal comportamiento en la madre o puede ocurrir en menos tiempo? ¿El tiempo transcurrido afecta por igual a ovejas primerizas que a multíparas?

Del mismo modo, se dispone de poca información sobre el tiempo necesario para que la hipoxia resultante de un parto distócico pueda revertirse o provoque secuelas que afecten el comportamiento del cordero neonato. Las alteraciones que puedan existir en el comportamiento ya sea de la oveja o del cordero evitarán que se logre un correcto vínculo madre-cría, imprescindible para la sobrevivencia del recién nacido.

El desarrollo de este trabajo de investigación pretende contribuir al aporte de conocimiento de las causas que disminuyen la sobrevivencia neonatal de corderos, un problema que afecta en gran forma los índices reproductivos de las majadas en nuestro país, así como en otros países donde la cría extensiva es el principal modo de producción ovina. Se busca recabar más información sobre el tiempo que se requiere para que la duración de la fase de expulsión fetal tenga consecuencias sobre los

factores comportamentales tanto de la madre como de la cría en el posparto inmediato. El conocimiento de estos factores se considera fundamental para la toma de medidas necesarias que apunten a aumentar la supervivencia de los recién nacidos, lo que evitaría pérdidas económicas y promovería el bienestar animal.

1.1. ANTECEDENTES

Las existencias ovinas han presentado durante las últimas décadas una marcada reducción, principalmente por las variaciones registradas en los precios de la lana, así como por la pérdida de competitividad frente a otros rubros agropecuarios. Desde hace algunos años, nuestro país ha seguido esta tendencia y su stock ovino se ha reducido fuertemente, por lo que se originó un cambio en su composición que ha resultado en una majada nacional relativamente más orientada hacia el proceso de cría (Montossi et al., 2005).

Tomando en cuenta que más del 60 % del stock ovino de nuestro país está representado por las razas corriedale y merino, las cuales presentan una tasa ovulatoria promedio de 1,2 (Banchero et al., 2016), podríamos obtener potencialmente un porcentaje de parición mayor al 100 %; sin embargo, a pesar de los buenos índices de preñez que se logran en nuestras majadas, desde décadas atrás, el porcentaje de señalada (número de corderos señalados/número de ovejas servidas) apenas supera en promedio el 70 % (DIEA, 2022). La mortalidad de corderos es una de las principales restricciones productivas que se pueden encontrar como causa de este bajo porcentaje.

Si tomamos en cuenta que la eficiencia reproductiva es resultado de la fertilidad y prolificidad de la hembra, así como de la supervivencia de sus crías, la baja supervivencia neonatal es una de las fuentes de pérdidas de eficiencia más visibles (Azzarini y Fernández Abella, 2004). Pero las pérdidas derivan no sólo de una menor producción de carne, sino que también se ve afectada la eficiencia en el avance genético por la reducción del número de animales disponibles para la reposición. En este sentido, Ganzábal y Echevarría (2005) aseguran que la mortalidad de corderos es, conjuntamente con la tasa ovulatoria, uno de los parámetros de mayor importancia en determinar los resultados reproductivos de un rebaño.

Los bajos porcentajes de señalada se deben principalmente a que la cifra promedio de mortalidad perinatal, en cría extensiva, se estima en 20 % de los corderos nacidos, con una variación del 10 al 30 % (Holmøy et al., 2017, Hinch y Brien, 2014, Dutra et al., 2007, Jordan y Le Feubre, 1989), siendo mayor en corderos mellizos (Fowler, 2007) y en los nacidos de ovejas primíparas (Nowak et al., 2000, Alexander et al., 1993), pero también puede verse influenciado por causas como la raza (Hinch y Brien, 2014), las características del predio, el clima y la presencia de predadores. Estas cifras sugieren la importancia del estudio de alternativas para incrementar la sobrevivencia de corderos en cría extensiva, ya que muchas veces todos los esfuerzos realizados para lograr alta tasas de preñez y partos múltiples se ven frustrados por un aumento de la mortalidad neonatal.

Para comprender las principales causas de mortalidad, es importante remarcar la característica extensiva de nuestra producción ovina. Existe una dependencia casi exclusiva del aporte nutricional del campo natural, el cual se caracteriza por una baja disponibilidad y calidad en los meses de invierno (Formoso, 2005), donde la mayoría de las ovejas están en el último tercio de la gestación. Además, la supervisión y asistencia de los partos es casi nula por las características de estos sistemas (ej., potreros demasiado grandes, baja disponibilidad de personal), lo cual trae como consecuencia una falta de información exacta sobre las causas precisas de muerte de los corderos. La causa final de las muertes neonatales está representada en parte por el complejo inanición-exposición, comprendiendo que esto incluye factores climáticos adversos (frío, lluvia, viento) y la incapacidad del cordero de alimentarse luego de nacido; pero muchos trabajos se basan en los hallazgos de autopsia de los corderos muertos, sin especificar los motivos primarios que llevan a que el recién nacido muera por no poder alimentarse (Jordan y Le Feubre, 1989). Es así que cada vez más se reconoce la importancia de los eventos relacionados con partos complicados como principal causa de mortalidad temprana (Flinn et al., 2020a, Jacobson et al., 2020, Dutra et al., 2007). Existe la posibilidad de que muchos corderos clasificados como muertos por inanición probablemente sean el resultado de una causa primaria, como la hipoxia sufrida debido a un parto distócico, o el abandono posparto inmediato por parte de la madre. Del mismo modo, en aquellos lugares donde existen predadores,

determinar si la causa de depredación es primaria o secundaria también es muy difícil cuando se trata de cría extensiva (Rowley, 1970).

Actualmente, los partos distócicos se identifican como un factor clave que emerge como la principal causa de muerte neonatal en corderos, representando un componente fundamental en la comprensión de las muertes tempranas. Las posibles alteraciones que un parto distócico pueda generar en el comportamiento ya sea de la oveja o del cordero evitarán que se logre un correcto vínculo madre-cría, imprescindible para la sobrevivencia del neonato.

1.2 COMPORTAMIENTO MADRE-CRÍA DURANTE EL PERIPARTO

1.2.1 Ocultadores y seguidores

De acuerdo con el tipo de relación que la cría tiene con su madre luego del parto, la mayoría de las especies de ungulados precociales se clasifican en una de dos categorías: ocultadores (inglés: *hiders*) o seguidores (inglés: *followers*) (Alexander, 1988, Lent, 1974). En los ocultadores, la cría queda escondida y, mientras la madre va a alimentarse, permanecen separados durante la mayor parte del día; esta conducta puede observarse durante varios días o semanas (dependiendo de la especie) teniendo un contacto diario limitado con la madre, sólo durante los momentos del amamantamiento. En cambio, en los seguidores las crías permanecen cerca de su madre, se paran y caminan rápidamente luego de nacer (a veces en unos pocos minutos), lo que les permite unirse a la manada/majada poco después del nacimiento. Este comportamiento da la posibilidad de que el amamantamiento sea frecuente, siendo en algunas especies hasta de 2 o 3 veces por hora. Las estrategias de esconderse o de seguir junto a la madre representan diferentes adaptaciones evolutivas para aumentar las posibilidades de supervivencia de los recién nacidos en diferentes entornos y condiciones ecológicas (Novak et al., 2000). Ambas estrategias de relación espacial madre-cría proporcionan protección contra la amenaza de predadores, ya sea mediante el ocultamiento del recién nacido o mediante el rápido desplazamiento de la madre y las crías en grandes grupos (King et al., 2012, Lent, 1974).

Los ovinos se clasifican como seguidores y su comportamiento gregario actúa como una importante defensa contra situaciones amenazantes (King et al., 2012).

Debido a esto, entre los animales de producción, los ovinos (junto con la mayoría de los camélidos) son prácticamente la única especie cuyas crías recién nacidas deben tener la capacidad de incorporarse y alimentarse rápidamente para poder seguir a su madre. El logro exitoso de esto dependerá de un reconocimiento mutuo entre la madre y su cordero, así como del rápido establecimiento de un vínculo exclusivo entre ambos que será irremplazable.

1.2.2. Establecimiento del vínculo madre-cría

En todos los mamíferos el desarrollo de un vínculo entre la madre y su cría es un aspecto crítico para la supervivencia del recién nacido. Debido a que la cría depende enteramente del suministro de leche brindado por su madre, una unión selectiva entre ambos durante las primeras horas después del parto es vital y representa una de las características esenciales del buen comportamiento materno de las especies precociales (Numan et al., 2006). Este vínculo permitirá a la oveja reconocer a su cordero, mantener el contacto y dejarlo mamar con exclusividad, rechazando con agresividad cualquier otra cría que no sea suya (Mora-Medina et al., 2016, Poindron y Lévy, 1990, Alexander, 1988, Poindron y Le Neindre, 1980).

1.2.2.1. Papel de la madre en establecer el vínculo con el neonato

El buen comportamiento de la madre inmediatamente luego del parto es esencial para que se establezca una relación única con el neonato (Dwyer, 2014). Dicho comportamiento incluye una serie de cuidados que la madre le brinda al cordero, lo que contribuye a generar un vínculo apropiado entre ambos. Una vez que se produce el nacimiento, las ovejas presentan patrones de comportamiento como el lamido del cordero y balidos de baja intensidad que le permitirán crear una memoria exclusiva con su hijo; en ese momento, el líquido amniótico, que es altamente rechazado en otras fases de su ciclo reproductivo, se vuelve muy atractivo (Dwyer, 2008a, Numan et al., 2006). Esta apetencia por el líquido amniótico comienza algunas horas previas al parto y se prolonga aproximadamente 4 horas luego de este, aunque declina de forma rápida durante la primera hora posparto (Arnould et al., 1991). El aseo no sólo limpia, seca y estimula al cordero, sino que ayuda a la madre a establecer el vínculo con él. Ese

vínculo es olfatorio y auditivo, ya que los balidos de baja frecuencia que emite durante el lamido tranquilizan al cordero y actuarán posteriormente como señales de mutuo reconocimiento (Nowak, 1990, Shillito-Walser y Hague, 1980). Keller et al. (2003) observaron que 30 a 60 minutos de contacto de la madre con el recién nacido ya son suficientes para que lo reconozca y, de este modo, rechace cualquier cordero ajeno. Los mismos autores señalan que el reconocimiento olfatorio es el primero en desarrollarse, mientras que el auditivo y el visual demoran más tiempo en adquirirse.

En las ovejas primerizas, se observa que el inicio del lamido del cordero es más lento en comparación con las ovejas multíparas y cualquier evento que interrumpa este proceso puede desencadenar un comportamiento agresivo hacia su propia cría (Lévy y Poindron, 1987). Esto es fundamental tomando en cuenta que, durante el periparto, las ovejas tienden a aislarse del resto de la majada, por lo que, en caso de que no se establezca una rápida relación madre-cría, el recién nacido quedará expuesto tanto al frío como a los predadores. La tendencia al aislamiento aparece antes del parto y se revierte rápidamente después de este (Poindron et al., 1997). Este cambio en el comportamiento social de la madre podría verse como una adaptación en animales gregarios como los ovinos para favorecer la interacción exclusiva con la cría y minimizar el riesgo de interferencia con otras ovejas preparturientas (Nowak et al., 2008), pero a la vez, es un punto débil en el caso que no se desarrolle rápidamente el vínculo con el cordero.

El comportamiento que favorece la selectividad incluye el acicalamiento y el contacto directo con el recién nacido (Dwyer et al., 2008a). Para las ovejas experimentadas, el lamido del líquido amniótico desempeña un papel facilitador, pero otras informaciones sensoriales pueden sustituir esta señal; sin embargo, en las primíparas, la limpieza del líquido amniótico es indispensable para el desarrollo normal del comportamiento maternal. En estas ovejas, la pérdida de esta información altera fuertemente el establecimiento del nexo con el neonato (Levy y Poindron, 1987).

1.2.2.2. Comportamiento del cordero en el establecimiento del vínculo

Inmediatamente posterior al nacimiento, el cordero realizará una secuencia específica de comportamientos dirigidos a pararse, encontrar la ubre y mamar. En

cuanto nace, mueve enérgicamente la cabeza, flexiona las patas, adopta una posición decúbito esternal y, por lo general, emite balidos de baja intensidad que llaman la atención de la madre (Nowak, 1990). Mientras la madre lo lame y lo seca, el cordero intentará pararse. La mayoría de los corderos lo logra en el transcurso de la primera media hora de nacido (Villar et al., 2023, López-Mazz et al., 2017, Banchero et al., 2010). Durante este evento, el comportamiento de la madre tiene una influencia limitada, ya que, incluso si no muestra interés o no acepta al cordero, este hará todo lo posible por pararse hasta lograrlo.

Una vez que logra caminar, comienza la búsqueda de la ubre para tener su primera ingesta de calostro, con la posibilidad de alimentarse y mantener la temperatura corporal. El proceso de encontrar la ubre y mamar se realiza normalmente en el transcurso de la primera hora de vida (Banchero et al., 2010, Nowak et al., 2000, Dwyer et al., 1996); pero esto no sólo dependerá de la eficacia del cordero en acceder a la ubre, sino que aquí el comportamiento de la madre juega un papel fundamental. Las madres más experimentadas colaboran para que el acceso a la ubre sea más fácil, mientras que las no experimentadas tendrán un comportamiento temeroso ante el acercamiento insistente del cordero, tratando de evadirlo o, incluso, mostrándose agresivas (Dwyer, 2008a, Dwyer y Lawrence, 2005, Kendrick et al., 1997).

Dwyer (2003) afirma que los corderos que más rápido se levantan y buscan la ubre (más vigorosos) se alimentan antes y poseen más chances de sobrevivencia en los primeros tres días de vida, considerando que no sólo se debe a los beneficios nutricionales e inmunológicos de la ingesta temprana de calostro, sino también al efecto que el amamantamiento tiene sobre el reconocimiento y creación del vínculo con su madre.

Al igual que sucede con las madres, la primera señal de reconocimiento que desarrollan los corderos es la olfativa (Vince y Ward, 1984), y horas más tarde adquieren la habilidad de reconocer a su madre a cierta distancia por señales auditivas y visuales (Nowak, 1991). Un cordero con mayor vigor estimula el comportamiento de la madre, ya que las ovejas se muestran más interesadas en corderos activos, que balan tempranamente (Stevens et al., 1984); aquellos corderos que tienen una alta

frecuencia de balidos, que se paran e intentan mamar rápidamente, se vuelven una señal importante para la atención de la madre (Nowak, 1990).

La realización exitosa de estos patrones de comportamiento tanto de la oveja como del cordero es fundamental para establecer un vínculo sólido entre ambos.

1.3 DURACIÓN DEL PARTO

Si bien al mecanismo del parto lo podemos dividir en 3 etapas: dilatación del cérvix (fase I), expulsión del feto (fase II) y expulsión de la placenta (fase III), durante este proceso, la etapa de expulsión fetal suele tener una duración menor en comparación con las otras fases. Esta etapa es la que mejor se aprecia, y su prolongada duración puede generar cambios en la conducta de la madre (Barrier et al., 2012, Hydbring et al., 1999).

La duración de la fase de expulsión del cordero puede variar desde unos pocos minutos hasta varias horas, dependiendo de la paridad, la raza, el tipo de parto (único o múltiple), el peso al nacer del cordero y el sexo. Sin embargo, varios autores registraron que la mayoría de los corderos nacen aproximadamente media hora después de haber comenzado la fase de expulsión (López-Mazz et al., 2017, Darwish y Ashmawy, 2011, Banchero et al., 2010).

Cuando las fases del parto se desarrollan normalmente, las ovejas muestran un rápido interés en el recién nacido; pero, si estas presentan alguna dificultad, el comportamiento se puede ver alterado rechazando a su cría (Dwyer, 2008a). En acuerdo con esto, se ha registrado que, frente a similares condiciones preparto, no todas las ovejas muestran el mismo comportamiento; algunas no limpian a sus corderos y los empujan y abandonan inmediatamente luego de paridos (Alexander, 1988). Este comportamiento se observa con frecuencia en primíparas, categoría en la cual se suelen se registran porcentajes de muerte neonatal superiores al de las multíparas (Jacobson et al., 2020). Una posible explicación a este fenómeno vincula la alta tasa de abandono con una mayor duración del parto que presentan las hembras primerizas (McHugh et al., 2016).

En los sistemas intensivos, la mortalidad de los corderos durante el parto y el período neonatal es minimizada mediante la supervisión y la asistencia (Binns et al.,

2002). Debido al manejo extensivo que se realiza en las majadas en nuestro país, esta práctica, aunque viene en aumento, no es comúnmente aplicada.

1.3.1. Alteraciones en la duración del parto: distocia

La distocia es una de las causas más relevantes de mortalidad de corderos en todo el mundo y sus consecuencias cobran mayor importancia en aquellos lugares donde se realiza cría extensiva (Jacobson et al., 2020). Implica asimismo consideraciones desde el punto de vista de las pérdidas económicas (Bruce et al., 2021), no sólo relacionadas con la mortalidad de corderos, sino también de ovejas. Es importante, a su vez, considerar el punto de vista de bienestar animal, ya que el dolor resultante de un parto distócico representa un problema potencial en este aspecto (Martínez-Burnes et al., 2021).

En oposición a un parto normal (eutócico), un parto distócico se define como un parto dificultoso debido a una prolongada fase de expulsión que puede requerir o no asistencia (Jacobson et al., 2020, Zaborski et al., 2009). Si bien la distocia puede tener un origen tanto materno (falta de dilatación cervical, inercia uterina, etc.) como fetal (fetos de gran tamaño o en mala presentación), ambos componentes están involucrados cuando se genera una desproporción entre el tamaño de la madre y el del feto (Jacobson et al., 2020).

El aumento en los partos distócicos se ha relacionado con la aplicación de estrategias tanto genéticas como de manejo con el fin de aumentar y mejorar la producción animal (Sánchez-Salcedo et al., 2019). En otras especies, pueden citarse como ejemplos tanto el aumento en el tamaño de las camadas como en el peso de la o las crías (Vanderhaeghe et al., 2013, Fix et al., 2010). En los ovinos, las razas que tienen una baja tasa de partos múltiples presentan un mayor riesgo de distocia en los casos de partos de corderos únicos y de gran tamaño (Banchero et al., 2016).

1.3.2. Consecuencias de un parto distócico

1.3.2.1 Consecuencias en el comportamiento materno

Un parto distócico suele estar relacionado con el abandono del cordero o con una falta total de interés hacia el recién nacido (ausencia de acicalamiento, olfateo o

apetencia por el líquido amniótico), lo que resulta en el desarrollo de un vínculo madre-cría débil o nulo (Dwyer, 2014, Levy y Poindron, 1987). Este comportamiento inadecuado se observa más frecuentemente en ovejas primíparas (Dwyer, 2014, Darwish y Ashmawy, 2011), lo que contribuye a tasas de mortalidad más elevadas en los corderos de esta categoría (Dwyer, 2008a).

1.3.2.2 Consecuencias para el cordero

Las primeras horas de vida son posiblemente la etapa más crítica para la supervivencia de cualquier neonato, ya que el proceso del nacimiento puede provocar un período de hipoxia o incluso asfixia a medida que el feto pasa de la respiración placentaria a la pulmonar (Dutra y Banchero, 2011).

Como consecuencias importantes que la asfixia tiene sobre el recién nacido, se describen la acidosis respiratoria y metabólica, la encefalopatía hipóxico-isquémica y el síndrome de aspiración de meconio (Martínez-Burnes et al., 2021, Martz et al., 2019, Dutra et al., 2007, Mota-Rojas et al., 2006).

— Acidosis respiratoria y metabólica

La restricción de oxígeno sufrida por el feto durante un parto prolongado es causa de acidosis respiratoria y, en casos más severos, de acidosis metabólica. A pesar de la rápida capacidad que tienen los neonatos para compensar la acidosis respiratoria y metabólica mixta con el inicio de la respiración, cuanto más prolongada sea la fase de expulsión, más extrema será la acidosis y más perjudiciales serán sus consecuencias (Martz et al., 2019).

Durante el período perinatal, el feto y luego el recién nacido dependen de sus reservas de glucógeno hepático, de la gluconeogénesis y del cambio a vías metabólicas anaeróbicas para mantenerse; esto puede causar un aumento en el ácido láctico y resultar en una acidosis metabólica (Martz et al., 2019, Bleul y Götz, 2013). Si la hipoxia persiste debido a la distocia, puede tener graves efectos negativos a largo plazo sobre la supervivencia del recién nacido o ser inmediatamente mortal (Martz et al., 2019).

— Encefalopatía hipóxico-isquémica

Cualquiera sea la etiología de la distocia, el incremento del riesgo de asfixia por la demora en la fase de expulsión trae relacionado la probabilidad de lesiones de encefalopatía hipóxico-isquémica como resultado de la falta de oxigenación y trauma al SNC (Dutra et al., 2007). Las lesiones más severas son seguramente causa inmediata de muerte de los corderos, mientras que las más leves probablemente les impide mamar y/o alteran su capacidad de adaptación al medio, lo que afecta su comportamiento y, por ende, la posibilidad de generar un rápido vínculo con su madre, sin el cual la supervivencia se verá comprometida (Dutra y Banchero, 2011, Dwyer, 2003, Dwyer et al., 1996).

— Síndrome de aspiración de meconio (MAS)

Otro indicador del estrés fetal resultante de la hipoxia intraparto es la expulsión de meconio en la bolsa amniótica, lo que causa tinción de la piel del feto y, en casos graves, aspiración y retención de meconio en los pulmones (Martínez-Burnes et al., 2021, Wong et al., 2002).

El síndrome de aspiración de meconio se ha reportado tanto en especies domésticas (Mota Rojas et al., 2006, López y Bildfell, 1992) como en humanos (Ward y Caughey, 2022, Monfredini et al., 2021, Olicker et al., 2021) como una de las principales causas potenciales de infecciones respiratorias en neonatos. La hipoxia sufrida durante el parto aumenta la actividad parasimpática en el feto, lo que desencadena el mecanismo de peristalsis intestinal y resulta en la expulsión de meconio (Olicker et al., 2021). Varios componentes del meconio son tóxicos para el tejido pulmonar (ej., bilis, bilirrubina) y pueden provocar una respuesta inflamatoria que causa neumonitis química, que podría llevar a la muerte del neonato, incluso varios días después del nacimiento (Olicker et al., 2021).

Debido a las serias consecuencias que la hipoxia intraparto puede acarrear para el cordero, es crucial poder detectar el nivel de oxigenación al nacer para poder implementar medidas terapéuticas o de manejo tempranas que contribuyan a su sobrevivencia. Se han utilizado diversas técnicas que permiten evaluar el grado de asfixia de los corderos al nacer. Entre estas técnicas se encuentra el uso de la gasometría (Vannucchi et al., 2012, Dutra y Banchero, 2011), pero el análisis de gases sanguíneos con fines no experimentales no es factible a campo. La validación de una

técnica sencilla, no invasiva y de fácil uso como lo es la oximetría de pulso constituiría una alternativa útil con este propósito.

1.4 HIPÓTESIS

1.4.1. Hipótesis general

La prolongada duración de la fase de expulsión fetal (fase II del parto) afecta tanto el comportamiento materno como el del cordero, lo que imposibilita el establecimiento de un vínculo apropiado madre-cría. Una disminución en el período de expulsión fetal permitiría mejorar estos parámetros y, por ende, mejorar las posibilidades de supervivencia neonatal.

1.4.2. Hipótesis específicas

— La duración de la fase de expulsión del parto afectará el comportamiento de las madres de manera diferente según su paridad. Se espera que las ovejas primíparas con una fase de expulsión prolongada tengan corderos con menor vigor y muestren un comportamiento materno deficiente en comparación con las ovejas multíparas.

— Un método no invasivo como la oximetría de pulso, para medir el estado de oxigenación en corderos recién nacidos, puede ser tan confiable como la gasometría para evaluar del grado de asfixia al nacer.

— La reducción de la fase de expulsión fetal mediante la asistencia programada al parto en ovejas primíparas mejoraría el comportamiento materno, así como el vigor del cordero al nacer.

1.5 OBJETIVOS

1.5.1. Objetivo general

Evaluar en qué medida la duración de la fase de expulsión fetal incide sobre el comportamiento posparto tanto de la madre como del cordero para determinar si existe un patrón de tiempo específico que llegue a afectar a ambos.

1.5.2. Objetivos específicos

— Caracterizar las diferencias de comportamiento materno al parto existentes entre ovejas multíparas y primíparas y determinar los parámetros que lo pueden afectar (categoría, condición corporal, peso vivo, duración del parto).

— Evaluar la vitalidad y el vigor de los corderos nacidos de madres primerizas o multíparas, relacionado con la duración del parto.

— Valorar de qué modo la duración de la fase II del parto influye sobre los niveles de asfixia que pueden sufrir los corderos al nacimiento y cómo repercute en su vigor y vitalidad.

— Validar la utilización de la oximetría de pulso como método alternativo para evaluar la oxigenación de los corderos neonatos.

— Comprobar si la disminución de la duración de la fase II (mediante asistencia programada al parto) logra mejorar tanto el comportamiento materno como el del cordero en ovejas primerizas.

1.6 PROPUESTA DE LA TESIS

El presente estudio busca contribuir al conocimiento existente y proporcionar información sobre las causas de muertes neonatales de corderos.

Dado la relevancia que los partos distócicos tienen en los ovinos, se evalúan las consecuencias de un aumento en la duración de la fase de expulsión fetal (fase II del parto) tanto sobre las características del comportamiento materno como en las posibles consecuencias que puedan registrarse en los corderos, debidas a un prolongado período de hipoxia sufrida durante el nacimiento.

Con el fin de evaluar los efectos que genera un parto prolongado, la estructura de esta tesis comprende 3 trabajos de investigación.

En el primer experimento se determinó el efecto de la duración del parto sobre el comportamiento materno en ovejas corriedale de parto único, criadas en forma extensiva, y se analizaron las diferencias entre categorías (primíparas vs. multíparas), así como la viabilidad de los corderos nacidos (capítulo 2).

En el segundo experimento, se evaluó la practicidad y precisión de la oximetría de pulso para valorar a campo el estado de oxigenación en corderos recién nacidos tanto de parto único como gemelar. Se correlacionó la oximetría de pulso con la gasometría y se relacionaron los resultados con el comportamiento de los neonatos. Se testeó la hipótesis de que un método no invasivo para medir el estado de oxigenación en corderos recién nacidos, como lo es la oximetría de pulso, puede ser tan confiable como la gasometría (capítulo 3).

Finalmente, en el tercer experimento, con el fin de acortar la fase de expulsión fetal, se propone la asistencia programada al parto como una estrategia de manejo preventiva que contribuya a aumentar la sobrevivencia de los corderos (capítulo 4).

2. LA DURACIÓN DE LA FASE II DEL PARTO AFECTA NEGATIVAMENTE EL COMPORTAMIENTO MATERNO Y LA VIABILIDAD DE LOS CORDEROS EN OVEJAS PRIMÍPARAS DE TIPO LANERO EN CRÍA EXTENSIVA

Regueiro M, López-Mazz C, Jorge-Smeding E, Baldi F, Banchero G

Resumen

Se determinó en qué medida la duración de la fase II del parto en la cría extensiva afecta la viabilidad de los corderos y el comportamiento materno en ovejas corriedale primíparas (P) (n = 63), utilizando como control ovejas multíparas (M) (n = 116). La duración del parto se dividió en: G1: ≤ 30 min; G2: 31-60 min; G3: 61-90 min y G4: ≥ 90 min para cada categoría. Se registró la condición corporal (BCS), la duración y la asistencia al parto, el escore de comportamiento materno (MBS, 1-5), la limpieza o no del cordero y la duración de la gestación. En los corderos, se registró test de Apgar (puntuación 0-10), tiempo en levantarse y mamar a las 2 h de vida, peso al nacer (BW) y mortalidad a las 72 h. El BCS previo al parto fue similar entre las categorías, mientras que en las P la gestación fue más corta (147,2 ± 0,3 vs. 148,0 ± 0,2 d), la fase de expulsión más larga (50,5 ± 4,2 vs. 32,2 ± 2,6 min), con mayor asistencia (22,2 vs. 11,2 %) que las M. Los corderos de ovejas P fueron más livianos (5,3 ± 0,1 vs. 5,8 ± 0,1). El Apgar fue similar entre categorías, pero en las ovejas P fue menor cuando la duración del parto fue mayor. El parto prolongado en las ovejas P influyó negativamente en el porcentaje de corderos que mamaron en las 2 h de nacidos (G1 = 95,5 %, G2 = 91,3 %, G3 = 75 % y G4 = 30 %), pero no en los nacidos de ovejas M. Entre categorías, el MBS fue diferente (P = 3,6 ± 0,2 vs. M = 4,7 ± 0,1), siendo menor en ovejas P de G3 (2,9 ± 0,3) y G4 (1,3 ± 0,2). La limpieza del cordero fue menor en ovejas P. La mortalidad de corderos fue mayor en P que en M (12,7 % vs. 1,7 %). El parto prolongado influye negativamente en el comportamiento materno de ovejas primíparas y en la supervivencia de corderos. El control de partos y la asistencia temprana en primíparas podría prevenir el abandono y la mortalidad de los corderos.

Palabras clave: comportamiento materno, mortalidad de corderos, vigor del cordero, duración del parto, ovejas primíparas

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Duration of phase II of labour negatively affects maternal behaviour and lamb viability in wool-type primiparous ewes under extensive rearing

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ABSTRACT

This study determined to what extent the duration of labour phase II under extensive rearing would affect lamb viability and maternal behaviour in primiparous (P) single-bearing Corriedale ewes (n = 63). Multiparous (M) ewes (n = 116) were used as control category, reared under the same conditions. Duration of labour was divided in 4 time-groups, G1: ≤ 30 min; G2: 31–60 min; G3: 61–90 min and G4: ≥ 90 min for each ewe category. Body condition score (BCS, scale 0–5), duration of labour, delivery assistance, maternal behaviour score (MBS, 1–5) and presence of grooming after parturition were recorded and length of gestation calculated. Lambs were Apgar tested (score 1–10) at birth; time elapsed to stand and successful suckling during the first two hours of birth was recorded as well as birthweight (BW) and mortality during their first 72 h. Prepartum BCS was similar between categories, while P ewes showed shorter gestation (147.2 ± 0.3 vs. 148.0 ± 0.2 days, P = 0.0474), longer expulsion phase (50.5 ± 4.2 vs. 32.2 ± 2.6 min, P < 0.0001) and required more delivery assistance (22.2 % vs. 11.2 %, P = 0.0496) than M ewes, with the highest percentage of assisted labours registered in G4 for both categories. Lambs born from P ewes were lighter than M-born lambs (5.3 ± 0.1 vs. 5.8 ± 0.1 kg, P < 0.0001) and BW and duration of labour had a significant correlation within each category. Apgar was similar between categories but among P ewes was lower when duration of labour was longer. Extended labour in P ewes had a negative influence on the percentage of lambs that sucked within 2 h of birth (G1 = 95.5 %, G2 = 91.3 %, G3 = 75 % and G4 = 30 %), but not in lambs born to M ewes. Between categories MBS was different (3.6 ± 0.2 vs. 4.7 ± 0.1 for P and M respectively) being lower in P ewes of G3 (2.9 ± 0.3) and G4 (1.3 ± 0.2). Grooming was observed in 100 % of M ewes but not in 20.6 % of P ewes. Lamb mortality was greater in P than in M ewes (12.7 % vs 1.7 %) with 75 % of the deaths registered within lambs born to primiparous when duration of labour was longer. It is concluded that in conditions of extensive breeding extended labour has a negative influence on lamb survival as well as on maternal behaviour in primiparous ewes. Birth control and perhaps a higher degree of assistance during phase II of parturition in primiparous becomes relevant to prevent ewe desertion and lamb mortality.

1. Introduction

Sheep production under intensive or semi-extensive systems has today reached optimal levels thanks to improvements in feeding, health management and advances in breeding strategies (De Arriba and Sánchez-Andrés, 2014). On the other hand, optimality is blurred under extensive rearing on pasture, the dominating form of production in most of the world, due to lamb mortality during and immediately after birth, a problem that despite the studies carried out to solve it still needs to be improved. In addition to the involved economic losses, caused by the loss of the lambs but also the decrease in wool production and the increased consumption of pastures of the pregnant ewe, animal welfare aspects are major, since many lambs suffer from hunger and cold for hours or even days before death (Banchero, 2003). During the process of parturition, phase II (expulsion of the foetus) is the one that causes the highest pain in the mother (Hydbring et al., 1999; Barrier et al., 2012),

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and its duration is in general directly related to the decrease in the vigour of the new-born or even death of the lamb/ewe (Dutra and Banchero, 2011). An extended duration of parturition causes the lamb to be born with some degree of asphyxia that will affect its vigour at birth (Dutra and Banchero, 2011). Besides aspects of asphyxia during a prolonged labour phase II, survival of the neonate largely depends on the establishment of a rapid mother-offspring bond immediately after delivery, one of the essential characteristics of good maternal behaviour. The first minutes postpartum are fundamental for mutual recognition and any factor that alters this fact will have an impact on this relationship (Nowak and Poindron, 2006).

Starvation in conjunction with exposure to cold weather is one of the leading causes of neonatal death under field conditions. This fact is related in most cases with the desertion of the lamb by the mother after birth, or with a total lack of maternal interest related to the newborn (absence of grooming, sniffing, or greediness for the amniotic fluid), which ends with the development of little or no link between the ewe and the lamb (Levy and Poindron, 1987; Dwyer, 2014). This misbehaviour is often observed in primiparous, leading to higher mortality rates compared to multiparous ewes; presumably in relation to their poorer body development and/or condition score during pregnancy, which in turn would lead to the birth of lighter lambs with less vigour (Dwyer, 2014). Under these conditions, if the first intake of colostrum is delayed, the energy reserves of the new-born are quickly depleted, highly reducing survival (Dwyer et al., 2005). A possible explanation for this high rate of ewe desertion and poor maternal behaviour among primiparous ewes could be linked with their longest time of labour phase II (Alexander, 1988).

The present study aimed therefore to determine to what extent the duration of labour phase II would affect lamb viability and maternal behaviour in single-lambing Corriedale primiparous ewes reared extensively. Multiparous ewes were used as control category, raised and reared under the same management and location. The hypothesis that the duration of the expulsion phase of parturition would affect mothers' behaviour differently according to their parity was tested. It is expected that primiparous ewes with a prolonged phase of expulsion will have lambs with less viability and will show poor maternal behaviour compared to multiparous ewes.

2. Material and methods

2.1. Location

The experiment was performed in an experimental station in eastern Uruguay (Estación Experimental B. Rosengurtt, Facultad de Agronomía, Udelar; located: 32° 21' S, 54° 26' W) following the experimental procedures approved by the Honorary Committee for Animal Experimentation of Universidad de la República (CEUA-Udelar-N°021130-001370-14).

2.2. Animals and general management

Data collected on 116 multiparous (three-to-six years of age) and 63 nulliparous (two years of age) single-bearing Corriedale ewes as a single flock were used. Two-hundred seventy-eight ewes were synchronized in oestrus using a Prostaglandin F2α analogue (Glandinex ® Universal Lab) with two doses of 160 mg Delprostenate per animal, separated by an interval of 8 days. Heat was detected twice a day using vasectomized rams. Artificial insemination (AI) was performed cervically 12 h after heat detection with fresh semen from one of seven Corriedale rams. The ewes were scanned (ALOKA Prosound 2 ultrasound) for pregnancy 45 days after the beginning of AI with a transrectal probe with a 7.5 MHz linear transducer. According to the size of the foetus and the day on which AI was performed, the expected date of parturition was calculated for each ewe. Litter size was recorded and only ewes carrying a single foetus were included in the experiment. All the animals were shorn prepartum at 104 ± 3.2 days of gestation.

2.3. Lambing control

From one week before the expected date of parturition the ewes were allocated in a 1.5-hectare paddock, grazing native pastures *ad libitum* and with free access to water. At night, and until next morning, the ewes were taken to pens near the daytime paddock, which had lighting for night control of births. Four days before the expected day of parturition, ewes were kept under 24 h surveillance which was done from at least 10 m distance (with the help of binoculars) so that the ewe that began labour phase II could be observed with minimal interference. Delivery assistance was provided only if more than 2 h elapsed since any part of the lamb was seen at the vulva without progressing, or in case of any evident malpresentation (Dwyer, 2003). After 2 days of giving birth and having obtained the corresponding data, the ewes with their respective offspring were separated from the rest of the flock in nearby pastures for about three to four days, and then taken to a mix-meadow (*Festuca arundinacea, Trifolium repens, Lotus corniculatus*) in which they remained until weaning. All ewes were acclimated to human presence before parturition until approach without disturbance.

2.4. Data recording

2.4.1. Mothers

Body condition score (BCS) was recorded in a scale 0 (emaciated) to 5 (obese) (Russel et al., 1969) one week before parturition. The score was performed by a single experienced technician for the entire flock. The duration of phase II of parturition was registered for each ewe, defined as the moment from which any part of the lamb could be seen until the moment of its total expulsion (Dwyer, 2003). Delivery assistance was avoided as far as possible, and only provided if strictly necessary (malpresentation of the lamb or more than 2 h elapsed from the beginning of labour) and recorded.

2.4.2. Lambs

Within the first minute of birth, an Apgar test for lambs (mnemonic for **a**ppearance, **p**ulse, **g**rimace, **a**ctivity and **r**espiration) was performed following the modifications described by Dutra and Banchero (2011) for the Apgar used for the evaluation of new-born babies (American Academy of Pediatrics, 2006). Apgar is a scoring system where each parameter evaluated is given a score of 0–2 so that an Apgar score between 0 and 10 can be obtained. The score was performed from a distance, without making contact with the newborn to avoid interference with maternal behaviour. Contact with the lamb was taken only in case one or more of the parameters evaluated were '0'.

Both latency from birth to stand up (when the lamb stood on its four legs extended for at least 6 s) and to suckle (the lamb effectively accessing a mother's teat and suckling for at least 5 s (Dwyer, 2003)) were recorded. About two hours after birth (after the lamb stood up and suckled) the new-born was controlled for sex, ear-tagged (plastic tags placed on the right ear) and weighed using a portable digital hanging weighing scale (Walmur ®), with a capacity of 50 kg and an accuracy of 20 g.

2.5. Maternal behaviour score (MBS) and grooming

Assessment of maternal behaviour was performed while the lamb was being ear-tagged and weighed. The behaviour of the ewe was recorded based on the distance away from her lamb when being manipulated and how long it took her to return back to the neonate once manipulation was finished. Ewe MBS was scored between 1 and 5, where 1 corresponds to a bad mother (moves away from the lamb and does not return) and 5 an excellent mother (stays very close to the lamb and makes physical contact with it when handled; O'Connor et al., 1985). Ewe's licking of amniotic fluid (grooming) immediately after

parturition was also recorded.

2.6. Lamb mortality

Mortality of lambs during the first 72 h of birth was recorded and expressed as percentage (number of dead lambs over the total live births x 100). Because the response variables sought in this experiment were mostly behavioural, ewes that delivered dead lambs were excluded from the results. Those lambs that were not recognized by their mothers after 24 h after birth were considered "deserted" and accounted as "dead" for statistical analyses.

2.7. Experimental design

All the ewes (2 categories; Primiparous: 2-year-old ewes lambing for the first time, (experimental group) or Multiparous: 3–6 year-old ewes with at least one previous lambing, (control)), were managed as a single flock since AI and during all gestation and lambing periods. Considering a previous experiment with the same flock (Regueiro et al., 2018) where the average phase II of parturition for single lambs was about 30 min; the duration of phase II was divided in 4 time-groups, namely G1: ≤ 30 min (normal); G2: 31–60 min (2x normal); G3: 61–90 min (3x normal) and G4: > 90 min (4x normal).

2.8. Statistical analyses

All recorded data were analysed using SAS/IML14.1 software (SAS Institute, 2015). All variables were analysed considering 2 different models: 1) Parity group as fixed effect (primiparous vs. multiparous ewes); 2) Duration of phase II within each parity group (G1 = ≤ 30 min, G2 = 31–60 min, G3 = 61–90 min and G4 = > 90 min) as fixed effect. The approach based on two simple models rather than a unique model considering the interaction effect, was preferred in order to gain statistical power. Lamb viability, maternal body condition score (BCS) at lambing, length of gestation, birth weight of the lambs and time elapsed to stand were analysed by least squares ANOVA using the PROC MIXED according to the two fixed effects models previously stated. The maternal BCS of the ewes, birth weight and sex of the lambs were always tested as covariates, except BCS and birth weight when they were considered as dependent variables. Due to lack of significance, all covariates were removed from the models. Apgar test and MBS were analysed considering a Multinomial distribution using PROC GENMOD. The frequency of lambs suckling during the 1st and 2nd hour of birth, mortality within the first 72 h, presence of grooming and delivery assistance was assumed as binomial as these variables were treated as categorical ones (yes/no) distribution and analysed with PROC GLIMMIX. Correlations between lamb birth-weight vs. duration of phase II and Apgar test vs. duration of phase II were performed with PROC CORR. Significant differences between means were considered when P ≤ 0.05. Data are presented as mean ± sem.

3. Results

From the 278 ewes that had been synchronized for breeding, 93 were discarded from the study because they were either carrying twins or they were not pregnant, thus leaving 65 primiparous and 120 multiparous ewes, from where data from two additional primiparous and four multiparous ewes could not be properly recorded. The final account of ewes presented in Tables 1 and 2 corresponds to 63 primiparous and 116 control multiparous ewes and their lambs. None of the ewes gave birth to a still-born lamb.

Body condition score measured one week before parturition did not differ between categories or groups (Table 1). The duration of gestation was shorter in primiparous (147.4 ± 0.4 days) than in multiparous ewes (148.0 ± 0.2 days). Within category, primiparous ewes in G1 showed shorter gestation length (146.7 ± 0.6) than those in G3 (149.0 ± 1.1)

Table 1
Body condition score (BCS), gestation length, duration of labour, delivery assistance, maternal behaviour score (MBS) and presence of grooming of Primiparous and Multiparous ewes in Groups according to duration of phase II of parturition. Different numbers in the same row denotes differences between categories. Values within rows with differing superscripts letters are significantly different between groups in each category. Values are presented as means ± SEM. Differences are considered significant when $P \leq 0.05$.

		Duration of labour phase II in Primiparous ewes					Duration of labour phase II in Multiparous ewes			
	100 % (**n = 63**)	Group 1 (< 30 min) 34.9 % (n = 22)	Group 2 (30–60 min) 36.5 % (n = 23)	Group 3 (60–90 min) 12.7 % (n = 8)	Group 4 (< 90 min) 15.8 % (n = 10)	**100%** (**n = 116**)	Group 1 (< 30 min) 62.9 % (n = 73)	Group 2 (30–60 min) 21.6 % (n = 25)	Group 3 (60–90 min) 10.3 % (n = 12)	Group 4 (< 90 min) 5.2 % (n = 6)
BCS (scale 0–5)	**3.3 ± 0.04**	3.2 ± 0.08	3.3 ± 0.07	3.3 ± 0.05	3.2 ± 0.09	**3.2 ± 0.04**	3.2 ± 0.05	3.2 ± 0.08	3.2 ± 0.12	3.1 ± 0.11
Gestation lenght (days)	**147.2 ± 0.3**[2]	146.2 ± 0.6[a]	147.1 ± 0.6[ab]	149.0 ± 1.0[b]	148.3 ± 0.8[b]	**148.0 ± 0.2**[1]	147.7 ± 0.3	148.3 ± 0.4	148.5 ± 0.7	149.6 ± 1.0
Duration of labour (min)	**50.5 ± 4.2**[2]	22.1 ± 1.2[a]	42.8 ± 1.8[b]	74.9 ± 2.3[c]	111.0 ± 7.0[d]	**32.2 ± 2.6**[1]	15.7 ± 0.8[a]	42.9 ± 1.7[b]	70.8 ± 1.9[c]	116.0 ± 8.0[d]
Delivery assistance (%)	**22.2**[2]	9.1[a]	4.3[a]	50.0[b]	70.0[b]	**11.2**[1]	6.8[a]	8.0[a]	25.0[ab]	50.0[b]
MBS (scale 1–5)	**3.6 ± 0.2**[2]	4.1 ± 0.3[a]	4.2 ± 0.3[a]	2.9 ± 0.6[b]	1.3 ± 0.2[c]	**4.7 ± 0.1**[1]	4.7 ± 0.1	4.7 ± 0.1	4.5 ± 0.3	4.7 ± 0.2
Presence of grooming (%)	**76.2**[2]	95[a]	91[a]	50[b]	20[b]	**100**[1]	100	100	100	100

Table 2
Live birth weight (LBW), Apgar test, time elapsed from birth to stand (Stands), suckling within 1 or 2 h of birth, and mortality at 72 h of lambs born to Primiparous and Multiparous ewes in Groups according to duration of phase II of parturition. Different numbers in the same row denotes differences between categories (Primiparous or Multiparous). Values within rows with differing superscripts letters are statistically different ($P \leq 0.05$) between groups in each category. Values are presented as means ± SEM.

		Duration of labour phase II in Primiparous ewes					Duration of labour phase II in Multiparous ewes			
	100 % (**n = 63**)	Group 1 (< 30 min) 34.9 % (n = 22)	Group 2 (30–60 min) 36.5 % (n = 23)	Group 3 (60–90 min) 12.7 % (n = 8)	Group 4 (< 90 min) 15.8 % (n = 10)	**100 %** (**n = 116**)	Group 1 (< 30 min) 62.9 % (n = 73)	Group 2 (30–60 min) 21.6 % (n = 25)	Group 3 (60–90 min) 10.3 % (n = 12)	Group 4 (< 90 min) 5.2 % (n = 6)
LBW (kg)	**5.3 ± 0.1^{2}**	5.1 ± 0.1^{a}	5.2 ± 0.1^{ab}	5.4 ± 0.4^{ab}	5.7 ± 0.3^{b}	**5.8 ± 0.1^{1}**	5.6 ± 0.1^{a}	6.0 ± 0.2^{b}	$6.3 \pm 0.3b^{c}$	6.6 ± 0.2^{bc}
Apgar (scale 0–10)	**9.0 ± 0.2**	9.2 ± 0.2^{a}	9.3 ± 0.1^{a}	9.1 ± 0.3^{a}	7.7 ± 0.7^{b}	**9.2 ± 0.1**	9.3 ± 0.1	9.0 ± 0.2	8.9 ± 0.3	9.2 ± 0.3
Stands (min)	**22.7 ± 1.2**	22.6 ± 2.2	21.5 ± 1.8	25.8 ± 4.6	23.3 ± 2.7	**22.3 ± 1.0**	23.7 ± 1.3	20.9 ± 1.9	19.2 ± 1.8	17.8 ± 2.7
Suckling within 1 h of birth	**$53.9\ \%^{2}$**	$77.3\ \%^{a}$	$78.3\ \%^{a}$	$50.0\ \%^{b}$	$20.0\ \%^{c}$	**$87.9\ \%^{1}$**	87.7 %	88.0 %	83.3 %	100 %
Suckling within 2 h of birth	**$82.5\ \%^{2}$**	$95.5\ \%^{a}$	$91.3\ \%^{a}$	$75.0\ \%^{b}$	$30.0\ \%^{c}$	**$100\ \%^{1}$**	100 %	100 %	100 %	100 %
Mortality at first 72 h	**$12.7\ \%^{2}$**	$0\ \%^{a}$	$8.7\ \%^{a}$	$37.5\ \%^{b}$	$30\ \%^{b}$	**$1.7\ \%^{1}$**	0 %	4 %	8.3 %	0 %

and G4 (148.3 ± 0.9). There were no significant differences in the duration of gestation between corresponding groups among multiparous ewes.

In general, duration of phase II was longer in primiparous ewes (50.5 ± 4.2 min) than in multiparous ones (32.2 ± 2.6 min) (Table 1). When graded for labour phase II duration, two third of multiparous ewes (62.9 %, 73/116) had an expulsion phase shorter than 30 min while only on third (34.9 %, 22/63) of the primiparous ones were registered in this time group. Delivery assistance was required in a higher proportion of primiparous ewes (22.2 %) than among multiparous (11.2 %) and, in both categories, the highest percentage of assisted labours was registered in G4. None of the primiparous ewes registered malpresentation at birth, while among the multiparous four ewes presented it but did not require assistance.

Duration of phase II was affected by lamb birth weight in both categories. Birth weight and duration of phase II had a significant but relatively low correlation within each category (primiparous: r = 0.30, P = 0.018; multiparous: r = 0.39, P = 0.002). Lambs born from primiparous ewes were lighter than multiparous-born lambs (5.3 ± 0.1 vs. 5.8 ± 0.1 kg, Table 2). Differences in birth weight were observed within multiparous groups while among primiparous groups the differences were observed only between G1 and G4 (Table 2).

Lamb vitality (Apgar test) was not different between categories (9.0 ± 0.2 vs. 9.2 ± 0.1 for primiparous and multiparous ewes respectively) but it was lower among lambs delivered from primiparous ewes with longer duration of phase II (G4 = 7.7 ± 0.7), being different from the rest of the groups in this category: G1 = 9.2 ± 0.2, G2 = 9.3 ± 0.1 and G3 = 9.1 ± 0.3. These values were in contrast with those of lambs born from multiparous ewes where there were no differences among groups (Table 2). There was a relatively low, negative correlation between Apgar test and duration of phase II for primiparous (r = -0.39, P = 0.002) but it was not significant for multiparous ewes (r = -0.15).

Almost all lambs stood up during the first 30 min post-partum with no differences between groups or categories (22.7 ± 1.2 vs. 22.3 ± 1.0, for primiparous and multiparous ewes respectively), while the frequency of lambs that successfully sucked within the first hour of life was lower in primiparous (53.9 %) compared to multiparous ewes (87.9 %). Two hours after birth, all lambs from multiparous ewes successfully sucked but 17.5 % of the lambs born from primiparous groups did not. These lower percentages of successful sucking among lambs born from primiparous were recorded in births having the largest duration of phase II (Table 2). During the first hour of life, lambs born from primiparous ewes in G1 and G2 successfully sucked (77 % and 78 % respectively) near 4 times more than G4 lambs (20 %). During the second hour after birth, the cumulative percentage of lambs born from primiparous ewes that successfully suckled was 30 % in G4, being different from the rest of the groups (Table 2).

Longer lambing time also negatively affected maternal behaviour in primiparous ewes. Maternal behaviour showed a significantly lower score in primiparous compared with multiparous ewes (3.6 ± 0.2 vs. 4.7 ± 0.1). Primiparous ewes with a longer duration of phase II had the lowest MBS (G4 = 1.3 ± 0.2) compared to the other groups in this category (G1 = 4.1 ± 0.3, G2 = 4.2 ± 0.3, G3 = 2.9 ± 0.6), while multiparous ewes depicted no differences between groups (Table 1). Grooming of the new-born (licking the amniotic fluid) was observed in all the multiparous ewes immediately after lambing, but 15 primiparous ewes (23.8 %) did not show that behaviour, coinciding with an MBS = 1 in all of them. The majority (12/15) of these ewes were registered in G3 or G4 (Table 1).

Lamb mortality during the first 72 h was higher in primiparous (12.7 %) than in multiparous ewes (1.7 %), with 75 % (6/8) of the deaths registered within lambs born from primiparous when duration of phase II was longer (G3 and G4). The sex of lambs did not affect any of the studied variables.

4. Discussion

The results of the present experiment supported the hypothesis that the duration of phase II of labour can affect maternal behaviour differently according to the parity of the ewe.

The expulsion phase labour was longer among primiparous ewes than in controls, yet birth weight of the lamb was used as a covariable. Within ewes lambing for the first time, extended phase II affected maternal behaviour, required a higher percentage of delivery assistance and prevent their lambs from suckling, resulting in a higher lamb mortality.

Birth weight and the duration of phase II of parturition significantly correlated for both ewe categories. It seems relevant to consider that expulsion time might not simply be related to a certain live weight of the lamb, but rather to the relation between the size of the foetus in relation to that of the mother, and the possibility that the pain experienced by the ewe during expulsion would condition the duration of labour rather than the absolute size of the foetus. Alexander et al. (1993) found that maternal misbehaviour was seen in 2–5 years-old ewes giving birth for the first time. Even in one of their experiments, primiparous 5-year-old ewes had a longer birth duration than 2-year-old ones, and the consequent increase in the percentage of lamb desertion. This leads us to think that the relaxation of the birth canal for the very first time is an element to be considered as the cause of the increase in the pain generated and the duration of labour, beyond the size of the offspring or the age of the mother.

Maternal behaviour was significantly affected in primiparous ewes. Maternal behaviour score was significantly lower in primiparous compared with multiparous ewes despite having a similar body condition score by the end of gestation. Indeed, Banchero (2004) working with adult Merino ewes reported that maternal behaviour is not influenced if the ewes have a BCS between 2.7 and 4.4, a range which the tested animals in the present study were well within. This suggests that the differences in maternal behaviour are related with the differences in the duration of labour.

Apgar test was not different between maternal categories. Despite of that, the test was significantly lower among lambs delivered from primiparous ewes with longer duration of labour (G4 = 7.7 ± 0.7) compared to the rest of the groups. Dutra and Banchero (2011) working with multiparous Texel and Polwarth ewes found that parturition duration increased linearly the risk of poor viability at birth. In accordance with this, in the present experiment a negative correlation was found between Apgar test and duration of labour in those lambs born from primiparous ewes, but this correlation was not significant in those born from multiparous ewes. A possible explanation for this is that average duration of labour for multiparous was shorter than in primiparous (32.2 vs. 50.5 min); this average being within the values described as normal. Thus, the possible correlation between Apgar test and duration of labour is expressed only in the primiparous ones, where this parameter had a marked increase.

The time taken by a new born lamb to first stand mostly depends on its individual ability and the constraints imposed by the parturition, while the interval from birth to first suckling has the added maternal component, in the sense of allowing access and even guiding the lamb to the udder or, on the contrary, preventing the lamb from accessing the udder, running or even bumping it (Alexander et al., 1993; Dwyer et al., 2003; Dwyer and Lawrence, 2005). In this sense, the maternal poor behaviour of primiparous females in groups with the longest labour (G3 and G4) also corresponded with a longest time elapsed to the first suckle observed on their lambs, thus combining both components (mother and offspring). In summary, primiparous ewes had a longer duration of labour which affected interval to suckling and lamb viability but not time elapsed from birth to stand.

Longer lambing time also negatively affected maternal behaviour in primiparous ewes. Primiparous mothers with a longer duration of labour had the lowest maternal behaviour score compared to the other groups in this category, while multiparous ewes depicted no differences between groups with different duration of phase II labour. Despite the animals were acclimated to human presence, delivery assistance could have been an influential factor in the maternal behaviour they displayed. The proportion of primiparous ewes requiring assistance doubled that of multiparous ewes, clearly indicating that lack of experience would have also played a role, alongside fear and pain. Remarkably, of the assisted primiparous ewes, the majority belonged to G3 and G4 (longer labour) which had a low MBS. Thus, considering that all assisted multiparous ewes as well as primiparous with shorter labour had high MBS, the bad maternal behaviour registered within primiparous ewes in groups 3 and 4, seems to be more linked to the duration of phase II than to delivery assistance itself.

Twelve out of 18 primiparous ewes (67 %) with the longest duration of phase II (G3 and G4) and a lowest MBS, did not groom their lambs after delivery. Grooming not only cleans, dries and stimulates the lamb but also helps the mother to establish an exclusive bond with her offspring (Poindron et al., 1984, 2010). Olfactory cues from fetal fluids are involved in licking behaviour (Otal et al., 2009). Amniotic fluid that is highly repulsive in other phases of ewe reproductive cycle becomes very attractive at lambing (Numan et al., 2006; Dwyer, 2007). This attraction begins a few hours before delivery and lasts for approximately 4 h after birth (Levy et al., 1983; Arnould et al., 1991) although it declines rapidly during the first hour. In primiparous ewes, licking amniotic fluid is necessary for a normal development of maternal behaviour while multiparous can use other sensory information in substitution (Levy and Poindron, 1987). Thus, once the mechanism for attraction for fetal fluids is triggered, if the primiparous ewes have a longer duration of parturition they may show declined avidity to groom their lamb either because it diminishes during the course of a long labour *per se* or because of a prolonged pain and the fear it causes; but in both cases the bond with the offspring will never be established and the risk of lamb desertion will be a fact. Dwyer (2003), working with primiparous Scotish Blackface, found that latency to groom was affected by birth difficulty and the proportion of time spent grooming was reduced by the duration of labour. In the present experiment, from the 15 lambs that were never groomed, 8 were abandoned or died.

The possible failures in maternal behaviour were studied and lamb mortality was considered during the first 72 h. Total lamb mortality for primiparous ewes sharply contrasted with that of multiparous ewes (12.7 % (8/63) vs. 1.7 % (2/116) respectively; Table 2), with 75 % (6/8) of the dead neonates among primiparous ewes belonging to ewes with the longest duration of phase II. In extensive rearing conditions it is important to differentiate whether the lambs die due to the abandonment of their mothers or as a consequence of dystocia. In the present study, all lambs managed to stand up and they had acceptable Apgar scoring averages. It remains to be established whether the fear and pain experienced by a primiparous ewe under a long expulsion phase of labour conditions her capacity to accept or prevent the newborn to suckle. If so, the consequences could lead to lambs dying.

Even under extensive rearing conditions, special care during lambing period for primiparous ewes becomes an essential management to avoid lamb mortality. Any tool that helps to reduce pain during expulsion phase of parturition should be evaluated and, if possible, applied to prevent prolonged suffering of the ewes, as well as the possible decrease in lamb vitality. In this sense, nutritional management in the last third of gestation must be considered carefully. During this period most of the increase in the size of the foetus takes place (Robinson et al., 1999) and changes in the nutrition of the mother can lead to lambs with high bodyweight at birth and the subsequent consequence (dystocia). Late gestation short-term feeding to increase the production and quality of colostrum available without increasing the weight of the lamb at birth (Murphy et al., 1996; Banchero et al., 2007, 2009), seems to be a valuable tool to avoid dystocia, thus preventing lamb desertion.

It appears relevant to study if a quicker assistance to the primiparous ewes, decreasing the interval of phase II would be significantly

beneficial. An objective measure for the degree of respiratory compromise of the lamb during labour would be also interesting to evaluate.

5. Conclusion

Extended labour had a negative influence on lamb survival as well as on maternal behaviour in primiparous but not in multiparous ewes reared under extensive conditions on pasture. It is concluded that even under conditions of extensive breeding, birth control of primiparous ewes becomes highly relevant to prevent lamb desertion and subsequent mortality.

6. Author contribution

Design of the study: MR and GB; sample collection: MR and CLM; data analysis: MR, EJS and FB; first draf: MR, CLM and GB. All authors participated in the writing and approved the final version of the manuscript.

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Declaration of Competing Interest

The authors declare that there is no conflict of interest that could inappropriately influence the content of this study.

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3. COMPARACIÓN ENTRE LA OXIMETRÍA DE PULSO Y EL ANÁLISIS DE GASES EN SANGRE VENOSA PARA EVALUAR LA ASFIXIA DEL CORDERO DURANTE EL PARTO

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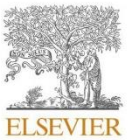
Resumen

Se consideró la practicidad y precisión de la oximetría de pulso para valorar el estado de oxigenación en corderos recién nacidos en condiciones de campo. La oximetría se comparó con el análisis de gases en sangre e incluyó la evaluación de la vitalidad (test de Apgar; puntuación 0-10) y el vigor (tiempo en levantarse y mamar) de 135 corderos finnish x polwarth. Las muestras se obtuvieron inmediatamente después de la expulsión fetal. El porcentaje de saturación de oxígeno ($satO_2$) se midió utilizando un oxímetro pinzado en una oreja, y se comparó con variables de gasometría medidas de una muestra sanguínea de vena yugular. Se estudiaron las correlaciones entre la $satO_2$ registrada mediante oximetría y los parámetros de gasometría venosa directos: presión parcial de dióxido de carbono (pCO_2), presión parcial de oxígeno (pO_2) y pH, o estimados: concentración de bicarbonato, exceso de bases del líquido extracelular y saturación de oxígeno. Considerando el pH como un buen indicador de hipoxia en el parto, los datos se agruparon como: G1 = pH < 7,1; G2 = 7,1 ≤ pH < 7,2; G3 =7,2 ≤ pH < 7,3 y G4 = pH ≥ 7,3. La $satO_2$ medida mediante oximetría se correlacionó con la pCO_2 (r = -0,50; P < 0,001), el pH (r = 0,36; P < 0,001) y la pO_2 (r = 0,2; P = 0,04). Los corderos con valores bajos de pH (G1 = pH ≤ 7,1: acidosis) mostraron el porcentaje más bajo de intento y éxito en levantarse y mamar, baja puntuación de Apgar (G1 = 6,7; G2 = 8,6; G3 = 8,6; G4 = 8,5; P = 0,025), el porcentaje más bajo de $satO_2$ medida por oximetría (G1 = 78,8; G2 = 87,5; G3 = 87,7; G4 = 92,1 %; P = 0.011) y la pCO_2 más elevada (G1 = 78,5; G2 = 73,8; G3 = 65,8; G4 = 53,8 mmHg; P < 0.001). La oximetría de pulso resulta un método práctico y preciso para evaluar la asfixia del cordero al nacer, ayudando a identificar las limitaciones de oxigenación durante el parto, facilitando la prioridad del manejo perinatal y mejorando así la supervivencia.

Palabras clave: oximetría de pulso, gasometría, asfixia, fase II del parto, ovino

Small Ruminant Research 210 (2022) 106665



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Comparison between pulse oximetry and venous blood gas analyses to assess lamb asphyxia at parturition

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ABSTRACT

Early detection of fetal distress at lambing is essential to reduce mortality. Practicality and accuracy of pulse oximetry to assess oxygenation status in newborn lambs under field conditions was evaluated. Oximetry was compared with blood gas analyses and included assessment of vitality (Apgar test) and vigour (attempt to and successful standing and suckling) of 135 Finnish by Polwarth lambs. Sampling of data was obtained immediately after fetal expulsion; percentage of oxygen saturation ($satO_2$) was measured using a pulse oximeter clamped to an ear, and was compared with gas analyses variables measured from a jugular vein sample (Gas Analyser: Siemens-Rapidlab 248®). Correlations between $satO_2$ measured by pulse oximetry and venous blood gas parameters either directly (partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2) and pH) or estimated (bicarbonate concentration, extracellular fluid base excess, and oxygen saturation) were studied. Considering pH as a good indicator of hypoxia at parturition, data was grouped as: G1 = pH < 7.1; G2 = 7.1 ≤ pH < 7.2; G3 = 7.2 ≤ pH < 7.3 and G4 = pH ≥ 7.3. Saturation of oxygen measured by pulse oximetry correlated significantly with pCO_2 ($r = -0.50$; $P < 0.001$), pH ($r = 0.36$; $P < 0.001$) and pO_2 ($r = 0.2$, $P = 0.04$) measured by blood gas analyses. Lambs with low pH values (G1 = pH ≤ 7.1, acidosis) showed the lowest percentage to attempt and success to stand and suck, lowest Apgar score (G1 = 6.7, G2 = 8.6, G3 = 8.6, G4 = 8.5, P = 0.025), lowest percentage of $satO_2$ measured by oximetry (G1 = 78.8%, G2 = 87.5%, G3 = 87.7%, G4 = 92.1%, P = 0.011) and highest pCO2 (G1 = 78.5, G2 = 73.8, G3 = 65.8, G4 = 53.8 mmHg, P < 0.001). Pulse oximetry appears an accurate method to evaluate lamb birth asphyxia, helping to identify oxygenation constraints during labour, facilitating priority of perinatal handling, and thus improving lamb survival.

1. Introduction

Sheep production under extensive rearing in temperate countries such as Uruguay is constrained by a rather long lambing season during late winter; climatic changes can compromise lamb survival (De Barbieri et al., 2012) but nutritional restriction of energy, protein and minerals due to reduced forage availability can eventually lead to dystocia (Jacobson et al., 2020). As a result, perinatal lamb mortality is particularly seen due to a prolonged expulsion phase of labour (phase II) where lamb asphyxia can occur, leading to different degrees of neonatal injury: from birth of dead lambs to low levels of oxygenation due to insufficient pulmonary function (Dutra and Banchero, 2011).

Indirect monitoring of pulmonary function by determining levels of oxygen saturation in blood is common practice in human medicine both during labour and immediately post-partum (Luttkus et al., 2003). Similar practices have been adopted experimentally in labouratory species, with a focus on newborn individuals, using blood gas analyses and/or pulse oximetry (Takada et al., 2011). However, such monitoring has been less used in cattle (Coghe et al., 1999; Uystepruyst et al., 2000; Bleul and Kähn, 2008; Bleul et al., 2008) or sheep (Norton et al., 1998), especially under grazing conditions (Dutra and Banchero, 2011), the latter owing to the inherent difficulties in using proper, portable and easy instrumentation in the field, under adverse climatic conditions.

Nowadays, there are new commercial instruments for both blood gas analyses or arterial oxygen-haemoglobin saturation measurement by pulse oximetry (Nitzan et al., 2014) that can increase the diagnostic capabilities to diminish perinatal mortality. Use of these instruments, in particular the oximetry, appears relevant for monitoring sheep lambing

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in the field since it can provide a quick indication of constrained newborn vitality.

The present study aimed to evaluate the practicality and accuracy of pulse oximetry to assess oxygenation status in newborn single and twin lambs immediately after phase II labour of Polwarth ewes extensively reared on natural pasture. Oximetry was compared with blood gas analyses followed by an assessment of vitality and behaviour of the neonates. We tested the hypothesis that a non-invasive method to measure oxygenation status in newborn lambs as oximetry can be as reliable as blood gasometry to predict the degree of asphyxia at birth.

2. Material and methods

2.1. Location

The study was performed at the Experimental Sheep Unit of INIA (National Institute for Agricultural Research) "La Estanzuela" Uruguay (latitude 34°19'57"S, longitude 57°40'07"W).

The experiment was designed and performed in accordance with the Experimental Directive concerning the use of Animals for Experimentation following the procedures approved by the Honorary Committee for Animal Experimentation of the University of the Republic, (CEUA-Udelar-N°021130–001370–14).

2.2. Animals and general management

Ninety-three (93) multiparous Polwarth ewes (three to eight-year-old) grazing improved pastures *ad libitum* as a single flock with permanent access to good quality water, were synchronized in oestrus by two doses of 160 mg Delprostenate (Glandinex®, Universal Lab, Montevideo, Uruguay) 9 days apart and mated with seven Finnish Landrace rams. The ewes were diagnosed pregnant (including twinning) by ultrasonography 45 days after the beginning of the mating period. One week before the expected date of lambing the ewes were allocated as a single flock in 5.5 ha with free access to water where lambing control was performed during 24 h /day for a month. At night-time, all ewes were moved to an illuminated pen with free access to water to be continuously monitored for signs of imminent parturition. Birth monitoring during 24 h was carried out in 8-hour shift work made up of three people each. Every shift was supervised by a veterinarian, who was the person in charge of performing the vein blood sampling, as well as the measurement with the pulse oximeter.

After parturition, the ewes with their respective lambs were separated from the experimental flock and taken to a 15 ha paddock of native pasture + *Lotus pedunculatus*. Ewes were clearly identified by paint-brands to facilitate recognition and they were accustomed to human presence and handling.

2.3. Data recording

2.3.1. Ewes

The onset and duration of phase II of labour (from appearance of foetal front or rear legs to total lamb expulsion) were recorded. For twin lambs, duration of phase II was considered separately for each lamb; so that each birth was studied as an independent event, regardless of litter size. Lambing assistance was restricted solely to those ewes with the second stage of parturition longer than 2 h since any part of the lamb was visible at the vulva without obvious progress or when malpresentation of the fetus was clinically documented by the operator (Dwyer, 2003). On the day after parturition, body condition score (BCS, scale 0–5, Russel et al., 1969) and body weight (BW) of the ewes were registered.

2.3.2. Lambs

2.3.2.1. Pulse oximetry. Immediately after birth, within the first minute, one of the lamb's ears was quickly dried with a disposable towel in order to clamp the pads of the adapted sensor for veterinary use of the hand-held pulse oximeter (model VE-H100B, EdanUSA, San Diego, Ca, USA, www.edanusa.com) to measure oxygen saturation ($satO_2$, 0–100%) and heart rate (bpm). Measurement was performed in approximately 5–10 s. The lambs used in this experiment did not have woolly ears or pigmented skin, since these elements could interfere with the accuracy of the oximeter (Norton et al., 1998).

2.3.2.2. Blood gas analysis. Simultaneously with pulse oximetry measure, a blood sample was taken from the jugular vein with a pre-heparinized 2 mL syringe (spray-dried, calcium-balanced Heparin, BD A-Line®) and a 21G needle. After sampling, the needle was removed, and the syringe was immediately sealed with a rubber plug to prevent air entrance. Blood gas analyses were performed with a gas analyzer Siemens Rapidlab 248® (courtesy of Microlab, Montevideo, Uruguay) located at a labouratory adjacent to the experimental paddock for the analyses of the directly measured blood gas parameters: partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2) and pH; or estimated: oxygen saturation ($satO_2$), concentration of actual bicarbonate (HCO_{3^-act}) and extracellular base excess (BE_{ecf}). Jugular vein sampling was preferred because it is more reliable under field conditions, reflecting the fetal acid-base status at birth (Westgate et al., 1994; Dutra and Banchero, 2011). Jugular venipuncture was performed quickly (less than 1 min from birth), avoiding possible maneuver-induced asphyxia, which could eventually be caused by pressing the neck area for a long time when puncturing the vein. Blood gas measurements were completed within 8 min of birth. After lambing, ewes were allowed to start grooming the newborn even when samples were being collected.

2.3.2.3. Lambs' behaviour. Apgar test for lambs (mnemonic for appearance, pulse, grimace, activity and respiration) was performed following the modifications described by Dutra and Banchero (2011) for the Apgar used for the evaluation of newborn babies (American Academy of Pediatrics, 2006). *Appearance* refers to the mucosa or skin color (0 = cyanotic; 1 = yellow skin stained with meconium; 2 = normal, clear skin); *pulse* was measured with the oximeter (0 = absent; 1 = <105 bpm; 2 = >105 bpm); *grimace* stands for reflex irritability (0 = absent; 1 = weak movements of the ears; 2 = sneeze, cough, shakes head); *activity* refers to muscle tone (0 = absent; 1 = legs flexion; 2 = active, sternal recumbence); and *respiration* (0 = absent; 1 = slow, irregular; 2 = good, regular). As each parameter evaluated is given a score of 0–2 units, an Apgar score between 0 and 10 units can be obtained.

The first attempt to stand from birth was measured within 30 min of birth. Time elapsed since birth to actually the lamb stood on its four legs for at least 6 s as well as the attempt to suckle and the moment in which it actually suckled for the first time was also recorded within the first hour of life. After one hour of birth, if the lamb could not stand, it was helped, and the same was done if it could not suck. After the lambs stood up and sucked, they were weighed, sex recorded, ear-tagged and spray marked with the number of its mother.

2.4. Experimental design

The experiment was designed to study any correlation between newborn lamb's oxygen saturation ($satO_2$, 0–100%) measured by pulse oximetry, and venous blood gasometry parameters. Since comparison between pulse oximetry and jugular vein blood gasometry could not be

directly performed because peripheral blood was used in the former while venous blood was used in the latter one, the associations between the values obtained by each technique were assessed through correlations. In addition, due to pH being a good indicator of hypoxia at lamb birth (Dutra and Banchero, 2011), ewes and their lambs were grouped into four arbitrary categories based on lamb's pH values obtained by blood gasometry (G1 = pH < 7.1; G2 = 7.1 ≤ pH < 7.2; G3 = 7.2 ≤ pH < 7.3 and G4 = pH ≥ 7.3) to test if pH value was associated with vitality and vigour of the lambs at birth. When pH < 7.1, it was defined as fetal acidosis (Helwig et al., 1996; Dutra and Banchero, 2011).

2.5. Statistical analyses

Data, except pH, were submitted to one-way ANOVA analysis using the SAS software (SAS Institute, ® Cary NC, USA). Variables with error normally distributed (BW and BCS of the ewes, birth weight of the lambs and blood gas parameters) were assessed by a linear model considering pH class as the fixed effect using the PROC MIXED procedure. Birth weight and duration of phase II of parturition were included as covariates but only the former one was retained in the model ($P < 0.05$). Oximetry and duration of phase II data were analysed considering a Poisson distribution using PROC GENMOD. Whenever a significant effect for pH class was found, *post hoc* multiple comparisons were performed by Tukey's honestly significant difference test.

Lamb behaviour, measured as the proportion of lambs that effectively performed each behaviour feature within the first hour of birth, was analysed according to Chi-square test using PROC FREQ. Apgar test was considered to have a Multinomial distribution and was analysed using PROC GENMOD, considering the pH class as the fixed effect. Pearson's correlation between pulse oximetry and blood gasometry values were analysed using the PROC CORR. Significant threshold was stated at $P \leq 0.05$ and tendency $0.05 < P \leq 0.10$. Data are presented as mean ± sd.

3. Results

Ninety-three ewes gave birth to 136 lambs. One ewe delivered a stillborn twin, so that lamb was eliminated from the experiment. Data presented correspond to 135 lambs (singletons, n = 50; twins, n = 85). Only one delivery required assistance for parturition; with most deliveries (phase II of parturition) occurring less than 15 min (64%), 21% of deliveries lasted between 15 and 30 min and only 15% lasted more than 30 min

Regarding pH groups, saturation of O_2 measured by pulse oximetry was different ($P = 0.009$) between lambs with the lowest (G1) and the highest (G4) pH, and a tendency was found between G1 *vs.* G2 ($P = 0.085$) and G1 *vs.* G3 ($P = 0.072$) (Table 1). Values for pCO_2 measured by blood gas analysis were higher for those lambs with low pH and decreased as blood pH increased. The highest pCO_2 values were registered in G1 and G2, both groups being different from G3 and G4 ($P < 0.001$). Bicarbonate was lower for G1 lambs compared to the rest of the groups ($P < 0.001$), and BE_{ecf} was also different for G1 lambs ($P < 0.001$); both parameters increased as the pH increased. Both pO_2 and $satO_2$ values measured by blood gasometry were not different between pH groups (Table 1).

The duration of phase II of parturition differed ($P = 0.021$) across groups as greater duration was observed for G1 (acidosis) *vs.* G2 ($P = 0.015$) and G3 ($P = 0.042$). The BCS and BW of the ewes were not different between groups as well as lambs' birthweight (Table 2).

Apgar test measured at birth was affected ($P = 0.025$) by pH group since it was lower ($P \leq 0.041$) for G1 compared to the other groups (Table 2). Similarly, the behavioural variables (% of lambs that attempted or succeed to stand and suckle) were also affected ($P = 0.002$) by the pH group as they were lower ($P \leq 0.001$) for G1 than for the other groups (Table 2).

Pulse oximetry presented a negative correlation with pCO_2 ($r = -0.50$), being higher for single lambs ($r = -0.60$) than for twins ($r = -0.44$) (Table 3, Fig. 1a). Oximetry showed a positive correlation with blood pH ($r = 0.36$), being higher for single lambs than for twins (Table 3, Fig. 1b). A low, but significant correlation with pO_2 was also observed. No correlations were registered between oximetry and the estimated blood gas parameters ($satO_2$, $HCO_{3\ act}$ and BE_{ecf}), measured by venous blood gasometry (Table 3).

4. Discussion

The hypothesis that pulse oximetry can be used as a reliable method to measure oxygenation status in newborn lambs was confirmed; oxygen saturation measured by pulse oximetry showed a positive correlation with pO_2 and pH and negative correlation with pCO_2 measured directly by venous blood gasometry. Oximetry registered a lower percentage of oxygen saturation in those lambs born from ewes with extended labour. Moreover, their vigour at birth was poorer compared to those lambs born from mothers with faster phase II of labour.

In mammals, neonatal hypoxia is naturally tolerated and rapidly reversed with neonates having the ability to resist short periods of oxygen deprivation at birth. Within the mechanisms implicated, the neonate reacts to asphyxia with a redistribution of blood flow to vital organs, thus avoiding harmful effects due to oxygen limitation which allows it to survive unless the asphyxia is deepened or prolonged (Parer and Livingston, 1990); but most of these adaptive mechanisms are not unlimited (Singer, 1999). In this sense, extended labour phase II, constitutes a risk factor that predisposes to respiratory acidosis in newborn lambs (Dutra and Banchero, 2011). In our experiment, those lambs that registered blood pH < 7.1 were the ones that showed an average phase II of labour remarkably longer, and in turn registered the highest values of pCO_2 and the lowest pulse oximetry percentages of $satO_2$. Similar findings have been reported by Takada et al. (2011) who demonstrated

Table 1
Association between lambs' venous blood pH at birth with pulse oximetry and blood gas analysis. Values are presented as mean ± sd.

		G1	G2	G3	G4	
		pH < 7.1	7.1 ≤ pH < 7.2	7.2 ≤ pH < 7.3	pH ≥ 7.3	
		S: n = 2; T: n = 4	S: n = 10; T: n = 21	S: n = 29; T: n = 35	S: n = 9; T: n = 25	*P* - value
Pulse Oximetry						
	O_2 sat (%)	78.8 ± 7.2^{b}	87.5 ± 7.8^{ab}	87.7 ± 10.3^{ab}	92.1 ± 10.2^{a}	0.011
Blood gas analysis						
	pCO_2 (mmHg)	78.5 ± 29.4^{a}	73.8 ± 8.7^{a}	65.8 ± 5.9^{b}	53.8 ± 5.1^{c}	< 0.001
	pO_2 (mmHg)	21.9 ± 9.0	19.6 ± 5.0	19.2 ± 5.8	17.5 ± 6.3	NS
	HCO_3^- act (mmol/L)	15.1 ± 9.1^{b}	26.2 ± 3.1^{a}	28.0 ± 2.4^{a}	28.1 ± 3.0^{a}	< 0.001
	BE ecf (mmol/L)	-10.9 ± 5.0^{c}	-2.4 ± 3.2^{b}	0.7 ± 2.5^{a}	2.3 ± 3.1^{a}	< 0.001
	O_2 sat (%)	17.2 ± 18.0	21.5 ± 8.7	24.4 ± 12.7	23.6 ± 14.8	NS

Means with different letters within rows are statistically different ($P \leq 0.05$). Litter size: S = singles, T = twins
The reported *P-value* indicates the significance of pH class given by the statistical test (*i.e.* ANOVA, Poisson regression, Chi-Square) performed for each variable according to its nature.

Table 2
Association between lambs' venous blood pH at birth and duration of phase II of labour, BCS and body weight (BW) of ewes; birth weight, lambs' behaviour (attempt or success to stand or suck) and vigour (Apgar test). Values are presented as mean ± sd.

		G1	G2	G3	G4	
		pH < 7.1	7.1 ≤ pH < 7.2	7.2 ≤ pH < 7.3	pH ≥ 7.3	
		S: n = 2; T: n = 4	S: n = 10; T: n = 21	S: n = 29; T: n = 35	S: n = 9; T: n = 25	*P* - value
Ewes' measures						
	Duration of phase II (min)	35.0 ± 16.4[a]	10.6 ± 8.0[b]	14.5 ± 10.4[b]	17.9 ± 14.5[ab]	0.021
	Body condition score (0–5)	3.4 ± 0.7	3.0 ± 0.6	3.3 ± 0.5	3.2 ± 0.6	NS
	BW at parturition (kg)	46.0 ± 4.4	46.8 ± 5.5	47.9 ± 5.1	47.6 ± 4.9	NS
*Lambs' measures**						
	Birth weight (kg)	3.88 ± 0.93	4.19 ± 0.69	4.24 ± 0.78	4.00 ± 0.69	NS
	% attempted to stand	16.7[b] (26.5)* *	96.8[a] (8.9 ± 6.0)	100.0[a] (8.2 ± 5.8)	100.0[a] (6.8 ± 6.0)	< 0.001
	% successfully stood	33.3[b] (31.5 ± 18.1)	96.3[a] (19.4 ± 11.0)	97.9[a] (18.6 ± 12.7)	100.0[a] (14.8 ± 8.7)	< 0.001
	% attempted to suck	33.3[b] (29.5 ± 22.0)	92.3[a] (19.8 ± 9.0)	95.9[a] (22.8 ± 15.1)	100.0[a] (17.4 ± 8.9)	< 0.001
	% successfully sucked	33. 3[b] (57.0 ± 17.1)	88.5[a] (29.9 ± 11.1)	86.7[a] (33.0 ± 18.9)	92.6[a] (28.4 ± 17.3)	0.002
	Apgar (score 0–10)	6.7 ± 0.7[b]	8.6 ± 1.6[a]	8.6 ± 0.8[a]	8.5 ± 1.1[a]	0.025

Different letters indicate significant differences (P ≤ 0.05) among groups (G1- G4). Litter size: S = singles, T = twins
The reported *P - value* indicates the significance of pH class given by the statistical test performed for each variable.
*Lambs behaviour variables are presented as the percentage of lambs that performed the current behaviour feature; the figures in parentheses represent time elapsed (minutes) from birth until the current behaviour (attempt or success to stand or suck) was performed in each group.
* * SD value is not reported since only one lamb attempted to stand in G1.

Table 3
Pearson correlations between percentage of O_2 saturation measured by pulse oximetry, and venous blood gas parameters measured by blood gas analysis at birth in singles and twins Finnish x Polwarth lambs.

Blood gas analysis	Total lambs (n = 135)		Single lambs (n = 50)		Twin lambs (n = 85)	
	r	*P - value*	*r*	*P - value*	*r*	*P - value*
pCO_2	-0.50	< 0.001	-0.60	< 0.001	-0.44	< 0.001
pO_2	0.20	0.04	0.21	0.24	0.20	0.11
pH	0.36	< 0.001	0.44	0.01	0.31	0.01
HCO_3^- act	-0.15	0.12	-0.20	0.27	-0.11	0.36
BE_{ecf}	-0.02	0.81	-0.02	0.93	-0.01	0.96
$O_{2\ sat}$	-0.06	0.58	0.25	0.17	-0.06	0.65

in a model of neonatal anoxia in rats, that low oxygen saturation values measured by pulse oximetry were in agreement with low pH and high pCO_2 values showing hypercapnia.

According to Parer and Livingston (1990) in a strict sense, all fetuses are born asphyxiated considering that during labour there is a mixed respiratory and metabolic acidosis generating hypoxemia. Respiratory acidosis is caused by a lack of pulmonary ventilation and can be rapidly reversed with the onset of pulmonary breathing. Therefore, the faster this transition from fetal to neonatal circulation, the less hypoxia will be produced in the fetus. On the other hand, when labour phase II is extended this increases the probability of metabolic acidosis as a consequence of prolonged hypoxemia; acidosis becomes more extreme increasing its detrimental consequences (Martz et al., 2019).

In farm animals as well as in humans, life unfolds between very narrow pH limits between 7.35 and 7.45. During respiratory acidosis there is a decrease in blood pH due to an increase in the partial pressure of CO_2, and in turn a compensatory increase in the concentration of bicarbonate (Aydogdu et al., 2018, Mangas et al.,2018). In the present study, an objective measurement of the acid-base status of the lambs was necessary to compare it with the oximetry measurement, and evaluate if the device could detect the differences between the lambs that presented asphyxia and those that did not. Pulse oximetry significantly correlated (P < 0.001) with the two parameters described as the most important in determining whether or not an animal is suffering acidosis: blood pH and pCO_2 (Bessho et al., 1997; Takada et al., 2011; Vannucchi et al., 2012). No correlation between oximetry and the calculated blood gasometry parameters was found, maybe due to the fact that in this experiment blood gas analysis was performed on venous and not on arterial blood. The lack of correlation between the $satO_2$ measured by pulse oximetry and the one measured by venous blood gasometry, was to be expected. The differences obtained between $satO_2$ measured by pulse oximetry (range: 78.8–92.1%) or venous blood (ranged: 17.3–23.6%) are in agreement with data reported by other authors (Sobiech et al., 2005; Ak et al., 2006; Bleul et al., 2008) who also did not found correlation between these two measures. On the other hand, several authors working not only with animals (Bleul et al., 2008) but also with humans (García-Alarcón et al., 2003; Ak et al., 2006;) described that pH, pCO_2 and HCO_3 values correlate very well between arterial and venous blood.

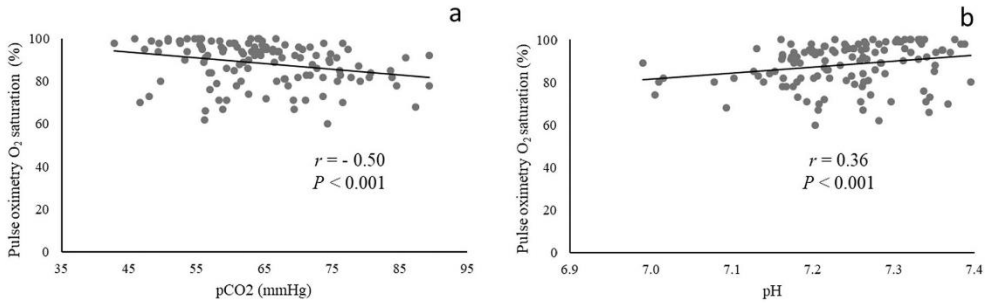

Fig. 1. Pearson correlation between O_2 saturation measured by pulse oximetry and venous blood pCO_2 (a) and pH (b) values at birth in lambs.

Considering that the experiment aimed to have a comparative method to objectively diagnose the acid-base status of newborn lambs, it was found that those lambs that were in acidosis (G1) (determined by the venous blood gases values: high levels of pCO_2, low pH and HCO_3 values), were also those in which low oximetry values were registered, with important clinical implications. Venous blood gas analysis has been reported as a valid alternative for the diagnosis of acid-base status since arterial puncture has many drawbacks (Lim and Kelly, 2010; Novovic and Topic, 2012); venous blood sample is easy to obtain, less painful and reduces the risk of infection or thrombosis (Ak et al., 2006). Blood gas analysis performed with jugular samples has been previously used in newborn lambs (Dutra and Banchero, 2011; Vannucchi et al., 2012), since in field conditions obtaining arterial blood samples would be very cumbersome. However, the use of blood gas analyses in a non-experimental way as a tool to diagnose asphyxia produced at birth is not feasible; thus, pulse oximetry becomes a useful alternative.

Only 15% of births in this experiment lasted more than 30 min. The fact that the ewes used in the experiment were multiparous and that most of the newborn lambs were twins could probably influence this parameter; labour phase II is usually shorter in multiparous ewes (compared to primiparous) as well as in twin-births due to the smaller size of the lamb. This probably resulted in a low number of animals in G1 (acidosis). However, data found for the lambs of this group are consistent, since the parameters that indicated the viability and behaviour of the lambs at birth (% of attempt and success in standing or suckling) were markedly lower compared to the rest of the groups.

Percentage of oxygen saturation measured by pulse oximetry showed differences between G1 and G4 lambs, although only a tendency was found between G1*vs* G2 and G1*vs* G3. From a clinical point of view, the percentage of $satO_2$ measured in G1 (78.8%) is important since a condition where the concentration of peripheral arterial oxygen is at or below 85% of normal is considered hypoxemia (Hay et al., 2002; Petrova and Mehta, 2006; Takada et al., 2011), increasing the risk of developing metabolic acidosis. The accuracy of the oximeter used in this experiment has not been previously assessed; but other authors who have used pulse oximetry in calves (Uystepruyst et al., 2000) or in humans (Nitzan et al., 2014) report that the oximeter accuracy is greater when it comes to values between 70% and 100% of O_2 saturation, but conclude that pulse oximetry overestimates the measure obtained by arterial blood gas when it comes to lower values ($\leq$70%). In our experiment, it is then possible that the low oximetry values found in lambs with acidosis (G1) are even lower. However, this level of accuracy seems to be sufficient to detect a significant decline in respiratory function, allowing us to differentiate whether or not a lamb is suffering from asphyxia.

In summary, the lambs in group G1 were the ones that presented blood gas values that indicated severe acidosis and these are in agreement with the lowest oxygen saturation values measured by the pulse oximeter.

In precocial species such as sheep, the faster the newborn succeeds to stand and suck colostrum is crucial. Lambs born with low or reduced vigour, take longer to stand up and suck (Dutra and Banchero, 2011) or they simply fail to do it if not helped. Early identification of these animals offers a great advantage; the sooner therapy is established in these lambs, the greater the possibility of survival (Sanchez-Salcedo et al., 2019). In this work, lambs in G1 group showed poor vigour at birth (only 33% of them managed to stand up and suck during the first hour of life) so help was needed to achieve the first intake of colostrum. Similar results have been reported by Dutra and Banchero (2011) and Castillo--Melendez et al. (2013) where lambs experiencing asphyxia displayed significant latencies to use all four legs, attain a standing position and successfully suck compared to non-asphyxiated lambs. Early detection of lambs with low O_2 saturation with an easy-to-use device such as a pulse oximeter identifies vulnerable neonates that require immediate support. It is also important to highlight that from the point of view of animal welfare, a simple and early diagnosis of these lambs would represent the possibility of increased survival, avoiding unnecessary suffering; and furthermore, this also represents a better economic result for the farms.

It is also worth mentioning that lambs that were slower to stand and suck as a result of delayed births are often abandoned by their mothers, this behaviour being more frequent in primiparous ewes (Regueiro et al., 2021). Moreover, in case of twin lambs vitality differences can also lead to the rejection of the weaker lamb by the mother (Nowak and Poindron, 2006).

The consequences of hypoxia that are seen in humans may be difficult to quantify in animals, but the simple fact that the lamb cannot follow its mother or suckle without help due to the asphyxia suffered at birth decreases its viability. A frequent check of those lambs that have low oxygen saturation allows to provide help during their first hours/days of life, thus avoiding death from starvation *per se* or due to maternal abandonment.

Asphyxia at birth is one of the main causes of neonatal mortality in most of domestic mammals (Galvin and Collins, 2004; Mota-Rojas et al., 2005; Aydogdu et al., 2018). Despite this, due to strategies that have been carried out to improve size and weight of the newborn in both intensive and extensive production systems, larger incidence of dystocia associated with oxygen restriction to the fetus has been detected, which elicits metabolic and respiratory acidosis (Sanchez-Salcedo et al., 2019). Pulse oximetry becomes a tool that can be used to check the evolution of those lambs with low oxygen saturation values, easy to handle, inexpensive and completely harmless for the newborn.

5. Conclusion

Pulse oximetry appears a relatively accurate method to evaluate lamb birth asphyxia, helping to identify oxygenation constraints during labour, detecting if present, acidotic lambs. This would facilitate priority of perinatal treatment and might result in better animal welfare and improved lamb survival.

CRediT authorship contribution statement

Mariel Regueiro: Conceptualization, Methodology, Investigation, Validation, Formal analysis, Writing – original draft, Project administration. **Ezequiel Jorge-Smeding:** Data curation, Formal analysis, Writing – review & editing. **Carlos López-Mazz:** Investigation, Writing – review & editing. **Anderson Saravia:** Resources, Writing – review & editing **Georgget Banchero:** Resources, Writing – review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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4. LA ASISTENCIA PROGRAMADA AL PARTO (PPA) EN OVEJAS PRIMÍPARAS DE TIPO LANERO MEJORA EL COMPORTAMIENTO MADRE-CRÍA AL PARTO

Regueiro M, Jorge-Smeding E, Baldi F, Idiarte Borda A, López-Mazz C, Banchero G

Resumen

Se evaluó el efecto de la asistencia programada al parto (PPA) sobre el comportamiento madre-cría en ovejas primíparas en cría extensiva. La PPA se definió como las maniobras realizadas inmediatamente al inicio de la fase de expulsión fetal para acortarla. Se utilizaron ovejas corriedale primíparas de 2 años (n = 28), con feto único. Antes del parto, las ovejas se asignaron a (i) parto programado asistido (PPA; n = 14): ovejas cuyo parto se programó para ser asistido o (ii) parto no asistido (NA; n = 14): ovejas que no fueron asistidas y sus corderos nacieron por parto natural. Se registró la duración de la fase de expulsión fetal, la puntuación de comportamiento materno (MBS, 1-5), el inicio de la limpieza del cordero, la relación de peso vivo cordero/oveja y el abandono de la cría. En los corderos se registró peso al nacer, test de Apgar (0-10), saturación de O_2, tinción con meconio, tiempo transcurrido hasta el primer balido, levantarse y mamar. Las ovejas PPA registraron menor duración del parto (19,2 ± 4,2 vs. 42,6 ± 7,8 min), inicio más temprano de la limpieza del cordero (1,2 ± 0,4 vs. 3,0 ± 0,6 min), mayor MBS (4,5 ± 0,1 vs. 3,1 ± 0,4) y no abandonaron ningún cordero durante las primeras 72 h. Los corderos del grupo PPA registraron mayor saturación de O_2 (97,6 ± 1,0 % vs. 93,4 ± 1,3 %), balaron antes (2,4 ± 0,5 vs. 4,6 ± 0,8 min), se levantaron antes (24,1 ± 4,2 vs. 36,8 ± 8,0 min) y registraron un menor tiempo para mamar (36,5 ± 6,7 vs. 71,0 ± 12,9 min). No se observó efecto del tratamiento sobre el test de Apgar ni en la tinción con meconio, pero, independientemente del tratamiento, los corderos teñidos de meconio presentaron una mayor relación de peso corporal cordero/oveja que los no teñidos. La reducción de la duración de la fase de expulsión fetal, mediante la PPA, afectó positivamente al vigor de los corderos, así como al comportamiento materno de las ovejas primíparas, mejorando las posibilidades de supervivencia y el bienestar de la unidad madre-cría.

Palabras clave: asistencia al parto, asfixia, comportamiento materno, oveja, cordero

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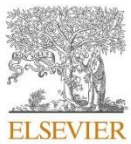

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Programmed parturition assistance (PPA) in primiparous wool-type ewes improves mother-lamb behaviour at lambing

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ABSTRACT

The effect of programmed assistance at parturition on the behaviour of the mother and its offspring in primiparous ewes under extensive rearing was evaluated. Programmed parturition assistance was defined as the manoeuvres performed immediately after the beginning of the expulsion phase to shorten it. Twenty-eight 2-year-old Corriedale primiparous ewes (body condition score (BCS): 3.4 ± 0.1; body weight (BW): 35.5 ± 0.7 kg) with a single foetus were used. Before lambing and considering BW, BCS and sire, the ewes were randomly assigned to (i) Programmed-parturition-assisted (PPA; n = 14): ewes whose lambing was programmed to be assisted or (ii) Not-assisted (NA; n = 14): ewes that were not assisted and their lambs were born through natural labour. The duration of the foetus expulsion phase, maternal behaviour score (MBS, 1–5), onset of grooming, lamb/ewe BW ratio and lamb desertion were determined in the ewes. Birth weight, Apgar test (score 0–10), O_2 saturation, meconium-stained coat, latency to first bleat, success to stand and suck, were registered in the lambs. PPA ewes registered shorter duration of labour (19.2 ± 4.2 vs. 42.6 ± 7.8 min), earlier onset of grooming (1.2 ± 0.4 vs. 3.0 ± 0.6 min), higher MBS (4.5 ± 0.1 vs. 3.1 ± 0.4) and did not desert any lamb during the first 72 h from birth. The lambs born to PPA mothers registered higher O_2 saturation (97.6 ± 1.0 % vs. 93.4 ± 1.3 %), bleated earlier (2.4 ± 0.5 vs. 4.6 ± 0.8 min), stood up earlier (24.1 ± 4.2 vs. 36.8 ± 8.0 min) and recorded shorter time to suck (36.5 ± 6.7 vs. 71.0 ± 12.9 min). No effect of treatment on Apgar test or meconium-stained coat was observed, but regardless of treatment, meconium-stained lambs had a higher lamb/ewe BW ratio than unstained ones. The reduction of the duration of foetal expulsion phase, through programmed parturition assistance, positively affected the vigour of the lambs as well as the maternal behaviour of primiparous ewes, which in turn would increase the chances of lamb survival and ultimately, improve the welfare of the ewe-lamb unit.

1. Introduction

During labour, foetal expulsion phase (phase II), although it is usually the shortest of the parturition process, is the one that can easily generate later consequences on the behaviour of the mother (Darwish and Ashmawy, 2011). Even though pain is a subjective measure difficult to be assessed in animals (Stasiak et al., 2003; Fitzpatrick et al., 2006), for numerous species labour is considered the most painful episode (Martínez-Burnes et al., 2021), even more in cases of prolonged and labour-intensive deliveries. The pain experienced during the expulsion phase could lead to misbehaviour that can include partial or total rejection of the lamb (abandonment) (Alexander, 1960; Banchero, 2004). This behaviour in extensive rearing, and considering precocial species such as sheep, can determine that in a relatively short time, the newborn would not survive (Nowak, 1996). Maternal misbehaviour is more frequently observed in primiparous ewes (Regueiro et al., 2021), in which the foetal expulsion phase is usually longer than in multiparous ones. Furthermore, Corriedale ewes usually have a low twinning rate (approx. 20%), which in primiparous is even lower (Banchero et al., 2016). This determines that with deliveries of single heavy lambs, as well as in dams with high or low weight, the risk of dystocia increases. Besides this, in first parity ewes is also associated with fetopelvic disproportion (Jacobson et al., 2020).

Moreover, it has been reported not only in sheep (Dutra et al., 2007;

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Jacobson et al., 2020; Bruce et al., 2021; Regueiro et al., 2022) but also in several species including humans (Martínez-Burnes et al., 2021; Nam and Sukon, 2021) that prolonged parturition may impair survival of newborn as a result of hypoxia during birth. These consequences may be mild, but if foetal hypoxia is prolonged the central nervous system can be affected, and even if the lambs survive the parturition process, they might eventually die within the next few days (Dutra et al., 2007).

In addition to the aforementioned, pain resulting from a dystocic birth represents a potential welfare concern (Martínez-Burnes et al., 2021). Furthermore, dystocia should not only be considered a problem from an animal welfare perspective, but also an issue to be regarded from the point of view of economic losses (Bruce et al., 2021), mostly related to lamb mortality, but eventually also of ewes (Jacobson et al., 2020).

In this study, the effect of programmed assistance at parturition on the behaviour of the mother and its offspring was evaluated, defining programmed assistance as manoeuvres that are carried out immediately after the beginning of the expulsion phase to facilitate the delivery of the foetus considering all births, including non-dystocic ones. This procedure attempts to achieve a double effect: reduce the period of pain that the expulsion phase causes in the mother, and a quicker passage of the foetus through the birth canal, avoiding or minimising asphyxia. We hypothesised that reducing the foetal expulsion phase through programmed assistance at lambing in primiparous ewes would improve the maternal behaviour, as well as the vigour of the lamb at birth when compared with ewes of the same category delivering without assistance.

2. Material and methods

2.1. Location

The experiment was conducted at Estación Experimental B. Rosengurtt, Facultad de Agronomía, Udelar (32°21′ S, 54°26′ W) following the experimental procedures approved by the Honorary Committee for Animal Experimentation of Universidad de la República (CEUA-Udelar-N°021130-001370-14).

2.2. Animals and general management

Data were collected on 28 primiparous Corriedale ewes (two-years-old at lambing) managed as a single flock. Forty-six primiparous ewes were synchronised in oestrus in April (Southern hemisphere autumn) with two doses of 100 μg Delprostenate (Glandinex®, Universal Lab, Montevideo, Uruguay), given 8 days apart. Vasectomised rams were used for heat detection twice a day. Artificial insemination (AI) was performed cervically 12 h after heat detection with fresh semen from one of four Corriedale rams. The ewes were scanned (ALOKA Prosound 2 ultrasound) for pregnancy 40 days after the beginning of AI with a transrectal probe with a 7.5 MHz linear transducer. A pregnancy rate of 67.4 % (31/46) was recorded. Ewes pregnant with twins (n = 1) were not included in the experiment, thus 30 ewes carrying a single foetus were initially used. Considering the day on which AI was performed and the ultrasound result, the expected date of parturition was calculated for each ewe, assuming an average of 147 days of gestation for primiparous ewes of the current experimental flock. Throughout the gestation and lambing period, the ewes grazed native pastures ad libitum, with permanent access to potable water; all of them were shorn pre-partum at 109 ± 2.5 days of gestation (Ungerfeld et al., 2018).

2.3. Experimental design

The experiment investigated whether programmed assistance at parturition could improve both maternal behaviour and lamb vigour at birth. Programmed assistance was defined as the manoeuvres performed immediately after the beginning of the expulsion phase to shorten it. The manoeuvres were considered as the movements applied to the foetus within the uterus to facilitate delivery.

One week before the onset of the lambing period, ewes were paired by body weight, body condition score and sire; within each matched pair, the ewes were randomly assigned (every second ewe) to: (i) Programmed-parturition-assisted (PPA; n = 14): ewes that their lambing was programmed to be early-assisted or (ii) Not-assisted (NA; n = 14): ewes were not-assisted and their lambs were born through natural labour. Ewes with a lambing expulsion phase longer than 2 h, as well as cases of malpresentation of the lamb, in both experimental groups were excluded from the experiment (PPA, 1 ewe with lamb malpresentation; NA, 1 ewe with labour longer than 2 h). Thus, 28 ewes and their lambs were finally tested.

2.3.1. Lambing control

One week before the expected onset of lambing period, the ewes were allocated as a single flock in a 1.5-ha paddock. Lambing control was carried out 24 h/day in 8-hour shifts work, made up of two people each. Every shift was supervised by a veterinarian responsible for carrying out the birth assistance manoeuvre. During the night hours, the flock was moved to a lighted pen (16 m × 20 m and approximately 15 lux) near the daytime paddock. Ewes were identified by paint-brands (RAIDEX® Animal Marking Spray) to enable recognition from a distance and were accustomed to human presence and handling.

2.3.2. Methodology for programmed parturition assistance

Once it was observed that some part of the lamb could be seen through the vulva, and the ewe was lying down to push, it was carefully approached by an operator (trying to avoid its field of vision), and gently restrained. The lamb was then removed by a veterinarian who matched efforts to pull out the lamb only with ewes' strains. Those ewes that did not lie down to push were then gently pulled down; the lamb was removed once the ewe was in the recumbent position. Once the lamb was completely removed from the birth canal, it was left next to the mother without removing the remnants of placental membranes from the face or other parts of the lamb (simulating a natural parturition process). As grooming is considered to be one of the first signs of acceptance of the lamb (Levy and Poindron, 1987), the ewe was not forced to start grooming but was given time to do so on its own initiative. Once the manoeuvre of assistance was completed, both operators left the place slowly, so as not to interfere with the behaviour of the ewe.

2.4. Data recording

2.4.1. Ewes

The primiparous ewes used in the experiment were those whose body weight (BW) at conception was equivalent to 70 % of their genotype's mature BW (Chappell, 1993). Before lambing, body condition score (BCS) was recorded on a scale of 0 (emaciated) to 5 (obese) (Russel et al., 1969). The score was performed by a single experienced technician for all the experimental animals assessing the extent of muscular (*m. longissimus dorsi*) and adipose tissues by palpation of lumbar vertebrae. Body weight of the ewes was recorded twice (Tru-test® scale): one week before the onset of the lambing period (to allocate the animals in each treatment group), and the day after parturition to obtain the precise weight of the ewe excluding the lamb. At lambing, the duration of phase II (expulsion phase) was registered, considered as the time elapsed since any part of the lamb could be seen until its total expulsion (Dwyer, 2003). After lambing, the onset of grooming (time elapsed from birth until the ewe first begins to smell and lick the lamb) and maternal behaviour score (MBS) were recorded. The behaviour of the ewe was observed while the lamb was being ear-tagged and weighed. To assess the MBS, a five-point score (O'Connor et al., 1985) based on the distance the ewe moves away from the lamb when it is handled was used, where 1 corresponds to a mother with poor maternal behaviour and 5 to an excellent one (1: ewe flees at the approach of the operator, shows no interest in the lamb and does not return to the lamb; 2: ewe retreats

further than 10 m but comes back to its lamb as the operator leaves; 3: ewe retreats 5–10 m; 4: ewe retreats but stays within 5 m of the lamb; 5: ewe stays within 1 m of its lamb and makes physical contact with it when handled).

To determine the relative birth weight of the lamb expressed as a percentage of its mothers' body weight, the lamb/ewe BW ratio was calculated as: lamb BW/ewe BW * 100, considering birth weight of the lamb and the weight of the ewe the day after lambing (Dutra and Banchero, 2011). We hypothesised that the risk of experiencing difficult lambing would be higher in ewes with a greater lamb/ewe BW ratio, taking into account the possibility of fetopelvic disproportion. Lamb desertion within 72 h after birth was also registered. A ewe was considered to be deserting its lamb when, at least for 24 h, the ewe did not stay close to the lamb in field conditions and did not let it suckle unless forced to do so. The lamb was then removed from its mother and fostered to prevent its death.

2.4.2. Lambs

Immediately after birth (total expulsion of the lamb), the Apgar test (mnemonic for appearance, pulse, grimace, activity and respiration) was performed following the modifications described by Dutra and Banchero (2011). Each parameter evaluated with the Apgar test is given a score of 0–2 so that the test can range from 0 to 10. To avoid interfering with maternal behaviour, the test was conducted from a distance, and contact with the lamb was established only if one or more of the parameters assessed were '0'.

Time elapsed from birth to first bleat, stand (when the lamb was able to stand for at least 6 s) and suck (when the lamb effectively sucked for at least 5 s (Dwyer, 2003)) was registered as well as the percentage of lambs in each group that stood and sucked within the first hour from birth. If two hours after birth the lamb was not able to suck on its own then it was helped. The presence or absence of lamb coat stained with meconium was also recorded at birth.

About two hours after birth (once most lambs had stood and sucked), lambs were identified with plastic ear-tags, sex recorded and weighed using a portable digital hanging scale (Walmur®), with a capacity of 50 kg and an accuracy of 20 g. Simultaneously, O_2 saturation was measured using a handheld-pulse oximeter (model VE-H100B, EdanUSA, San Diego, Ca, USA), previously validated for its use in newborn lambs (Regueiro et al., 2022).

2.5. Statistical analyses

Data with error normally distributed (BW and BCS of the ewes, lamb/ewe BW ratio, birth weight and saturation of O_2 of lambs) were submitted to one-way ANOVA analysis using SAS software (SAS, 2015) considering the treatment (PPA or NA) as fixed effect. Birth weight was included as covariate in the model ($P < 0.05$). The lamb sex and sire were considered as random effects, and removed in the final model because the covariance parameter estimation was near zero. The ewe-lamb pair was considered as the experimental unit. Latency to the onset of grooming, as well as time elapsed from birth to lambs' first bleating, standing and suckling, presented a Poisson distribution and thus they were analysed with generalised linear mixed model using the PROC GLIMMIX. Apgar test and MBS were considered to have a multinomial distribution and were analysed with PROC GLIMMIX. All traits assessed with PROC GLIMMIX were analysed with a model considering the treatment (PPA or NA) as a fixed effect, and birth weight as a covariate ($P < 0.05$). Tested random effects (lamb sex, sire) were not included in the final model because the covariance parameter estimation was near zero. The proportion of lambs that effectively performed each behaviour feature (effectively stand or suck within the first hour of birth), the proportion of lambs stained with meconium, as well as the proportion of ewes that abandoned their lambs, were analysed with the Fisher's exact test using the PROC FREQ. Pearsons correlation between lamb/ewe BW ratio vs. duration of parturition, as well as lamb/ewe BW ratio vs. MBS, were analysed using PROC CORR. Additionally, meconium stained vs. unstained lambs were compared ad hoc in terms of their lamb/ewe BW ratio by t-test using. Significant differences between means were stated at $P \leq 0.05$, and a tendency at $0.05 < P \leq 0.10$. Data are presented as mean ± sem.

3. Results

3.1. Ewes' recordings

None of the 28 births observed was stillborn, but one lamb in the NA group died 48 h after birth. Duration of the expulsion phase of labour was 55 % shorter ($P < 0.001$) for PPA than NA group (19.2 ± 4.2 vs. 42.6 ± 7.8; Table 1), where 86% (12/14) of ewes in the PPA group had an expulsion phase shorter than 30 min while in the NA group only 21 % (3/14) of ewes lambed in that time. Ewes in the PPA group started earlier ($P = 0.004$) to groom their lambs and showed better MBS ($P = 0.004$) than NA ewes. In addition, body weight, BCS and lamb/ewe BW ratio did not differ between groups (Table 1). However, within the NA group, 28.6 % of ewes (4/14) had a duration of labour within 1–2 h, recording a high lamb/ewe BW ratio (14.2 % ± 0.5) compared to the mean ratio of ewes in the same group (NA group = 11.9 % ± 0.5, $P < 0.001$) and poor MBS (1.5 ± 0.5) (Figs. 1 and 2); two of those ewes never groomed their lambs nor allowed them to suckle. Among the NA group, a positive correlation ($r = 0.94$, $P = 0.001$) was found between the lamb/ewe BW ratio and duration of labour (Fig. 1), and the same group showed a negative correlation ($r = -0.72$, $P = 0.003$) between lamb/ewe BW ratio and MBS (Fig. 2). In the PPA group the above-mentioned correlations did not follow the same pattern, as they were low and non-significant (Figs. 1 and 2).

3.2. Lambs' recordings

Lambs born from the PPA group showed a shorter time to bleat, stand and suck than those born from the NA group (Table 2). The percentage of lambs that successfully stood within the first hour after birth did not differ between groups ($P = 0.389$), but time elapsed to stand was shorter in the PPA group. The PPA group showed a higher proportion ($P = 0.005$) of lambs sucking during the first hour from birth. Likewise, the percentage of O_2 saturation measured by pulse oximetry showed differences between groups, being higher in lambs born from the PPA group ($P = 0.007$) than from NA group (Table 2). The Apgar test was not different between groups (Table 2); almost all lambs showed Apgar values above 7 at birth, except for two lambs in the NA group, born from births lasting almost two hours.

Lamb/ewe BW ratio was not different between groups (Table 1) and neither was the proportion of meconium-stained lambs (Table 2). However, when comparing lambs stained vs. non-stained with meconium (regardless of treatment) a difference in the lamb/ewe BW ratio was obtained. Stained lambs showed a higher ratio than the unstained

Table 1
Body weight (BW), body condition score (BCS), duration of expulsion phase of labour, onset of grooming, maternal behaviour score (MBS), and lamb/ewe body weight ratio of primiparous ewes programmed-assisted (PPA) or not-assisted (NA) at parturition. Values are presented as mean ± sem. Differences are considered significant when $P \leq 0.05$.

Ewes 'attribute	PPA	NA	*P value*
BW (kg)	35.9 ± 1.1	35.1 ± 1.0	NS
BCS (0–5)	3.4 ± 0.1	3.4 ± 0.1	NS
Duration of expulsion phase (min)	19.2 ± 4.2	42.6 ± 7.8	< 0.001
Onset of grooming * (min)	1.2 ± 0.4	3.0 ± 0.6	0.004
MBS (1–5)	4.5 ± 0.1	3.1 ± 0.4	0.004
Lamb/ewe BW ratio ** (%)	12.1 ± 0.4	11.9 ± 0.5	NS

* Does not include two ewes who never groomed their lambs
** Ewe body weight corresponds to the day after parturition.

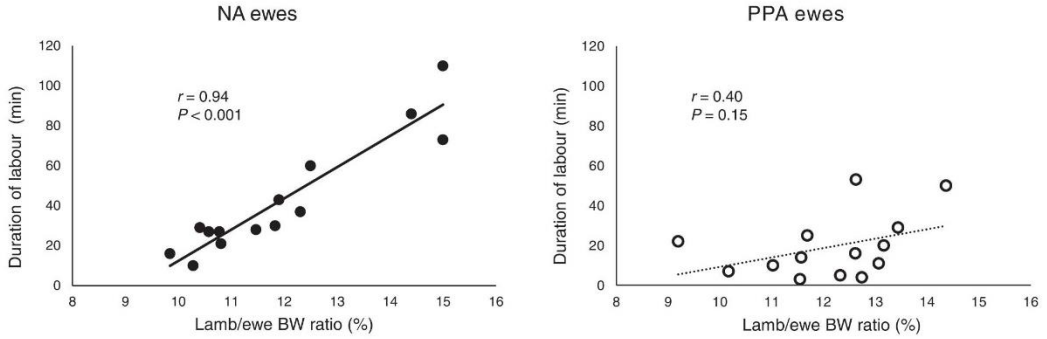

Fig. 1. Pearson correlation between lamb/ewe body weight ratio and duration of labour (duration of phase II of parturition) in not-assisted (NA) or programmed-assisted (PPA) parturition in primiparous ewes.

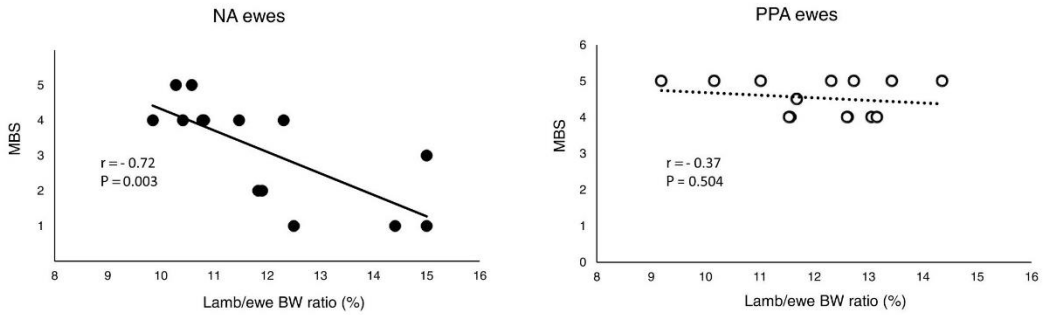

Fig. 2. Pearson correlation between lamb/ewe body weight ratio and maternal behaviour score (MBS) in not-assisted (NA) or programmed-assisted (PPA) parturition in primiparous ewes.

Table 2
Birth weight, time elapsed from birth to the first bleat, stand and suck, and frequency of lambs that successfully stood and suck within one hour of birth, Apgar test, meconium-stain coat, O_2 saturation (measured by pulse oximetry), and percentage of deserted lambs (abandoned within 72 h from birth) born from programmed-assisted (PPA) or not-assisted (NA) primiparous ewes. Values are presented as mean ± sem. Differences are considered significant when $P \leq 0.05$.

Lambs' attribute	PPA	NA	*P value*
Birth weight (kg)	4.4 ± 0.2	4.2 ± 0.2	NS
Time elapsed to first bleat (min)	2.4 ± 0.5	4.6 ± 0.8	0.002
Successfully stood % (1st h)	92.8 (13/14)	85.7 (12/14)	NS
Time elapsed to stand (min)	24.1 ± 4.2	36.8 ± 8.0	< 0.001
Successfully sucked % (1st h)	92.8 (13/14)	42.8 (6/14)	0.006
Time elapsed to first suckle (min) *	36.5 ± 6.7	71.0 ± 12.9	< 0.001
Apgar test at birth (score 0–10)	9.5 ± 0.1	9.1 ± 0.3	NS
Stained with meconium (%)	50 (7/14)	50 (7/14)	NS
O_2 saturation 2 h after birth (%)	97.6 ± 1.0	93.4 ± 1.3	0.007
Abandoned within 72 h (%)	0 (0/14)	21.4 (3/14)	NS

The figures in parentheses represent the number of lambs with this feature/total lambs in each group.
* Does not include two lambs that did not suckle after 2 h elapsed from birth.

ones (12.8 % ± 0.38 vs. 11.3 % ± 0.35, P < 0.001, Fig. 3).

Within the first 72 h from birth no lambs were abandoned in the PPA group, while desertion was registered in 21.4 % (3/14, 2 ungroomed + 1 groomed) of the lambs born to NA ewes (Table 2).

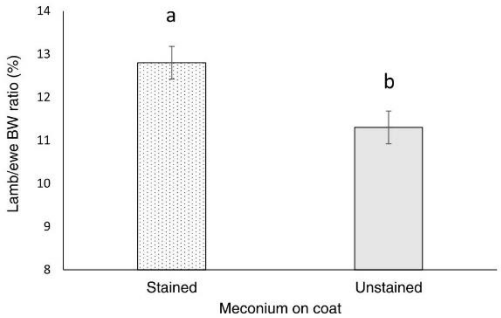

Fig. 3. Comparison of lamb/ewe body weight ratio in lambs stained or unstained with meconium at birth. The comparison was performed regardless of treatment, therefore in each column there are lambs from both PPA and NA groups. Values are presented as mean ± sem. Different letters mean significant difference (P < 0.001).

4. Discussion

The hypothesis that programmed assistance in primiparous ewes would improve mother-lamb behaviour at birth was accepted. The expulsion phase was shortened (55 %) by the intervention at birth in the PPA group. Even a shorter expulsion phase was expected in the assisted

group, but it should be noted that the experiment was conducted with primiparous ewes carrying a single lamb, which makes the expulsion more difficult (Dwyer et al., 2003; McHugh et al., 2016), and assistance was rendered considering ewe's strains to pull the lamb out. Additionally, once the lamb removal process started, not all ewes had the same frequency of pushes, so the duration varied among them despite the assistance.

Programmed assistance at birth also resulted in improved maternal behaviour reflected by the higher MBS and earlier onset of grooming. In sheep, the onset of grooming is essential as the mother learns the odour of its lamb (Nowak and Poindron, 2006). This appetite for amniotic fluid is lower in primiparous than in experienced ewes. For experienced ewes, amniotic fluid plays a facilitating role, but other sensory information may replace this signal; however, in primiparous, the amniotic fluid is mandatory for the normal development of maternal behaviour. In these ewes, the loss of this information strongly disturbs the establishment of contact with the neonate (Levy and Poindron, 1987). The delayed onset of grooming in NA ewes would be associated with a longer labour duration. Furthermore, 14 % of NA ewes rejected to groom their lambs, which were eventually abandoned. In PPA group, the onset of grooming was earlier, and all ewes groomed their lambs with no abandonment recorded. These results agree with Dwyer et al. (2003) who observed in primiparous ewes, that latency to groom was affected by lambing difficulty. Our results suggested that an early onset of grooming is beneficial, but the presence or absence of it is critical to establish the mother-lamb bond.

The poorer maternal behaviour shown by NA ewes during lamb tagging is consistent with previous data indicating that longer labour duration in primiparous ewes was associated with poorer MBS when compared with multiparous, or primiparous counterparts with no prolonged labour (Regueiro et al., 2021). Generally, primiparous ewes display maternal behavioural problems more frequently than multiparous ewes (Poindron et al., 1984), showing less intense and slower maternal behaviour to begin newborn care (Dwyer, 2008a). A study by Alexander (1960) showed that well-fed primiparous ewes lambing large lambs that experienced parturition difficulties, exhibited maternal behaviour detrimental to their lambs. Parity differences may be because maternal behaviour in multiparous ewes is facilitated by the conditioned reflex during previous lactations, whereas in primiparous it is probably altered by pain experienced at lambing (Dwyer, 2008a). Our results indicate that besides behavioural differences reported between experienced and non-experienced ewes, in primiparous the pain suffered during parturition also leads to differences within this category. Indeed, programmed assistance reduced the correlation between lamb/ewe BW ratio and MBS observed in the NA group. This may suggest that, even in cases of large lambs, PPA is helpful to shorten duration of labour and the pain experienced, improving MBS.

Moreover, maternal behaviour is stimulated by a vigorous lamb. Ewes are more interested in active lambs that bleat quickly (Stevens et al., 1984). A lamb that bleats immediately after birth, stands and attempts to suck quickly, becomes an important signal for maternal attention (Nowak, 1990). Those minutes between birth and the first bleat seem to be relevant, as it could be attractive for the mother, acting as a trigger to commence grooming. On average, PPA lambs required half of the time to first bleat than NA lambs. The longer time elapsed between birth and the first bleat, the higher risk that any interference delaying the onset of grooming (i.e. theft of the lamb by a periparturient ewe, predators) could determine the abandonment of the newborn. The slower onset of bleating in NA lambs was possibly due to partial asphyxia suffered by a delayed birth. However, these results do not correlate with the Apgar score obtained. It would be expected for NA lambs a lower Apgar score than PPA lambs, but it was not different. The Apgar test has been previously used in lambs (Dutra and Banchero, 2011; Vannucchi et al., 2012; Barreto et al., 2021) and the former authors described that a long labour decreased the Apgar score at birth. The lack of differences observed between groups might be because all lambs in the experiment were born within two hours from the onset of parturition. Apgar values for all lambs were above 7 at birth, except for two lambs in NA group whose births lasted almost two hours. This suggests that perhaps differences in Apgar would have been noticeable if lambs born from births lasting more than two hours, had also been included in this study.

Survival rate is related to how quickly the lamb stands and sucks (Dwyer et al., 2003). A fast colostrum intake enhances the establishment of the mother-lamb bond due to the suckling effect (Nowak, 1996; Banchero et al., 2015). Time elapsed to stand and suck was longer in NA lambs. Lambs in PPA group managed to suck in about half the time required by NA lambs. In lambs born to multiparous ewes, standing and suckling is influenced by the mother as she plays a key role in encouraging the newborn to stand and find the udder (Kendrick et al., 1997). In contrast, aggressive behaviour preventing the lamb from finding the udder, is frequently observed in primiparous ewes (Dwyer, 2008a). The results suggest that prolonged parturition would not only consequence in a slower lamb but also disrupts the behaviour of the mother, delaying the onset of suckling. This is consistent with Redfearn et al. (2023), who observed the same pattern of maternal behaviour disruption in ewes experiencing prolonged labour.

Oxygen saturation in PPA lambs tended to be higher than in NA group. Lamb oxygenation is related to the duration of parturition. Experiments by Dutra et al. (2007) and Dutra and Banchero (2011) investigated the causes of lamb mortality, highlighting that a high proportion of newborns dying in the early perinatal period present brain lesions of hypoxic-ischaemic encephalopathy. Moreover, a biphasic pattern was observed, where neuronal necrosis, caused by a secondary reperfusion, is added to the original brain lesion (Dutra et al., 2007). These injuries are likely the result of asphyxia and trauma to the central nervous system during the birth process. Severe lesions are likely to be the immediate cause of death, while the milder ones probably prevent the lamb from suckling and/or alter its ability to survive and adapt to the environment. The improved vigour observed in the assisted lambs could be related to better brain oxygenation. In our study, oximetry values were in general higher than those found immediately after birth (Regueiro et al., 2022), which is consistent with data showing that oximetry increases as time elapses from birth (Vannucchi et al., 2012). The lower O_2 saturation observed in NA lambs two hours after birth, may reflect longer-term consequences than simply momentary and partial hypoxic events at parturition.

Another indicator of foetal intrauterine hypoxia is the ejection of meconium into the amniotic sac causing skin staining and, in severe cases, aspiration and retention of meconium in the lungs (Wong et al., 2002; Martínez-Burnes et al., 2021). Meconium aspiration syndrome (MAS) has been reported in domestic species (Lopez and Bildfell, 1992; Mota-Rojas et al., 2006), as well as in humans (Monfredini et al., 2021; Olicker et al., 2021; Ward and Caughey, 2022), as one of the main potential causes of respiratory infections in neonates. The hypoxia suffered during labour increases parasympathetic activity in the foetus, which triggers the mechanism of intestinal peristalsis and relaxation of the anal sphincter, resulting in meconium expulsion. Multiple components of meconium are toxic to lung tissue, and provoke an inflammatory response causing chemical pneumonitis, which could lead to lambs' death even several days after birth (Olicker et al., 2021). Meconium-stained lambs showed no differences between groups, but considering lambs stained (regardless of treatment), they had a higher lamb/ewe BW ratio than those unstained, suggesting probably a higher degree of birth asphyxia. Whereas both, brain injuries caused by asphyxia and MAS are frequently the consequence of delayed births, and they can lead to lamb death both in the immediate postpartum period or several days after birth, is expected that programmed parturition assistance will improve lamb survival.

Lamb/ewe BW ratio was not different between groups. However, when the BW ratio was compared with the duration of labour it was observed that in the NA group there was a correlation, showing that the

higher the BW ratio, the longer the duration of parturition; this correlation was not significant in the PPA group. This suggests that assisted births would not necessarily follow the pattern that heavier lambs (with a high lamb/ewe BW ratio) will have a longer duration of labour.

Prolonged labour may be better tolerated by multiparous than by primiparous ewes, which indicates that in terms of maternal behaviour parity makes a difference but, for the lamb, the consequences of asphyxia remain the same, and this determines its viability. Several studies have attempted to solve the problem of birth asphyxia. Although therapy using melatonin (Aridas et al., 2018; Flinn et al., 2020; Candia et al., 2022), magnesium sulphate (Galinsky et al., 2016), umbilical cord blood mononuclear cells (Aridas et al., 2016) have been applied in lambs to prevent brain damage potentially caused by hypoxia, in primiparous ewes there is still another issue to be solved: maternal misbehaviour after prolonged labour.

Results obtained in previous work, raised the question of whether the dams' rejection of the newborn after labour being ultimately assisted, was due to long labour duration and/or to the human intervention performed to remove the lamb (Regueiro et al., 2021). The current results show that, in primiparous ewes accustomed to human presence, lambing assistance not only does not lead to subsequent lamb rejection but also improves the establishment of the ewe-lamb bond, possibly due to a shorter and less painful lambing process. Thus, it seems to be the duration of the expulsion phase per se likely to induce behavioural changes in both mother and lamb, and not the assistance provided. Although pain is a challenging variable to subjectively measure in animals, several authors working with sheep have used behavioural responses to assess experienced pain (Molony et al., 2002; Fitzpatrick et al., 2006); but the question arises as to whether what we are assessing in the present experiment is a response to pain, a response to exhaustion following prolonged labour, or perhaps both. But, in spite of the uncertainty about the specific mechanism involved (whether pain or exhaustion), the assistance provided improved maternal behaviour, leading to an enhanced bond with the lamb.

Programmed parturition assistance could be a potential and promissory management strategy to improve lambs' survival and reduce fostered lambs. However, it is worth considering in which context birth assistance might be beneficial. Dwyer (2008b) suggests that lambing assistance might lead to a problem when keeping the offspring of assisted ewes, for this reason, selection should include easy lambing. Therefore, in terms of the purpose of the production system, a two-pronged approach should be considered: it could be promoted for economic benefit in commercial lamb-producing flocks undergoing terminal crossbreeding, and perhaps exclude those flocks that serve as a source of replacement ewe lambs. Despite this, there are ethical and behavioural issues that need to be addressed. Production in species bred for human consumption has improved considerably (Sanchez-Salcedo et al., 2019), but this had led to side effects, such as an increase in birth weight. Furthermore, breed differences in the percentage of ewes with dystocic lambing have been reported (Alexander et al., 1983; Dutra and Banchero, 2011). As PPA is a procedure of which there is no information of being performed on sheep before, more studies should be conducted to explore its impact in intensive rearing, or even in extensive systems when applied to selected groups of animals. However, since dystocia remains a high-incidence problem in sheep production (Jacobson et al., 2020), in primiparous ewes PPA could be a useful tool to improve lamb survival, further benefitting the welfare of ewes and lambs.

5. Conclusion

Reduction of the foetal expulsion phase through programmed assistance at parturition improved the vigour of the lambs as well as the maternal behaviour of the ewes. The improvement in the welfare of the ewe-lamb unit would increase, in turn, the survival of the lambs.

CRediT authorship contribution statement

Design of the study: MR and CLM; sample collection: MR, CLM and AIB; data analysis: MR, EJS and FB; first draft: MR, EJS, CLM and GB. All authors participated in the writing and approved the final version of the manuscript.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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5. DISCUSIÓN GENERAL Y CONCLUSIONES

La hipótesis general de la investigación fue confirmada, dado que la prolongada duración de la fase de expulsión fetal afectó el comportamiento tanto de las madres como de los corderos. El vínculo madre-cría se vio alterado cuando la duración del parto fue mayor, observándose una correlación lineal entre esta variable y el mal comportamiento materno únicamente en ovejas primíparas. El grado de hipoxia sufrida, así como el vigor de los corderos, también se afectó en los partos prolongados. La reducción de la duración del parto mediante la asistencia programada resultó en una mejora en los parámetros registrados tanto de la madre como del cordero, lo que permitió establecer un vínculo madre-cría apropiado.

5.1 EFECTO DE LA DURACIÓN DEL PARTO SOBRE EL COMPORTAMIENTO MATERNO

Los resultados obtenidos demostraron que una mayor duración de la fase de expulsión fetal puede afectar el comportamiento materno de manera diferente según la paridad de la oveja, lo que disminuye tanto el escore de comportamiento materno (MBS) como la demora en el inicio de la limpieza del cordero, o incluso provoca la falta total de esta. En ovejas primíparas, se observó una correlación entre el MBS y la duración del parto, indicando que a medida que esta última aumenta el MBS disminuye. El mismo efecto se reflejó en la presencia o no de la limpieza del cordero, ya que, en las primerizas, el porcentaje de madres que no lo hicieron también se correlacionó con una prolongada duración del parto. Sin embargo, este patrón no se registró en las ovejas multíparas, en las que una prolongada fase de expulsión fetal no disminuyó el MBS ni tuvo influencia sobre la limpieza o no de la cría. Esto corrobora los datos obtenidos por Meurisse et al. (2005), quienes observaron que es común que las ovejas primerizas exhiban un comportamiento materno inadecuado hacia sus crías e incluso las abandonen, mientras que esto es poco común en las ovejas multíparas.

Si bien ha sido documentado anteriormente que las ovejas de primer parto que experimentan partos demorados desarrollan un comportamiento materno deficiente comparado con las multíparas (Dwyer, 2014, Dwyer, 2003, Alexander, 1988), estos

estudios no relacionan cuánto tiempo debe transcurrir en la fase de expulsión fetal para que la respuesta comportamental se vea afectada. En este sentido, estratificar la duración de dicha fase permitió identificar la correlación lineal existente entre el tiempo transcurrido y el incremento del porcentaje de ovejas primerizas que demostraron mal comportamiento (capítulo 2). Los resultados muestran que no todas las primerizas tienen un comportamiento deficiente, sino que el incremento en el porcentaje de ovejas con bajo MBS y ausencia de limpieza del cordero aumenta en forma lineal con la duración del parto (capítulos 2 y 4). En esta categoría, un parto que se prolonga casi 2 horas es potencialmente un factor determinante para que la madre primeriza no establezca el vínculo con el cordero y lo abandone. Estos resultados son consistentes con lo descrito por Nowak y Poindron (2006), quienes señalan la importancia de la limpieza y el aprendizaje del olor del cordero como elementos cruciales en ovejas primerizas, elementos sin los cuales difícilmente se establezca la unión con el neonato. Los resultados obtenidos evidencian que el inicio temprano de la limpieza del cordero es beneficioso, pero su presencia o ausencia es crítica.

El comportamiento selectivo que desarrolla la madre incluye la limpieza y el contacto directo con su cordero, y aunque las ovejas tienen una capacidad de defensa limitada contra predadores, una vez que se establece el vínculo, son capaces de proteger a su cría, lo que aumenta las posibilidades de supervivencia (Dwyer, 2008a). Además, en condiciones de cría extensiva y con situaciones climáticas adversas (frío, lluvia), la posibilidad de sobrevivir del cordero depende también de que su madre lo acepte en los primeros minutos de vida, antes de que la hipotermia sea irreversible. La falta de interés y la incapacidad de establecer ese vínculo con el recién nacido reducen significativamente la posible viabilidad de este. La reducción de la fase de expulsión fetal mediante la asistencia planificada al parto (PPA) en ovejas primíparas mejoró tanto el escore de comportamiento materno como el inicio de la limpieza del cordero en comparación con las no asistidas, sin que se registraran abandonos.

Otro factor que influyó sobre el comportamiento materno fue la relación existente entre el peso del cordero y el de la madre (relación de peso cordero/oveja, capítulo 4). Este indicador ha sido asociado previamente con partos distócicos (Berry et al., 2007, Dutra y Banchero, 2011). Si bien en los corderos mellizos el bajo peso es

un factor predisponente a la mortalidad, en el caso de los corderos únicos el alto peso es también una limitante y más aún cuando se trata de hembras primerizas donde la relación de peso entre el cordero y su madre es elevada. Se observó una fuerte correlación entre el aumento de la relación de peso cordero/oveja con la duración prolongada del parto, al igual que con el MBS en las ovejas que no fueron asistidas. Sin embargo, cuando se realizó asistencia programada, se logró modificar ese patrón lo que determinó que la relación entre el peso de la madre y el cordero no tuviera la misma influencia sobre el comportamiento.

La asociación encontrada entre la relación de peso de cordero/oveja, la duración del parto y el mal comportamiento materno probablemente sea la consecuencia del prolongado tiempo de dolor experimentado durante la fase de expulsión. Aunque el dolor es una variable difícil de medir subjetivamente en los animales, varios investigadores han utilizado respuestas conductuales en ovinos para evaluarlo (Fitzpatrick et al., 2006, Molony et al., 2002). Sin embargo, cabe cuestionarse si el mal comportamiento observado es una respuesta al dolor, una respuesta al agotamiento tras un parto prolongado o quizás ambas cosas. De todos modos, a pesar de la incertidumbre sobre el mecanismo específico involucrado (ya sea dolor o agotamiento), la asistencia proporcionada mejoró el comportamiento materno de las madres primerizas en comparación con las que no recibieron asistencia.

5.2 CONSECUENCIAS DE LA DURACIÓN DEL PARTO SOBRE EL CORDERO

Los parámetros medidos en los corderos como respuesta a la mayor duración de la fase de expulsión se vieron afectados, pero con variaciones entre los experimentos realizados. Con una prolongada duración del parto, se observaron consecuencias en los corderos nacidos de madres primíparas, tales como la disminución en el puntaje del test de Apgar, el aumento en el tiempo requerido para mamar y una reducción en el porcentaje de corderos que lograron mamar durante las dos primeras horas de vida (capítulo 2). Sin embargo, en el mismo experimento, esos parámetros no mostraron cambios en los corderos nacidos de ovejas multíparas. Estos resultados sugieren que un parto prolongado no sólo resultaría en un cordero más lento, sino que el tiempo que

demora en mamar está determinado en gran parte por el mal comportamiento de la madre, retrasando el inicio de la lactancia. Esto concuerda con lo reportado por otros autores, quienes observaron un patrón similar de alteración del comportamiento materno en ovejas primerizas que experimentaron un parto prolongado (Darwish y Ashmawy, 2011, Dwyer et al., 2003).

En cuanto al tiempo que los corderos demoraron en levantarse, en el primer experimento no se observaron diferencias entre categorías ni tampoco entre grupos dentro de la misma categoría (capítulo 2). En cambio, en los experimentos 2 y 3 (capítulos 3 y 4), los corderos nacidos de partos prolongados sí registraron demoras tanto en el tiempo en levantarse como en el inicio de la lactación. Estas diferencias podrían estar relacionadas con las condiciones específicas de cada experimento y las diferentes formas en que se crearon los grupos experimentales.

Según Nowak y Poindron (2006), el tiempo que tarda un cordero en levantarse puede estar influenciado por varios factores, como el peso al nacer, el sexo (los machos suelen ser más lentos) y el tamaño de camada (los mellizos demoran más que los únicos). Es importante destacar que sólo en el experimento 2 (capítulo 3) se utilizaron ovejas preñadas de mellizos y, aunque en dicho experimento el número de corderos clasificados como acidóticos (pH < 7,1) fue bajo, el 67 % de esos animales fueron mellizos, lo cual podría haber influido en el resultado. En cuanto al experimento 3, es posible que la diferencia encontrada en el tiempo en levantarse entre los grupos asistido y no asistido pueda considerarse como una disminución del tiempo requerido como consecuencia de la asistencia, en lugar de un aumento del tiempo en el no asistido.

5.2.1 Niveles de hipoxia y uso del oxímetro de pulso

La duración de la fase de expulsión fetal influyó sobre los niveles de hipoxia registrados en los corderos al nacer, afectando en el vigor y la vitalidad de estos.

Los corderos que por gasometría presentaron niveles de pH sanguíneo inferiores a 7,1 (acidosis), registraron también bajo porcentaje de oximetría y tuvieron una duración del parto mayor respecto a los nacidos con pH sanguíneo superior a ese valor. El hecho de que, debido al material del experimento 2, los corderos fueran hijos sólo

de ovejas multíparas probablemente determinó que el promedio de la duración de parto en aquellos que presentaron acidosis no fue tan elevado como en los experimentos 1 y 3. Esto indicaría que la acidosis en los recién nacidos es consecuencia de un parto prolongado, pero no todos los partos prolongados producen necesariamente acidosis.

La oximetría de pulso se valoró como un método relativamente preciso para evaluar la oxigenación al nacimiento en corderos, ayudando a identificar los corderos nacidos con bajo porcentaje de oxigenación por situaciones de asfixia generadas durante el parto. Esto facilitaría la priorización del seguimiento de los corderos con baja oxigenación para la aplicación de medidas tanto terapéuticas (administración de bicarbonato de sodio en situaciones en que la baja $satO_2$ se prolongue, para evitar el riesgo de acidosis metabólica) como de manejo.

Los recién nacidos tienen una muy buena capacidad para corregir por sí mismos los desequilibrios metabólicos y respiratorios causados por la hipoxia (Martz et al., 2019). De ese modo, la acidosis respiratoria causada por la falta de ventilación pulmonar puede revertirse rápidamente con el inicio de la respiración. Sin embargo, el componente metabólico puede requerir un plazo de 24 a 48 horas para su compensación (Parer y Livingston, 1990). Pero, a pesar de la capacidad para compensar la acidosis metabólica y respiratoria mixta con el inicio de la respiración pulmonar, cuanto más se prolongue la segunda fase del parto y más extrema sea la acidosis, más perjudiciales serán sus consecuencias (Martz et al., 2019). La hipoxia persistente durante un parto prolongado puede provocar efectos negativos a largo plazo para la sobrevivencia del neonato o ser inmediatamente fatal. Por lo tanto, cuanto más rápido sea esta transición de la circulación fetal a la neonatal, menos hipoxia se producirá en el feto.

Como consecuencia de las lesiones provocadas por hipoxia, los corderos no sólo corren el riesgo de morir durante o poco después del nacimiento (Dutra et al., 2007), sino que el riesgo persiste debido a la cadena de eventos que ocurren en los días siguientes, relacionados a una interacción madre-cría deficiente y a la incapacidad de regular la temperatura o de alimentarse. En este aspecto, en razas donde la presencia de distocia es frecuente, al igual que en aquellas que presentan un alto porcentaje de partos de mellizos, el uso de implantes de melatonina ha demostrado ser una alternativa

muy eficaz para incrementar la sobrevivencia a partos prolongados (Davis et al., 2021). La melatonina protege el cerebro fetal de las lesiones hipóxico-isquémicas que puedan originarse durante el parto, aumenta el flujo sanguíneo uterino, incrementa la capacidad de termorregulación neonatal y aumenta la acumulación de grasa parda en el feto (Canto et al., 2023, Flinn et al., 2020b, Sales et al., 2017). Sin embargo, a pesar de los buenos resultados obtenidos con el uso de melatonina y otras terapias alternativas para prevenir el daño cerebral, como el sulfato de magnesio (Galinsky et al., 2016) o el uso de células mononucleares de la sangre del cordón umbilical (Aridas et al., 2016), en partos de ovejas primerizas queda aún el otro problema por resolver: el mal comportamiento de la madre cuando existe un parto prolongado.

Otro indicador del estrés fetal resultante de la hipoxia intraparto es la presencia de meconio en el recién nacido. Los corderos teñidos con meconio no se relacionaron con la duración del parto, ya que se registró en la mitad de los animales de cada grupo (asistido o no asistido, capítulo 4). Dado que la hipoxia intraparto puede provocar la expulsión de meconio en la bolsa amniótica y considerando que de algún modo todos los corderos sufren algún grado de hipoxia durante el parto, el nacimiento de corderos teñidos no sería, en una primera instancia, un problema. El problema surge cuando el parto se prolonga y el riesgo de aspirar el meconio expulsado aumenta, con la probabilidad de causar el síndrome de aspiración de meconio (MAS). En estos casos, la retención de meconio tanto en vías respiratorias altas como en los pulmones puede desencadenar una reacción inflamatoria que potencialmente puede ser fatal (Martínez-Burnes et al., 2021, Wong et al., 2002).

Con una asistencia temprana al parto, se podría disminuir el período de estrés fetal provocado por la hipoxia sufrida en el período de expulsión y prevenir lesiones irreversibles en el cordero que limitarían su viabilidad o sobrevivencia.

5.3 CONSECUENCIAS EN EL ESTABLECIMIENTO DEL VÍNCULO MADRE-CRÍA

En condiciones extensivas, el establecimiento apropiado de la unidad madre-cría es claramente un elemento fundamental para la sobrevivencia del neonato y el comportamiento materno inadecuado conduce inevitablemente a una muerte temprana

(Nowak, 1996). La principal consecuencia de la falta de un vínculo apropiado fue el abandono del neonato registrado en ovejas primíparas. En ningún experimento se permitió morir a los corderos que eran abandonados, pero se consideraron como muertos (capítulo 2) para el análisis de los datos, ya que en esa situación en cría extensiva las chances de sobrevivencia son muy bajas. La mortalidad fue superior en las ovejas primíparas en comparación con las multíparas (12,7 % vs. 1,7 %), registrándose el 75 % de las muertes en aquellos corderos nacidos de partos que duraron más de una hora.

Según estudios realizados desde décadas atrás hasta otros actuales, la muerte de los corderos por inanición-exposición como consecuencia de partos dificultosos es la causa dominante de las pérdidas (Hinch y Brien, 2014, Dutra et al., 2007, Holst et al., 2002, Hughes et al., 1964). En el mismo sentido, Jordan y Le Feubre (1989) documentaron que el 67 % de las muertes por inanición estaban relacionadas, en su mayoría, con un mal comportamiento materno y/o el abandono del cordero. En nuestros resultados se observa claramente un notorio componente de comportamiento materno inadecuado como consecuencia de una prolongada duración del parto. En ovejas primerizas, una fase de expulsión fetal que se prolonga por más de 90 minutos parecería ser determinante de un mal comportamiento (probablemente debido al dolor o al agotamiento sufrido).

En los corderos nacidos de partos prolongados no se identificó una correlación lineal entre la duración del parto y la disminución del puntaje de Apgar o del vigor observado. Por los datos obtenidos, las fallas existentes en establecer el vínculo madre-cría parece más preciso atribuirlas al mal comportamiento de la madre y no como consecuencia de una disminución de la vitalidad y vigor de los corderos. Esto se confirma por el hecho de que sólo se registraron puntajes bajos en el test de Apgar en los nacimientos cuya fase de expulsión superó los 90 minutos.

De todos modos, aunque en el presente trabajo no se tomaron en cuenta las muertes producidas luego de las 72 horas, habría que considerarlas, ya que estarían relacionadas con aquellos corderos que sufrieron lesiones por asfixia severa, aspiración de meconio o ambas. En estos casos, la correcta relación con la madre estaría también limitada por un pobre comportamiento de la cría.

5.4 CONSIDERACIONES FINALES

En suma, un parto prolongado afecta tanto el comportamiento de las madres como el de los corderos, aunque estos parecen ser más resilientes para enfrentar las consecuencias que se generan. Del mismo modo, las ovejas que ya han experimentado un parto anterior no demuestran cambios en el comportamiento ante una demora en la fase de expulsión fetal. El mayor desafío está planteado, entonces, en lograr disminuir los efectos que un eventual parto dificultoso tiene sobre el comportamiento de las ovejas primíparas. Una asistencia temprana al parto podría considerarse como una alternativa válida para disminuir el alto índice de abandono de las crías, ya que, en primíparas, los efectos de la duración prolongada de la fase de expulsión fetal ya se aprecian a partir de los 30 minutos.

Sin embargo, la utilización de esta medida puede ser controversial. Dwyer (2008b) sugiere que la asistencia al parto puede generar problemas al conservar las hembras nacidas de ovejas asistidas, ya que la que la selección debería incluir la facilidad de parto; pero la misma autora afirma que reducir la intervención en los partos puede llevar a un aumento de la mortalidad tanto de ovejas como de corderos, con un costo inaceptable en términos del bienestar animal (Dwyer y Bünger, 2012). Por lo tanto, desde el punto de vista de la finalidad del sistema de producción, se podría considerar un doble enfoque: podría promoverse para obtener beneficios económicos en las majadas de producción comercial de corderos sometidos a cruzas terminales, y tal vez excluir a los rebaños que utilizan a las corderas nacidas como fuente de reemplazos. De todos modos, hay implicancias éticas y de bienestar animal que deben tenerse en cuenta.

La producción en las especies criadas para el consumo humano ha mejorado considerablemente, pero esto ha generado efectos secundarios, como lo es el aumento del peso al nacer (Sánchez-Salcedo et al., 2019). Esto evidencia también un problema ético, ya que plantea la interrogante de hasta qué punto es aceptable incrementar el tamaño del producto (en este caso, del cordero) sin considerar las consecuencias que esto representa en el momento del parto. El impacto de la selección por rasgos de producción no ha sido tan estudiado en ovinos como en otras especies, sin embargo, se han identificado diferencias entre razas en el riesgo de distocia (Dwyer y Bünger,

2012). En un estudio realizado por estos autores, se registró que el porcentaje de partos asistidos en cruzas terminales con texel y suffolk ascendieron a valores tan elevados como 56 % y 30 %, respectivamente.

Olivera-Muzante (2017) observó que el uso de tecnologías como la sincronización de celos y el uso de IATF sin supervisión de partos puede resultar contraproducente e incluso generar pérdidas económicas debido a los costos asociados a la sincronización. Por lo tanto, en sistemas de cría extensiva, el uso de refugios para partos en combinación con una asistencia temprana de los mismos se presenta como una estrategia eficiente que tendría efectos positivos tanto en la economía del establecimiento como en el bienestar animal.

Plantearse una reducción rápida de la distocia a través de la selección genética directa representa un problema debido a la baja heredabilidad de esta y de algunos de sus indicadores, como la facilidad de parto (Jacobson et al., 2020). Por otro lado, se ha reportado que el comportamiento materno tiene también una baja heredabilidad (Houpt, 2011) y, por los resultados obtenidos en el presente trabajo, el mal comportamiento parecería estar más ligado a partos prolongados que a un problema genético.

Décadas atrás, Alexander (1984) sugirió que la mayoría de las pérdidas neonatales en los rebaños estaban estrechamente vinculadas al proceso de parto en sí y que esto merecía mayor consideración, ya que era un aspecto no tenido en cuenta por los productores comerciales para disminuir las elevadas pérdidas de corderos. Sin embargo, actualmente, la distocia sigue siendo un problema de alta incidencia en la producción ovina (Jacobson et al., 2020, Dwyer y Bünger, 2012), por lo que nuevos estudios serían necesarios para explorar el impacto de una inmediata asistencia al parto tanto en cría intensiva como semiintensiva o incluso en sistemas extensivos cuando se aplica a grupos seleccionados de animales. Principalmente en ovejas primíparas, la PPA podría ser una herramienta útil para mejorar la supervivencia de los corderos, promoviendo que se establezca un adecuado vínculo madre-cría.

5.5 CONCLUSIONES

En condiciones de cría extensiva, la prolongada duración de la fase de expulsión fetal tuvo una influencia negativa en la supervivencia de los corderos, así como en el comportamiento materno de las ovejas primíparas, pero no en las ovejas multíparas, por lo que el control de partos en las ovejas que paren por primera vez se vuelve altamente relevante para prevenir el abandono de la cría.

Los corderos nacidos de partos prolongados parecen ser más tolerantes a los cambios que produce la duración del parto, revirtiendo, en su mayoría, las consecuencias producidas por la hipoxia al nacer.

La oximetría de pulso resulta un método relativamente preciso para evaluar el grado de hipoxia que presentan los corderos al nacer, lo que facilitaría el seguimiento de aquellos que requieran medidas terapéuticas o de manejo.

La reducción de la fase de expulsión fetal mediante la asistencia temprana al parto mejoró el establecimiento del vínculo madre-cría. Por los resultados obtenidos, podemos afirmar que, si los animales están acostumbrados a la presencia humana, los beneficios de una asistencia temprana pueden ser relevantes.

La mejora en el bienestar de la unidad madre-cría mediante un vínculo apropiado aumentaría la supervivencia de los corderos y es un aspecto fundamental a tener en cuenta desde el punto de vista del bienestar animal.

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