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Developing a modified Apgar scoring system for newborn lambs

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ABSTRACT

The Apgar (appearance, pulse, grimace, attitude, respiration) score is an accepted method for assessing newborn viability in humans and domestic animals. The purpose of this research was to modify an existing Apgar scoring system for lambs and compare Apgar score with litter size and birth order, as well as time-to-stand and time-to-suckle. Polypay lambs (n = 75) delivered naturally were used for this study. Pulse (<100 bpm = 0; 100–175 bpm = 1; >175 bpm = 2) and respiration (<45% SpO_2 = 0; 45–65% SpO_2 = 1; >65% SpO_2 = 2) were measured with a pulse oximeter attached to the lamb's ear. Appearance, grimace, and attitude were assessed using mucous membrane color (cyanotic = 0; pale = 1; pink = 2); response to nose stimulation (no response = 0; moves head slightly = 1; shakes head = 2); and response to rump stimulation (no movement = 0; moves but no attempt to stand = 1; attempts to stand = 2), respectively. The Apgar score was measured within 5 min of birth (T0), 15 min (T15) and 60 min (T60) after birth. The time-to-stand and time-to-suckle were recorded and compared to Apgar scores. Apgar scores did not differ by litter size or birth order. There were no significant correlations between the Apgar scores and time-to-stand. There was a moderate positive correlation between attitude and time-to-suckle at T0 (R^2 = 0.467), which may affect the ingestion of adequate colostrum in a timely manner. Producers may choose to consider using Apgar scoring so that assistance can be provided to lambs before serious complications arise.

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1. Introduction

Postnatal mortality in lambs represents a large monetary loss to the sheep industry with about 10% of lambs dying before weaning [1]. Approximately one-third of these losses occur within the first 5 days after birth and mortality is significantly higher in triplets compared to singletons or twins [2]. Identifying at risk lambs will allow producers to provide additional care that may reduce mortality rate.

The Apgar scoring system was developed for human medicine to serve as a guide to the clinical care of vulnerable babies immediately postpartum. The Apgar scoring system was designed by Virginia Apgar, a human obstetrical anesthesiologist, to monitor the effects of anesthesiology administered to the mother on the newborn infant [3]. The system scores 5 categories: **A**ppearance (color), **P**ulse, **G**rimace (reflex irritability), **A**ttitude (muscle tone), and **R**espiration on a scale of 0–2 [4]. The APGAR scoring system has been adapted for use in pigs [5,6], horses [7], calves [7], dogs [8], donkeys [9], and sheep [10]. It was found that total Apgar scores used as a basis for resuscitation intervention increased survival rates and low Apgar scores correlated to higher mortality rates in puppies [8,11].

The purpose of the current research was to modify an existing Apgar scoring system for lambs. It was hypothesized that higher Apgar scores would correlate with faster times-to-stand and suckle.

2. Materials and methods

Polypay ewes (n = 45) lambing in January and February 2019 at the Oregon State University Sheep Research Center were used for this study. The median age of ewes at the time of lambing was 3 years (range: 2–10 years). Ewes were not part of an intensive sheep breeding system. All ewes were managed under similar conditions. Ewes were fed a concentrate mixture of dried corn and orchard hay during gestation. Ewes were body condition scored regularly and those that presented with a body condition score (BCS) of less than 3 (on a scale of 1–5) were examined for parasites (and treated as needed) as well as fed separately. Ewes were housed indoors in groups of 12–14 ewes per pen until delivery. Shortly after giving birth, each ewe and offspring were placed into individual lambing

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jugs. There were 75 lambs born in this study (42 males, 32 females, 1 lamb whose gender was not recorded; 19 singletons, 44 twins, 12 triplets).

An Apgar scoring system previously developed for lambs included assessment of heart rate, respiration rate, activity, grimace, and appearance [10]. This scoring system was modified in the current study to improve assessment of oxygenation status. The modified Apgar scoring system used in the current study is summarized in Table 1. Briefly, the numeric Apgar score for mucous membrane color (from cyanotic to pink) was recorded. Pulse and oxygen saturation (indirect measurement of respiration) was measured using a pulse oximeter (#PM-92, Mindsinglong Science and Technology Co., Ltd, Shenzhen, China) attached to the lamb's dried ear. The absolute values for pulse (beats per minute; bpm) and oxygen saturation (SpO_2) were recorded. A pulse score of 2 was given to lambs with a heart rate >175 beats/minute; a pulse score of 1 was given to lambs with a heart rate of 100–175; a pulse score of 0 was given to lambs with a heart rate of <100. A respiration score of 2 was given to lambs with an SpO_2 >65%; a respiration score of 1 was given to lambs with an SpO_2 of 45–65%; a respiration score of 0 was given to lambs with an SpO_2 of <45%.

Grimace was evaluated by using a finger to gently tickle the nasal mucosal surface of the lamb to elicit a response and the corresponding Apgar score was recorded. Attitude was evaluated by using fingers to gently scratch the rump of the lamb to elicit a response and the corresponding Apgar score was recorded. The total Apgar score was the sum of the individual scores. Each parameter was evaluated within 5 min of birth (T0) in all lambs as well as at 15 (T15) and 60 (T60) minutes in a subset of the group (n = 33). For all lambs, the time-to-stand and time-to-suckle were recorded in minutes. Weight at birth, birth order, and delivery interval (for multiple births) was also recorded for all lambs. Multiple observers trained by the author (TF) performed the Apgar scoring and recorded the weight at birth and birth order. The first successful attempts to stand and suckle were recorded for time-to-stand and time-to-suckle. Other than the stimulation provided by APGAR scoring, no resuscitation methods were applied in the study.

Using a Shapiro-Wilk normality test, the data were found to not have a Normal distribution. Data were presented as medians and ranges. Apgar scores were compared between timepoints using a Friedman test for repeated measures for singletons, twins and triplets as well as all lambs combined. Apgar scores at each timepoint were compared between male and female lambs as well as singleton and twin lambs using a Mann-Whitney *U* test. Short (<30 min) and long (≥30 min) delivery intervals were compared to Apgar scores at T0, time-to-stand and time-to-suckle for twin and triplet lambs using a Mann-Whitney *U* test. Apgar scores at each timepoint were compared between birth order for twin lambs (first born vs second born) using the Wilcoxon signed rank test. The Kruskal-Wallis test was used to compare birth weights between single, twin and triplet lambs. Correlation coefficients and linear regression analysis were used to measure the degree of relationship between continuous variables for Apgar scores at each timepoint to birth weight and delivery interval. In addition, Apgar scores at birth and birth weights were compared to time-to-stand and time-to-suckle using linear regression analysis. GraphPad Prism version 8.0 (San Diego, California) and Microsoft Excel (Redmond, Washington) software were used for the data analysis. Significance was defined as $P < 0.05$.

3. Results

Total Apgar score increased over time for triplets ($P = 0.043$) but did not differ significantly for singletons, twins or all lambs combined (Table 2). There was no significant change in any individual Apgar parameter over time for singletons, twins, triplets, or all lambs combined.

There was a trend ($P = 0.055$) for the grimace score at 15 min after birth to be lower in twins (1, 0–2) compared to singletons (2, 0–2), but there were no significant differences at any of the other timepoints with any of the other single parameters (Table 2). In addition, the total Apgar score did not differ significantly within 5 min of birth or at 60 min after birth between twins and singletons. However, the total Apgar score was significantly lower in twins (7, 4–10) compared to singletons (9, 4–10) at 15 min after birth ($P = 0.048$).

The delivery interval between twins, triplets, and twins and triplets combined was 26 min (2–62 min), 15 min (5–41 min), and 22.5 min (2–62 min), respectively. There was no significant effect of delivery interval on any of the individual Apgar parameters or total Apgar score within 5 min of birth (Table 3). In addition, there was no significant effect of delivery interval on time-to-stand or time-to-suckle in twins and triplets (Fig. 1, Table 4).

There was no significant difference in Apgar parameters at any timepoint between first and second born lambs (Table 5). There was no significant difference in time-to-stand between birth order. However, there was a trend ($P = 0.058$) for a shorter time-to-suckle when compared between first born (20 min, 13–35 min) and second born lambs (41 min, 10–62 min).

Birth weight of singletons (4.86 kg, 2.64–6.32 kg) was significantly heavier ($P = 0.027$) compared with twins (4.155 kg, 1.87–6.35 kg) and triplets (3.855 kg, 2.61–4.76 kg). But there was no effect of birth weight on any individual Apgar parameter or total Apgar score at any timepoint (Table 2). In addition, there was no effect of birth weight on time-to-stand or time-to-suckle (Fig. 2, Table 4). While there was no effect of any individual Apgar parameter on time-to-stand, there was a significant relationship between attitude and time-to-suckle within 5 min of birth ($R[2] = 0.467$; Table 4). With respect to sex, there was no significant difference between birth weight but there was a trend for females to have a higher attitude score within 5 min of birth ($p = 0.066$) and a faster time-to-stand ($p = 0.019$) compared to males (Table 6).

Table 1
The Apgar scoring system adapted used to evaluate newborn lambs.

Parameter	0 points	1 point	2 points
Appearance (mucous membrane color)	Cyanotic	Pale	Pink
Pulse (beats/minute)	<100	100–175	>175
Grimace (nasal stimulation)	No response	Moves head slightly	Sneezes/moves away/shakes head
Attitude (croup stimulation)	No response	Moves with no attempt to stand	Attempts to stand
Respiration (oxygen saturation; SpO2)	<45%	45–65%	>65%

Table 2
The median (and ranges) for Apgar scores, time-to-stand, time-to-suck, birth weight (BW), pulse (beats per minute) and oxygen saturation (%) as measured from a pulse oximeter within 5 min of birth (T0), 15 min of age (T1) and 60 min of age (T2) for singleton, twin, triplet and all lambs combined.

	Singletons			Twins			Triplets			All Lambs		
	T0	T1	T2	T0	T1	T2	T0	T1	T2	T0	T1	T2
A	2 (0–2)	2 (1–2)	2 (2-2)	2 (0–2)	2 (1–2)	2 (1–2)	2 (1–2)	2 (1–2)	2 (1.75–2)	2 (0–2)	2 (0–2)	2 (1–2)
P	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	0.5 (0–2)	1.5 (0–2)	1 (0–1)	1 (0–2)	1 (0–2)	1 (0–2)
G	2 (1–2)	2 (1–2)	2 (1–2)	2 (0–2)	1 (0–2)	2 (0–2)	2 (1–2)	2 (1–2)	2 (1.5–2)	2 (0–2)	2 (1–2)	2 (0–2)
A	2 (0–2)	2 (0–2)	2 (0–2)	1.5 (0–2)	2 (0–2)	2 (0–2)	2 (1–2)	2 (2-2)	2 (1–2)	2 (0–2)	2 (0–2)	2 (0–2)
R	2 (0–2)	2 (2-2)	2 (2-2)	2 (0–2)	2 (2-2)	2 (2-2)	2 (0–2)	2 (2-2)	2 (2-2)	2 (2-2)	2 (2-2)	2 (2-2)
Total	8.5 (3-10)	9 (4-10)	8.5 (6-10)	7 (4-10)	7 (4-10)	8 (5-10)	7.625 (3-10)	9 (7-10)	8 (7–9)	8 (4–9)	8.5 (4-10)	8.5 (6-10)
BPM	159.5 (90–250)	151 (54–250)	142 (59–208)	118 (26–250)	135.5 (38–250)	120 (73–250)	104.5 (75–226)	170 (42–260)	125 (75–148)	117 (71–250)	160 (56–250)	136 (86–250)
SpO_2	99 (35–99)	99 (85–99)	99 (70–99)	99 (35–99)	99 (90–99)	99 (85–99)	99 (44–99)	99 (99-99)	99 (99-99)	99 (90–99)	99 (85–99)	99 (70–99)
BW	4.9 (2.6–6.3)			4.2 (1.9–6.3)			3.8 (2.6–4.8)			4.2 (1.9–6.3)		
Time-to-stand	14 (5-24)			10.5 (0-30)			5 (4-13)			10 (4-30)		
Time-to-suck	24.5 (9-53)			20 (5-62)			16 (8-20)			20 (8-65)		

4. Discussion

An Apgar scoring system has been reported in other domestic animals [5–10]. For horses [7] and donkeys [9], respiration for Apgar scoring has been measured by counting breaths/min. In dogs [8], the parameter for Apgar respiration has been defined using two criteria: how much a puppy cries after birth (no crying, mild crying, crying) as well as its respiratory rate (<6 to >15 breaths/min). Because newborn lambs do not vocalize like puppies and monitoring breaths/min using a stethoscope or watching the rib cage rise and fall has a potential for inter-observer error, the original Apgar scoring system for lambs qualitatively assessed respiration as good, regular (score = 2), slow, irregular (score = 1), and absent (score = 0) [10]. This method for evaluating respiration needed to be modified to better reflect viability. In the modified Apgar scoring system in the current study, respiration was quantitatively determined using oxygen saturation (SpO2) as detected by the pulse oximeter. The pulse oximeter is a relatively inexpensive tool that is easy to use under field conditions and small enough to carry in a pocket. Previous literature about normal SpO_2 in newborn lambs is limited. Apgar scoring for the respiration parameter in the current study was based upon previous research with normal lambs described as having an SpO_2 of 67 ± 15% and abnormal lambs as having an SpO_2 of 48 ± 6% [12]. In the current study, no correlation was found between respiration and time-to-stand or time-to-suckle. However, it is important to mention that the time-to-stand and time-to-suckle was about 50% faster (Table 2) than what has previously been reported for lambs (20 min and 34 min, respectively) [10]. In addition, none of the lambs in the current study had a low enough Apgar score to need assistance, which could be because the neonatal mortality rate for this flock is <0.05%.

In newborn horses [7] and dogs [8], appearance (the Apgar parameter that corresponds with mucous membrane color) correlates with cardiovascular and respiratory distress, which are strong indicators of the need for intervention. In the current study, we also used mucous membrane color to determine appearance. There was no difference in appearance (mucous membrane color) at T0, T15, and T60 within singleton, twin, and triplet lambs. In addition, there was no difference in appearance at T0, T15 or T60 when compared between birth order for twin lambs. It is possible that there was no significant difference in appearance between timepoints because the group of lambs tested did not display severe respiratory or cardiovascular distress symptoms.

Lambs that are born weak or slower to react to stimuli can miss establishing a strong ewe-lamb bond within the first hour of life, which could increase newborn mortality [13]. In puppies, grimace

Table 3
The median (and ranges) for Apgar scores, time-to-stand, time-to-suck, pulse (beats per minute) and oxygen saturation (%) as measured from a pulse oximeter within 5 min of birth (T0) for second born twin lambs, or second and third born lambs combined divided by delivery interval.

	Delivery Time <30 min		Delivery Time >30 min	
T0	Twins	Twins and Triplets	Twins	Twins and Triplets
Appearance Score	2 (1–2)	2 (1–2)	2 (1–2)	2 (1–2)
Pulse Score	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)
Grimace Score	2 (1–2)	2 (1–2)	1.2 (1–2)	1 (1–2)
Attitude Score	2 (0–2)	2 (0–2)	1.5 (0–2)	1 (0–2)
Respiration Score	2 (2–2)	2 (2–2)	2 (0–2)	2 (0–2)
Total Apgar Score	8 (6–9)	8 (6–9)	7 (6–9)	7 (6–9)
Pulse	118 (88–204)	118 (82–204)	128.5 (26–226)	100 (26–226)
SpO_2	99 (98–99)	99 (88–99)	99 (35–99)	99 (35–99)
Time-to-stand	8 (5–20)	6 (5–60)	20 (0–33)	15.5 (0–33)
Time-to-suckle	20 (13–70)	20 (8–70)	34 (15–38)	27 (10–38)

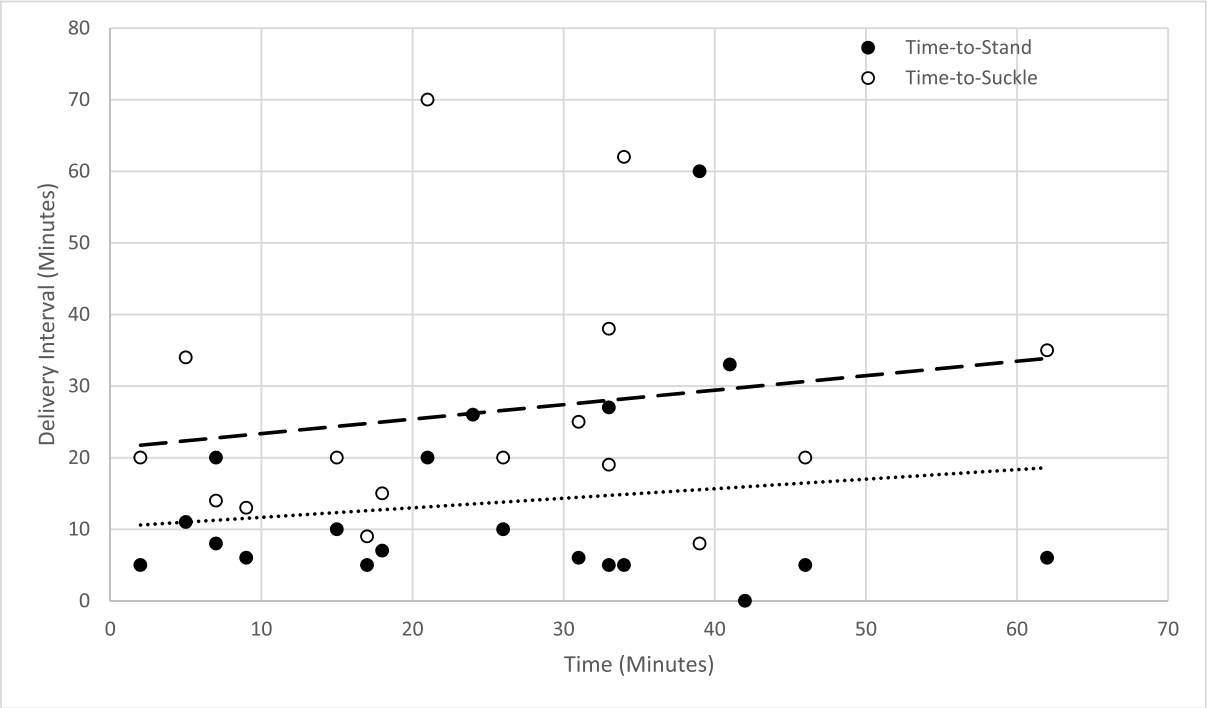

Fig. 1. Linear regression for delivery interval (minutes), time-to-stand (minutes, solid-circles with dotted line) and time-to-suckle (minutes, open-circles with dashed line).

is evaluated using the response to a toe pinch. In the current study, grimace was evaluated in a method similar to foals and donkeys [7,9] by measuring the response to nasal stimulation. The parameters for assessing the grimace response previously reported for sheep [10] (e.g. sneezing, coughing moving ears, shakes) were used in the current study. We found that grimace was lower for twin lambs compared to singletons at T1, which is supported by the original Apgar study in lambs showing decreased responsiveness in twins compared to singletons [10].

The Apgar scoring method for measuring attitude was modified for lambs to mimic responses to maternal affection (specifically, rump stimulation). In foals [7] and donkeys [9], attitude was measured by the ability to maintain sternal recumbency; whereas attitude was measured by the strength of spontaneous movement in puppies [8]. The attitude evaluation used in the current study was a combination of methods used in other species, but better adapted to natural sheep responses. In the current study, attitude did not differ significantly between time points but attitude at T0 was positively correlated with time-to-suckle (R [2] = 0.467). The correlation between attitude and time-to-suckle in the current study is supported by the lamb's stand and suckle response to maternal licking [14]. It has been shown that lower Apgar scores correlated with decreased suckling and swallowing reflexes in puppies [8].

Similar to horses [7], dogs [8], donkeys [9], and the previous study in sheep [10], heart rate was used in the current study to assess neonatal viability. Data available in the literature for newborn heart rates in lambs varies considerably from a mean ± standard deviation of 92 ± 42 (n = 22) to 151 ± 47 (n = 14) [15,16]. The heart rate results from the current study (121 (26–250)) are most similar to those of Vannucchi and colleagues (2012) likely because of the proximity to birth when the heart rates were determined [15]. In addition, the distribution of the pulse score results at T0 from the current study was similar to that of Batista and coworkers (2014) [17]. Over 30% of lambs had a pulse score of 2 (>175 beats/minute); 40% had a pulse score of 1 (100–175 beats/minute); less than 30% of lambs had a pulse score of 0 (<100 beats/minute). Neither the heart rate or pulse score at any time-point was correlated with time-to-stand or time-to-suckle.

There was a trend (p = 0.059) to increase total Apgar scores over

Table 4
Correlation coefficients (R^2) for each Apgar parameter between birth weight, time-to-stand and time-to-suckle within 5 min of birth (T0), 15 min of age (T1) and 60 min of age (T2) for all lambs. There was a moderate correlation between attitude and time-to-suckle at T0 (*p < 0.05). Correlation coefficients (R^2) for each Apgar parameter, time-to-stand and time-to-suckle between delivery intervals in twins.

Apgar parameter	Birth Weight			Time-to-stand			Time-to-suckle			Delivery Interval
	T0	T1	T2	T0	T1	T2	T0	T1	T2	
Appearance	0.008	0.003	0.018	0.022	0.002	0.045	0.041	0.000	0.018	0.002
Pulse	0.036	0.013	0.004	0.023	0.004	0.006	0.051	0.007	0.000	0.067
Grimace	0.007	0.071	0.090	0.097	0.245	0.000	0.098	0.050	0.062	0.017
Attitude Score	0.041	0.002	0.020	0.1638	0.164	0.000	0.467*	0.063	0.027	0.006
Respiration	0.000	0.033	0.059	0.009	0.000	0.005	0.017	0.006	0.020	0.004
Total Apgar	0.000	0.001	0.051	0.031	0.014	0.013	0.097	0.023	0.037	0.042
Time-to-stand	0.024									0.023
Time-to-suckle	0.000									0.034

Table 5
The median (and ranges) for Apgar scores within 5 min of birth (T0), 15 min of age (T1) and 60 min of age (T2) for first and second born lambs.

	First born			Second born		
	T0	T1	T2	T0	T1	T2
Appearance Score	2 (0–2)	2 (1–2)	2 (1–2)	2 (1–2)	1(1–2)	2 (1–2)
Pulse Score	1 (0–2)	1 (0–2)	1 (0–2)	1 (1–2)	1 (0–2)	1 (0–2)
Grimace Score	2 (0–2)	2 (1–2)	2 (1–2)	1 (0–2)	1 (1–2)	2 (0–2)
Attitude Score	1 (0–2)	2 (1–2)	1 (0–2)	1 (0–2)	1 (0–2)	2 (1–2)
Respiration Score	2 (2–2)	2 (2–2)	2 (2–2)	2 (2–2)	2 (2–2)	2 (2–2)
Total Apgar Score	8 (6–9)	7 (6–10)	8 (6–9)	8 (6–9)	7 (4–10)	9 (5–10)
Pulse	139 (71–235)	150 (68–250)	130 (93–207)	152 (105–250)	137 (81–244)	157 (86–250)
SpO_2	99 (90–99)	99 (96–99)	99 (85–99)	99 (97–99)	99 (90–99)	99 (85–99)
Time-to-stand	10.5 (5–17)			12.5 (5–30)		
Time-to-suckle	20 (13–35)			41 (10–62)		

the first hour after birth. This finding is supported by the trend in that average Apgar scores in puppies increased from 6.2 to 7.4 between 5 and 60 min after birth [17]. In addition, total Apgar score in triplets increased significantly over time from 7 (3–8) at T0, to 9 (7–10) at T1 and to 8 (7–9) at T2, which is supported by research in piglets showing lower Apgar scores with larger litters [6]. This could be due to intrapartum hypoxia secondary to prolonged labor, which causes initially lower Apgar scores that could improve as the neonate adjusts to extrauterine life.

In addition to increased litter size, increased delivery interval and birth order could result in intrapartum hypoxia. Human twin babies have displayed lower second born Apgar scores when compared to first born babies except when the delivery interval was very short [18]. In twin lambs, delivery interval is typically within 30 min of the first born [19]. For the current study, delivery interval was defined as long if it was ≥30 min and short if it was <30 min. We found that delivery interval did not affect individual Apgar score parameters, or total Apgar score within 5 min of birth in twin or triplet lambs. In addition, there was no significant difference in any individual Apgar parameter, total Apgar score or time-to-stand for first and second born lambs. However, there was a trend for shorter time-to-suckle in first born lambs ($p = 0.058$). The decreased time-to-suckle in first born lambs could have been due to reduced intrapartum hypoxia compared to second born lambs.

In humans, babies with low and very low birth weight increased the risk of low Apgar scores [20]. In addition, canine Apgar score is influenced by birth weight [21]. However, in the current study, birth weight did not correlate with Apgar scores, time-to-stand or time-to-suckle. This could be due to the relatively high birth weight in the current study (median: 4.24 kg, range: 1.87–6.35 kg) in contrast to the average Polypay lamb birth weight (3.78 ±0 .05 kg) [22].

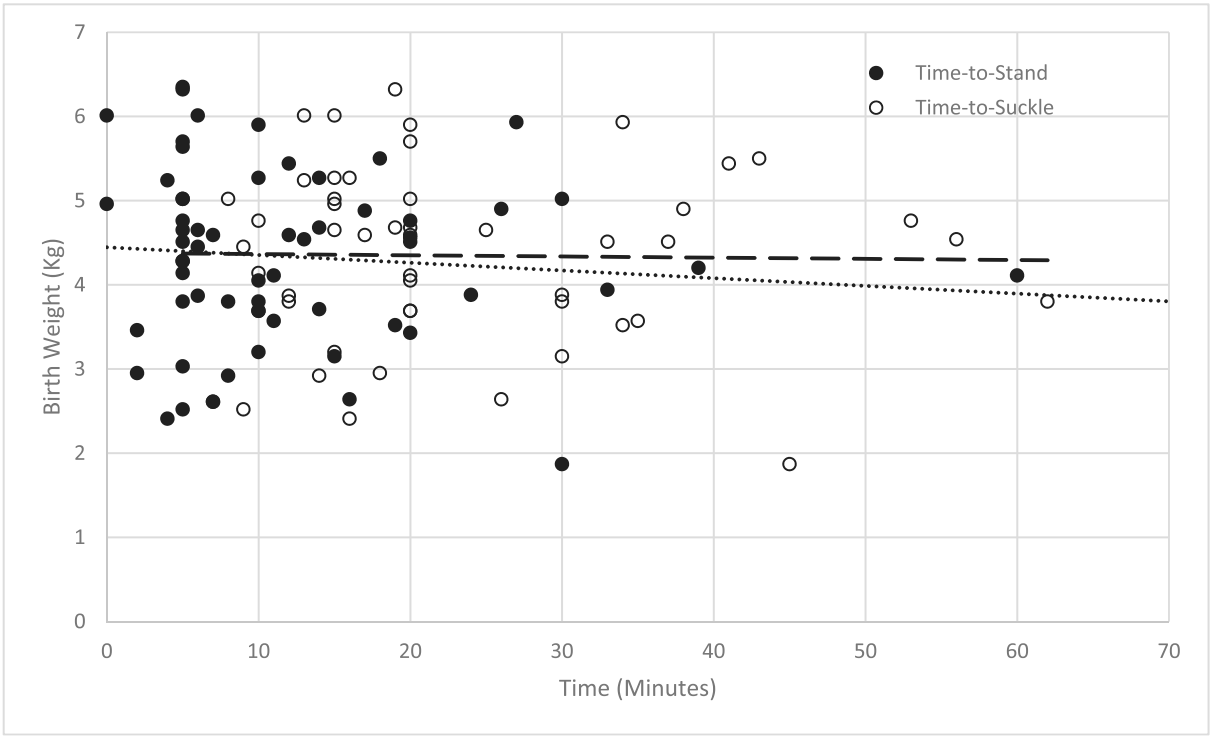

Fig. 2. Linear regression for birth weight (kg), time-to-stand (minutes, solid-circles with dotted line) and time-to-suckle (minutes, open-circles with dashed line).

Table 6
The median (and ranges) for Apgar scores within 5 min of birth (T0), 15 min of age (T1) and 60 min of age (T2) for female and male lambs. Note: there was one lamb whose sex was not reported that was excluded from this table.

	Female			Male		
	T0	T1	T2	T0	T1	T2
Appearance Score	2 (0–2)	2 (1–2)	2 (1–2)	2 (0–2)	2 (1–2)	2 (1–2)
Pulse Score	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)	1 (0–2)
Grimace Score	2 (0–2)	2 (0–2)	2 (0–2)	1 (0–2)	2 (1–2)	2 (1–2)
Attitude Score	2 (0–2)	2 (0–2)	2 (0–2)	1 (0–2)	2 (0–2)	2 (0–2)
Respiration Score	2 (0–2)	2 (2–2)	2 (2–2)	2 (2–2)	2 (2–2)	2 (1–2)
Total Apgar Score	8.5 (3–10)	8 (4–10)	9 (6–10)	7 (5–10)	7 (4–10)	8 (5–9)
Pulse	116 (26–250)	135 (68–250)	129 (86–244)	130 (71–250)	143 (54–250)	111 (59–250)
SpO_2	99 (35–99)	99 (92–99)	99 (85–99)	99 (38–99)	99 (85–99)	99 (86–99)
Time-to-stand	6.5 (0–20)			13 (0–33)		
Time-to-suckle	20 (8–62)			29 (9–53)		
Birth weight	4.5 (2.5–6.0)			4.6 (2.6–6.3)		

5. Conclusion

The Apgar scoring system is a valuable method to quantify the overall viability of newborns. The Apgar scoring method was developed to serve as a guide to the clinical care of vulnerable individuals immediately postpartum. In newborn lambs, attitude (responsiveness to rump stimulation) within the first 15 min of life is positively correlated with time-to-suckle, which could impact a lamb's ability to absorb adequate colostrum as well as maintain a normothermic and normoglycemic state. In addition, respiratory rate (SpO_2) measured soon after birth is valuable information for producers because the viability of neonatal lambs can be greatly impacted by oxygenation status. Producers should consider using Apgar scoring so that assistance can be provided to lambs before serious complications arise.

CRediT authorship contribution statement

Tasman Flora: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Mary Smallman:** Investigation, Project administration, Resources, Visualization, Supervision, Writing - original draft. **Michelle Kutzler:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Validation, Visualization, Writing - original draft, Writing - review & editing.

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