Untersuchungen verschiedener Einflussfaktoren auf Gesundheit und Produktivität beim Schaf

Dissertation
zur Erlangung des Doktorgrades
der Fakultät für Agrarwissenschaften
der Georg-August-Universität Göttingen

vorgelegt von
Christina Schichowski
geboren in Lahn-Gießen

Göttingen, Februar 2010

D 7

1. Referent: Prof. Dr. Dr. Matthias Gauly
2. Koreferent: Prof. Dr. Georg Erhardt

Tag der Disputation: 26.01 2010

Inhaltsverzeichnis

1. Einleitung und Fragestellung....2
2. Literaturübersicht....4
2.1 Muttereigenschaften....4
2.2 Absetzen....6
2.3 Absetzen und Parasitenresistenz....8
Breed differences in maternal behaviour in relation to lamb....11
(Ovis orientalis avis) productivity....11
Effects of weaning lambs in two stages or by abrupt separation 27
on their behavior and growth rate....27
Influence of age of weaning on the effect of an experimental....38
Haemonchus contortus infection on parasitological measurements,....38
behaviour and performance....38
6.1 Muttereigenschaften....49
6.2 Absetzen....50
6.3 Absetzen und Parasitenresistenz....51
7. Zusammenfassung....53
7.1 Muttereigenschaften....53
7.2 Absetzen....54
7.3 Absetzen und Parasitenresistenz 54
8. Summary....56
8.1 Maternal Behaviour....56
8.2 Weaning 56
8.3 Weaning and parasite resistance....57
9. Literaturverzeichnis....58
Eidesstattliche Erklärung....73
Schulbildung....75
Studium....75

1. Einleitung und Fragestellung

Die Wirtschaftlichkeit der Schafhaltung wird wesentlich durch die Zahl abgesetzter Lämmer bestimmt (RIEDEL, 1993). Grundlage dafür ist die Ablammrate. Durch die Steigerung der Anzahl der Mehrlingslämmer steigt allerdings auch die Zahl der Problemlämmer. Um dadurch gesteigerte Lämmerverluste möglichst gering zu halten, muss bei der Zucht ein besonderes Augenmerk auf gute Muttereigenschaften und Lämmervitalität gelegt werden (WOLLNY & FESSER, 1986; DWYER, 2007). Grundlegend für das Überleben der Lämmer ist eine enge Mutterschaf-Lamm-Bindung, da sowohl die Entwicklung als auch die Gewichtszunahme der Lämmer stark von der Fürsorge durch das Mutterschaf abhängen (BURFENING & KRESS, 1993). Mütterliches Verhalten wird durch verschiedene Faktoren, wie den Genotyp (WHATELEY ET AL., 1974; ALEXANDER ET AL., 1990; LENEINDRE ET AL., 1998; DWYER ET AL., 2004), das Alter und die Erfahrung des Schafes (MEURISSE ET AL., 2005) und das Verhalten der Lämmer (DWYER & LAWRENCE, 1998; DWYER, 2007), beeinflusst. Weiterhin gibt es Faktoren, die durch das Management beeinflusst werden können, wie die Fütterung des Mutterschafes vor und nach dem Ablammen, das Separieren von Mutterschaf und Lamm von der Herde, um die Mutterschaf-Lamm-Bindung zu intensivieren, und das Alter zum Zeitpunkt des Absetzens.
Die kurzzeitige Isolation des Mutterschafs von den Lämmern gibt gute Informationen über das mütterliche Verhalten der Schafe (POINDRON ET AL., 1980; MEURISSE ET AL., 2005).

Unter natürlichen Bedingungen löst sich die Mutterschaf-Lamm-Bindung mit dem Ende des Säugens nicht vollständig. Beide bleiben noch über einige Wochen oder sogar Monate verbunden (HINCH ET AL., 1990). Das natürliche, langsame Entwöhnen der Lämmer hat nur geringe sichtbare Konsequenzen für die Mutterschafe und ihre Lämmer. Im Vergleich dazu bedeutet künstliches Absetzen, durchgeführt durch den Menschen, eine gleichzeitige Trennung zwischen Mutterschaf und Lamm, sowie eine drastische Änderung der Futtergewohnheiten der Lämmer. Dies kann enormen Stress für beide Seiten bedeuten (ORGEUR ET AL., 1998). LANE & ALBRECHT (1991) kamen zu dem Ergebnis, dass das Absetzen Wachstum und Gewichtsentwicklung herabsetzt. Künstliche Aufzuchtsysteme können schlechte Gesundheitszustände und geringe Gewichtsentwicklung der Lämmer bedingen (PETERS & HEANEY, 1974; MCKUSICK ET AL., 2001). Eine Veränderung der Wachstumsrate kann auch auf der

geringeren aufgenommenen Futtermenge oder einer Verschlechterung der Verdauungsfunktionen aufgrund des Absetzstresses beruhen (DANTZER & MORMÈDE, 1979).

Zur Verbesserung der Wachstumsleistung und der Produktivität der Lämmer ist es wichtig mögliche Parasiteninfektionen gering zu halten, da dies zu Gewichtsverlust und schlechtem Allgemeinzustand der Schafe und vor allem der Lämmer führen kann.
Eine Infektion mit dem Magen-Darm-Parasiten *Haemonchus contortus* kann bei Schafen Gesundheitsprobleme wie z.B. eine Anämie verursachen, was zu geringeren Wachstumsraten, Gewichtsverlust oder sogar zum Tod führen kann. Eine Infektion mit diesem Parasiten bedeutet eine Beeinträchtigung der Tiere und geht einher mit erhöhten Kosten für Wurmkuren und Veränderungen im Betriebsmanagement (COOP & HOLMES, 1996; GAULY ET AL., 2002). Viele Faktoren beeinflussen die Schwere der Erkrankung. Dies sind die Anzahl der Würmer, der Gesundheitszustand der Tiere vor der Infektion, der immunologische Zustand, die genetische Prädisposition, das Alter der Tiere sowie umweltbedingte Einflussfaktoren wie Fütterung, Weideland, Haltungsbedingungen, Besatzdichte und Stress, ausgelöst z.B. durch Managementvorgänge, schlechte Fütterung oder schlechtes Wetter (DEMELER ET AL., 2005).
Lämmer und ältere Schafe unter großem Stress sind am häufigsten und am schwersten betroffen (DEMELER ET AL., 2005). Das Absetzen ist ein stressauslösender Vorgang für Mutterschaf und Lämmer. Diesen Stress möglichst gering zu halten sollte das Ziel eines Schafbetriebs sein, um das Vorkommen von Erkrankungen und Gesundheitsproblemen herabzusetzen und eine normale Entwicklung der Lämmer zu gewährleisten (NEARY, 1992).

In der vorliegenden Arbeit wurde untersucht, wie sich verschiedene Schafrassen bezüglich ihrer Muttereigenschaften unterscheiden und welchen Einfluss dies auf die Lämmeraufzucht hat, ob und in welcher Form die Absetzmethode und das Absetzalter die Gewichtsentwicklung der Lämmer beeinflussen und in welcher Wechselbeziehung das Absetzen zu einer Parasiteninfektion steht.

2. Literaturübersicht

2.1 Muttereigenschaften

Das Überleben eines neugeborenen Lammes hängt stark von einer optimalen Interaktion mit dem Mutterschaf ab. Nach der Geburt erhebt sich das Schaf meist sofort, wendet sich dem Neugeborenen zu und verzehrt in der Regel zunächst die Amnionhüllen, um daraufhin einige Minuten lang das Lamm intensiv zu belecken. Dieser Vorgang ist für die Mutterschaf-Lamm-Bindung von großer Bedeutung. Es entsteht hierdurch ein olfaktorischer Kontakt, der es der Mutter ermöglicht, das eigene Junge anhand dessen spezifischen Körpergeruchs zu erkennen (Dwyer, 2007). Optische und akustische Merkmale vervollständigen das „Bild“ vom eigenen Lamm erst etwas später. Voraussetzung ist allerdings, dass der Leckvorgang mindestens 20 Minuten andauert (Smith et al., 1966). Danach ist die Mutterschaf-Lamm-Beziehung im Sinne einer Prägung irreversibel. Die Entwicklung der Mutterschaf-Lamm-Bindung steht sowohl unter dem Einfluss hormoneller als auch visceral somatosensorischer Stimulationsfaktoren, welche beim Muttertier durch Ausschüttung von Steroidhormonen und mechanische Stimulation der Gebärmutter und der Vagina während der Geburt (Kendrick & Keverne, 1991; Nowak et al., 2007; Poindron et al., 2007) und beim Neugeborenen durch Ausschüttung von Cholecystokinin und orale Stimulation beim ersten Saugakt freigesetzt werden (Nowak et al., 2007).

Natürliches mütterliches Verhalten der Mutterschafe während und nach der Geburt fördert das gegenseitige Erkennen und eine enge, exklusive Mutterschaf-Lamm-Bindung und maximiert die Überlebensrate (Walser & Alexander, 1980; Lévy, F., 2002; Shayit et al., 2003; Searby & Jouventin, 2003; Dwyer, 2008), unter anderem da sie die Versorgung mit Kolostralmilch mit ihrem immunologischen Schutz gewährleistet (Singer, 1998; O’Connor et al., 1992; Capper et al., 2006). In den ersten Lebenstagen erkennt das Mutterschaf ihr Lamm und kann es von anderen unterscheiden, so dass die mütterliche Fürsorge nur dem eigenen Nachwuchs zugute kommt (Poindron et al., 1984; Lévy et al., 1995). Auch Gewichtszunahme und Entwicklung der Lämmer sind eng mit der Fürsorge durch das Mutterschaf verbunden (Burfening & Kress, 1993; Nowak et al., 2000). Schwach ausgeprägtes mütterliches Verhalten kann, besonders bei Mehrlingen, zur Erhöhung der Lämmersterblichkeit führen (Nowak, 1996).

Für das Neugeborene erfüllt das mütterliche Leckverhalten eine ausschließlich physiologische Funktion. Es verhindert eine übermäßige Unterkühlung des Lammes, regt dessen Atmung und auch die periphere Blutzirkulation an (LENT, 1974; ALEXANDER, 1988; NOWAK ET AL., 1997). Lämmer, die nicht beleckt wurden, weisen eine höhere Sterblichkeit auf. Neben dem mütterlichen Leckverhalten ist auch Hilfe bei den ersten Stehversuchen und bei der Suche nach dem Euter von großer Bedeutung. Natürlich darf das Mutterschaf keinerlei Aggressionen ihrem eigenen Nachwuchs gegenüber zeigen (NOWAK ET AL., 2000).

In der Regel sucht das Muttertier das Lamm zum Säugen auf bzw. fordert es durch Rufen zum Saugen auf. Da dies in den ersten Tagen nach der Geburt alle 40 – 60 Minuten geschieht (EWBANK, 1967), ist insofern ein gewisser Zusammenhalt zwischen Mutter und Jungtier gegeben. Dennoch kommt es in dieser Zeit nicht selten zu einer Verwaisung der Lämmer infolge mangelnden mütterlichen Pflegeverhaltens. Der Kontaktbruch in der Mutterschaf-Lamm-Beziehung tritt signifikant häufig bei erstgebärenden Schafen und nach Schwergeburten auf (ALEXANDER, 1958).

In den ersten Stunden nach der Geburt gestattet die Mutter dem Lamm das Saugen jederzeit, unterbricht die Saugakte, die allmählich in ihrer Frequenz abnehmen, in den folgenden Wochen dann aber zunehmend häufiger durch plötzliches Weitergehen. Vom dritten Lebensmonat an wird das Lamm immer häufiger von der Mutter am Saugen gehindert, zugleich verringert sich die Saugappetenz (EWBANK, 1967).

Mütterliches Verhalten wird beeinflusst durch den Genotyp (WHATELEY ET AL., 1974; RENSING, 1985; ALEXANDER ET AL., 1990; SCHLOLAUT & WACHENDÖRFER, 1992; LENEIDRE ET AL., 1998; LÖER, 1998; DWYER & LAWRENCE, 1998; KUCHEL & LINDSAY, 1999; DWYER ET AL., 2004), das Alter und die Erfahrung (DWYER & LAWRENCE, 2000; LAMBE ET AL., 2001; MEURISSE ET AL., 2005), das Temperament, den Geburtstyp (DWYER & LAWRENCE, 1998; LAMBE ET AL., 2001), die Lämmervitalität (RENSING, 1985; SCHLOLAUT & WACHENDÖRFER, 1992; DWYER, 2003) das Verhalten des Lammes (Dwyer & Lawrence, 1998) und die Wechselwirkungen des Verhaltens zwischen Mutterschaf und Lamm (NOWAK, 1996; LÖER, 1998; LAMBE ET AL., 2001; EVERETT-HINCKS & DODDS, 2007). Weitere relevante Faktoren, wie Fütterung und Kondition der Mutterschafe vor, während und nach der Geburt (NOWAK, 1996; DWYER ET AL., 2003) und das Separieren von Mutterschaf und Lamm in einer speziellen Ablammbucht, ergeben sich durch das Betriebsmanagement.

Die Mütterlichkeit von Schafen kann mit Hilfe verschiedener Methoden aufgezeigt werden. Die Trennung der Lämmer vom Mutterschaf gibt deutliche Aufschlüsse über das mütterliche Verhalten der Schafe (POINDRON ET AL., 1980; MEURISSE ET AL., 2005). O'CONNOR ET AL. (1985) beschrieben eine Möglichkeit zur Quantifizierung des mütterlichen Verhaltens. Dabei wird die Fluchtdistanz der Mutterschafe mit Hilfe des Maternal Behaviour Score (MBS) 24 Stunden nach der Geburt, beim ersten Kontakt der Lämmer zu einem Menschen, bewertet. Die Untersuchungen von O'CONNOR ET AL. (1985) zeigten, dass Lämmer von Schafen mit einem hohen MBS höhere Absetzgewichte hatten als Lämmer von Schafen mit geringerem MBS. Auch DWYER & LAWRENCE (1998) und LAMBE ET AL. (2001) verwendeten die 6-Punkte-Skala nach O'Connor, um das mütterliche Verhalten unter natürlichen Bedingungen zu bewerten. SCHLOLAUT & WACHENDÖRFER (1992) entwickelten eine 3-Punkte-Skala, um das Verhalten der Mutterschafe mit ihren Lämmern bei Annährung eines Menschen zu bewerten und somit auf die Mütterlichkeit zu schließen. Dabei erhalten Mutterschafe, die sich von ihrem Nachwuchs entfernen, eine geringe Mütterlichkeitsnote und Schafe, die ihre Lämmer sogar verteidigen, eine hohe Mütterlichkeitsnote.
Eine weitere Möglichkeit zur Bewertung des mütterlichen Verhaltens beschrieben DWYER & LAWRENCE (1998), die das Folgeverhalten der Mutterschafe benoteten. Mit Hilfe einer 4-Punkte-Skala wird bewertet, ob und in welcher Form das Mutterschaf ihren Lämmern folgt, die aus der Herde isoliert werden.

2.2 Absetzen

Das Absetzen der Lämmer ist mit entscheidenden Veränderungen der Beziehung zwischen Mutterschaf und Lamm verbunden (ORGEUR ET AL., 1999). Die Trennung kann für beide mit großem Stress verbunden sein (NEARY, 1992; NAPOLITANO ET AL., 2008). Dabei kommen für das Lamm zwei stressauslösende Faktoren, die Trennung vom Muttertier und die Umstellung auf milchlose Fütterung, zusammen (ORGEUR ET AL., 1998). Zusätzlicher Stress kann z.B. durch Kennzeichnung, Impfung, Kastration o. ä. hinzukommen. Der Absetzstress kann reduziert werden, wenn die Lämmer bei der Trennung vom Mutterschaf in der gewohnten Umgebung verbleiben. Unter natürlichen Bedingungen erfolgt die Trennung zwischen beiden schrittweise und die Mutterschaf-Lamm-Bindung löst sich nach der Säugeperiode nicht vollständig. Die Laktation des Mutterschafes ist ausschlaggebend für die Festigkeit der Mutterschaf-

Lamm-Bindung und eine Abnahme der Milchproduktion führt zu einer Entfremdung beider Partner. Durch die Änderungen der Anforderungen der Lämmer an ihre Nahrung wird der Prozess des Entwöhnens der Lämmer eingeleitet (PRYCE, 1992). Jedoch bleiben Mutterschaf und Lämmer auch noch nach dieser Zeit miteinander verbunden (HINCH ET AL., 1990). Im Gegensatz dazu erfolgt das Absetzen durch den Schafhalter in der Regel abrupt und kann Veränderungen im Verhalten, dem Immunstatus, der Vitalität und der Entwicklung hervorrufen (NAPOLITANO ET AL., 2008). ORGEUR ET AL. (1999) zeigten in ihrer Untersuchung an Schafen der Rasse Ile-de-France, dass die Absetzmethode das Plasma Cortisol Level der Tiere nicht beeinflusst. Jedoch konnte beobachtet werden, dass abrupt abgesetzte Lämmer eine signifikant höhere Anzahl an ausgeschiedenen Oocysten und eine verminderte Wachstumsrate zeigten. NAPOLITANO ET AL. (2008) stellten in ihrer Untersuchung an Lämmern die im Alter von zwei Tagen abrupt abgesetzt wurden fest, dass sich das frühe Absetzen negativ auf die Entwicklung natürlichen Sozialverhaltens auswirkt. Diese Lämmer zeigten abnormale Verhaltensweisen wie das Besaugen des Nabels oder der Genitalien anderer Lämmer. Neben den Verhaltensänderungen war die zelluläre und humorale Immunantwort der früh abgesetzten Lämmer stark herabgesetzt.

Der Stress des Absetzens zeigt sich bei Mutterschaf und Lamm durch gesteigerte Unruhe und Lautäußerungen (ALEXANDER, 1977; TORRES-HERNANDEZ & HOHENBOKEN, 1979). Durch das Absetzen ausgelöste Verhaltensänderungen können einige Tage oder sogar Wochen beobachtet werden (VEISSIER & LE NEIDRE, 1989). FEINSTEIN & THOMAS (2003) konnten bei ihren Untersuchungen über Lautäußerungen bei Schafen ein Bild genau definierter akustischer Marker für Stress nachweisen. Schafe zeigen Stress mit Hilfe ihrer Lautäußerungen durch Veränderung der Klangfarbe. Die Studie von ORGEUR ET AL. (1998) zeigt einen Vergleich zweier Absetzverfahren, der schrittweisen Trennung der Lämmer von den Mutterschafen ab einem Alter von drei einhalb Wochen mit jeweils längerer Dauer bis zum endgültigen Absetzen mit drei Monaten und dem abrupten Absetzen im Alter von drei Monaten, an Ile-de-France Schafen und ihren Lämmern. Die Trennung zeigte bei den jungen Lämmern einen starken Anstieg der Lautäußerungen, die jedoch mit der Zeit abnahmen, so dass die Tiere kaum Verhaltensreaktionen auf das endgültige Absetzen zeigten. Die abrupt abgesetzten Mutterschafe und Lämmer zeigten im Gegensatz dazu beim Absetzen starke Lautäußerungen und Unruhe, jedoch war der Normalzustand nach ungefähr

zwei Tagen wieder erreicht. Der Stress, ausgelöst durch die Trennung von Mutterschaf und Lämmern, kann die Immunantwort der Lämmer beeinflussen (ORGEUR ET AL., 1998; NAPOLITANO ET AL., 2008). Die täglichen Gewichtszunahmen können durch negativen Stress gestört sein, da die Produktion von glucocorticoiden Hormonen mit einer Abnahme von Wachstumshormonen einhergeht (KUHN ET AL., 1990). Eine Veränderung der Wachstumsrate kann auch durch die weniger aufgenommene Nahrung oder eine Schwächung der Verdauungsfunktionen, ausgelöst durch den Absetzstress, hervorgerufen werden (DANTZER & MORMÈDE, 1979). HALEY ET AL. (2005) führten eine Studie über alternative Absetzmethoden für Kälber durch. Sie zeigten, dass das Verhindern des Säugens der Kälber einige Zeit vor der Trennung von Mutterkuh und Kalb die Verhaltensänderungen beim Absetzen verminderten.

2.3 Absetzen und Parasitenresistenz

Endoparasiteninfektionen führen zu erheblichen wirtschaftlichen Verlusten in der Schafhaltung. Diese werden u.a. durch Gewichtsverluste, Leistungseinbußen sowie durch nachfolgende Wachstums- und Entwicklungsstörungen vor allem der Lämmer hervorgerufen (BOUILHOL & MAGE, 2001).
ROMMEL ET AL. (2000) zeigten, dass die Schädigung des Wirtstieres durch einen Parasiten vom Infektionsdruck, der Pathogenität des Parasiten und den Abwehrmechanismen des Wirtes, wie Resistenz bzw. Toleranz, abhängt. Mangelernährung, Infektionen oder Stress begünstigen einen Parasitenbefall, dabei sind Lämmer stärker gefährdet als adulte Schafe (BAKER ET AL., 1999). Vor allem beim Absetzen sind Lämmer, abhängig von Absetzalter und Absetzverfahren, großem Stress ausgesetzt, der sie anfälliger für eine Parasiteninfektion macht.

Als geeignetes Indikationsmerkmal für den Grad einer Parasiteninfektion gilt unter anderem die Eizahl pro Gramm Kot (EpG) (WOOLASTON, 1992; MORRIS ET AL., 1995; BISSET ET AL., 1996; GRAY, 1997; BISHOP & STEAR, 1999b; POLLOT ET AL. 2004) sowie der Hämatokrit (ALBERS ET AL., 1987; WOOLASTON & PIPER, 1996).
Lämmer sind gewöhnlich empfänglicher für eine Infektion mit Magen-Darm-Strongyliden und zeigen im Vergleich zu erwachsenen Schafen höhere EpG-Werte (WOOLASTON & PIPER, 1996; BAKER ET AL., 1999). Ein geringes Körpergewicht der Schafe erhöht die Anfälligkeit für eine Parasiteninfektion und die Eiausscheidung (MCCLURE &

EMERY, 2007).

Zum klinischen Bild einer Endoparasiteninfektion gehört im Regelfall eine chronische Anämie, die durch den Abfall des Hämatokrit unter den Normalbereich gesunder Mutterschafe (0,27 - 0,41 l/l (BICKHARDT & KÖNIG, 1985)) charakterisiert ist (BERIAJAYA & COPEMAN, 2006). Die Bestimmung des Hämatokrit ist als Indikator einer Anämie anzusehen (ALBERS ET AL., 1987; WOOLASTON & PIPER, 1996).

Die größte wirtschaftliche Bedeutung eines Endoparasitenbefalls bei Schafen haben Infektionen mit parasitären Würmern (Helminthen) (BÜRGER, 1992). Ein massiver Befall kann sogar zum Verenden der Tiere führen. Nach SCHNIEDER (2000) stellen dabei die Nematoden aufgrund der Befallshäufigkeit, der Befallsstärke und der pathogenen Wirkung die wichtigsten Helminthen dar. Für die Weideschafhaltung sind Trichostrongyliden die bedeutendsten Parasiten (BOSTEDT & DEDIÉ, 1996). Zur Familie der Trichostrongylidae gehören die Gattungen *Haemonchus, Ostertagia, Trichostrongylus* und *Cooperia.* Nach SCHNIEDER (2000) sind sie Erreger der parasitären Gastroenteritis. Die Eier der Trichostrongyliden werden über den Kot der Wiederkäuer ausgeschieden und können über das Futter oral vom nächsten Wirtstier aufgenommen werden.

Der weltweit bedeutendste Rundwurm der Schafe ist der Labmagenwurm (*Haemonchus contortus*), der Erreger der Magenwurmseuche. *Haemonchus contortus* verursacht teils heftige Entzündungen und Blutungen der Labmagenschleimhaut. Seine in den Drüsen des Labmagens heranwachsenden Larven sind die Ursache erheblicher Verdauungsstörungen, hervorgerufen durch eine starke Verringerung der Salzsäurebildung. Infolge dieser Veränderung stellt sich eine deutlich verminderte Wirksamkeit der Verdauungsenzyme ein und damit eine immer schlechtere Verwertung des Futters. Bei akuten Infektionen sind Fieber, Blutarmut, eine Verminderung der weißen Blutkörperchen, eine beschleunigte Atmung, geschwollene Lymphknoten und zunehmend stärker werdender Durchfall die typischen Leitsymptome. Eine charakteristische Folge des Proteinverlustes über den Darm sind Ödeme im Kehlgangsbereich. Auffällig sind auch die Veränderungen der Wolle. Das Wollwachstum geht zurück und die Wolle wird brüchig. Eine deutlich verringerte Mastleistung und Fruchtbarkeitsstörungen sind ebenfalls auf den Wurmbefall zurückzuführen. Massive Krankheitsausbrüche werden meist im August

beobachtet. Eine sehr zweckmäßige Anpassung dieser Würmer an das hormonelle Geschehen im Wirtstier ist deren sprunghaft verstärkte Eiproduktion im Frühjahr zum Zeitpunkt des Ablammens der Mutterschafe. *Haemonchus contortus* überwintert im Allgemeinen nicht auf der Weide. Ab dem frühen Herbst entwickeln sich die Larven zunehmend nicht mehr weiter, sondern verharren bis zum nächsten Frühjahr in einem Ruhestadium und werden erst dann geschlechtsreif. Eine wirkungsvolle Bekämpfung ist von großer Bedeutung, da die Infektion mit *Haemonchus contortus* die Gesundheit und Vitalität der Schafe maßgeblich beeinflusst (GETACHEW ET AL., 2007).

Die Züchtung auf Parasitenresistenz der Schafe ist eine wichtige Möglichkeit zur Bekämpfung von Endoparasiten. Dabei liegt der Vorteil in der reduzierten Anzahl mit dem Kot ausgeschiedener Eier, wodurch die Kontamination der Weide und die Gesamtzahl der Parasiten im Produktionssystem herabgesetzt werden. Die Untersuchungen von Woolaston & Eady (1995) zeigten, dass parasitentolerante Tiere, trotz einer Infektion, die Fähigkeit besitzen ihre Produktionsleistung aufrecht zu erhalten. Nach Gray et al. (1992) und Sréter et al. (1994) bilden Schafe, die auf Resistenz gegen bestimmte Nematoden, z.B. *Haemonchus contortus*, gezüchtet wurden, auch eine Resistenz gegen andere Spezies wie *Trichostrongylus colubriformis* oder *Ostertagia circumcincta* aus.

Die Durchführbarkeit der Zucht auf Parasitenresistenz wurde an verschiedenen Rassen untersucht. ALBERS ET AL. (1987) untersuchten Merinoschafe, BOUIX ET AL. (1998) Polish Longwool, BISHOP & STEAR (2001) Scottish Blackface und GAULY & ERHARDT (2001) und HIELSCHER ET AL. (2006) Merino Landschafe und Rhönschafe.

Für die Zucht auf Parasitenresistenz sind neben dem Genotyp auch Alter und Geschlecht der Tiere von großer Bedeutung (BAKER ET AL., 1999). ALBERS ET AL. (1987) konnten erst nach der Geschlechtsreife geschlechtsbedingte Unterschiede in der Parasitenresistenz und –toleranz erkennen. BARGER (1988) stellte dabei fest, dass eine Behandlung mit Anthelmintika einer Resistenzbildung entgegenwirkt.

Das Ziel des Schafbetriebes sollte das Erlangen einer Immunität der Lämmer gegenüber einer Parasiteninfektion vor dem Absetzen sein, daher sollten die Tiere bis zu diesem Zeitpunkt ein ausreichendes Gewicht erreichen und einem geringen Infektionsdruck ausgesetzt sein (MCCLURE & EMERY, 2007).

Breed differences in maternal behaviour in relation to lamb (*Ovis orientalis avis*) productivity

C. Schichowski, E. Moors, U. von Borstel, M. Gauly*
Georg August University Göttingen, Department of Animal Science
Albrecht Thaer Weg 3, 37075 Göttingen, Germany.

*Corresponding author: Tel.: +49-551-395602; Fax +49-551-395587;
E-mail address: MGauly@gwdg.de (M. Gauly)
(submitted to Livestock Science in August 2009)

Abstract

Fundamental to the survival and development of lambs is the formation of a close and exclusive bond between the ewe and her lambs. Maternal behaviour plays an important role in the establishment of this bond, and it is influenced by several factors including genotype. The aim of the present study was to detect differences in maternal behaviour in ewes (n = 602) of five different breeds during periods of separation from their lambs (n = 1003) and to relate the behaviour measurements in ewes to productivity traits of the lambs. Sheep belonged to one of the following German sheep breeds that have evolved under different husbandry intensities (in order from most to least intensive): Merino Landschaf (ML), Deutsches Schwarzköpfiges Fleischschaf (BH), Weißes Deutsches Bergschaf (MS), Rhönschaf (RS), Graue Gehörnte Heidschnucke (GS). Within 12 – 24 hours after birth, lambs were separated from their dams, and dams were scored for maternal behaviour such as vocalising during separation and sniffing and licking after reunification. GS showed highest rates (***P < 0.001) of vocalisation and agitation during separation, whereas BH showed lowest rates. Behaviour after reunification did not differ significantly (P > 0.05) between breeds. Older ewes showed more interest in their offspring (*P < 0.05) and had lambs with higher birth weights (*P < 0.05). Significant (**P < 0.01) correlations were found between maternal behaviour and breed, mortality rate and birth weights. Therefore, it can be concluded that maternal behaviour differs between the observed breeds and selection for maternal behaviour may improve animal welfare and economy of sheep farming.

Keywords: *maternal behaviour; breed differences; vocalisation; sheep; lambs; productivity*

1. Introduction

In sheep inadequate maternal care invariably leads to early death of the offspring, because growth and development of lambs depend heavily on the care from the dam (Burfening and Kress, 1993). This is especially true for twins (Nowak, 1996). Behavioural interactions between the ewe and her lambs in the very first hours following birth are fundamental to the development of the bond and the future of the neonate (Lévy, 2002; Shayit et al., 2003). The two main factors that contribute to the formation of this early bonding are suckling and postnatal vocal communication (Alexander, 1988; Nowak et al., 1997). The latter includes a low-pitched bleating, a specific lambing vocalisation emitted by the ewe (Shillito and Hoyland, 1971). Other maternal behaviour includes licking or grooming the lamb (Lent, 1974; Alexander, 1988; Nowak et al., 2000), absence of aggression towards the lambs, co-operation with lambs' attempts to suck, and concern at the absence of the neonate (Nowak et al., 2000). During the first hours of life the ewe forms a memory for her own lambs that allows her to restrict maternal care exclusively to her own offspring (Poindron et al., 1984; Lévy et al., 1995). However, maternal behaviour is influenced by several factors including genotype of the animal (Whateley et al., 1974; Alexander et al., 1990; LeNeindre et al., 1998), its age and experience (Meurisse et al., 2005), its emotivity, and the behaviour of the lamb (Dwyer and Lawrence, 1998). Other factors influencing maternal behaviour can be manipulated through management, such as the time spent at the birth site and nutrition before and at lambing.

Since the behaviour of the ewe affects lamb development and survival, it is of interest to identify potential breed differences for possible future selection programmes which may include measurements of ewe maternal ability. Depending on the age of lambs, isolation of ewes from their lambs gives good information about the ewes' maternal behaviour (Poindron et al., 1980; Meurisse et al., 2005). Furthermore it is of interest to quantify correlations between behaviour traits and productivity. Therefore, the aim of the study was to compare maternal behaviour in ewes of five different breeds (Merino Landschaf (ML), Deutsches Schwarzköpfiges Fleischschaf (BH), Weißes Deutsches Bergschaf (MS), Rhönschaf (RS), Graue Gehörnte Heidschnucke (GS)) one day after birth during periods of separation, and to relate ewes' behaviour traits to productivity traits of lambs.

2. Material and methods

2.1 Experimental flock and design

A total of 602 pure bred ewes aged between one and nine years old and their lambs (n = 1003) from one lambing season were available for the present study. Litter size ranged from one to four lambs, and all sheep were pure bred belonging to one of five different German sheep breeds:

- Merinolandschaf (German Merino, ML),
- Deutsches Schwarzköpfiges Fleischschaf (German Black Head Mutton, BH),
- Weißes Deutsches Bergschaf (German White Mountain Sheep, MS),
- Rhönschaf (Rhönsheep, RS),
- Graue Gehörnte Heidschnucke (German Grey Heath, GS)

Details of ewe and lamb numbers, age and litter sizes per breed are given in Table 1.

Table 1. Number, age and littersize of the ewes and lambs used in the study (± SD)
(ML = Merinolandschaf, BH = Deutsches Schwarzköpfiges Fleischschaf, MS = Weisses Deutsches Bergschaf, RS = Rhoenschaf, GS = Graue Gehoernte Heidschnucke)

Breeds	Number of ewes	Average age	Number of lambs	Average littersize
ML	282	3.6 ± 1.2	474	1.7 ± 0.6
BH	19	4.2 ± 1.1	31	1.6 ± 0.5
MS	50	3.4 ± 1.3	81	1.7 ± 0.5
RS	230	4.1 ± 1.1	382	1.7 ± 0.6
GS	23	4.0 ± 1.2	35	1.5 ± 0.5

Prior to lambing, ewes were kept together in a barn on straw in groups of 30 to 60 ewes (1.5 m^2/ewe). All lambs were born indoors. Within 12 hours after lambing the ewes and their lambs were taken out of the groups and placed together with their offspring in a lambing pen (1.5 x 1.5 m) for 48 hours. Lambing pens were located within the same barn and constructed from wooden gates. Therefore, the animals had auditory, olfactory and visual contact with the rest of the group. All lambs were individually weighed at birth as well as at 13 weeks of age. Daily weight gain was calculated on this basis. At the day of lambing, litter size and sex of lambs were recorded. No medical treatments were used in ewes and lambs during the study.

Lambs were earmarked (Twintag earmark nipper for plastic earmarks) the day after birth, once behavioural tests were concluded (see 2.2). Water, hay and a standard pellet diet (ME 11.5 MJ/kg, 19.5 % crude protein) was available to all ewes and lambs ad libitum.

Table 2. LS means (± SE) of birth weight (kg) and daily weight gain (g) until weaning in relation to breed (ML = Merinolandschaf, BH = Deutsches Schwarzköpfiges Fleischschaf, MS = Weisses Deutsches Bergschaf, RS = Rhoenschaf, GS = Graue Gehoernte Heidschnucke)

Breeds	n	Birth weight (kg)	Daily weight gain (g)
ML	473	5.16 ± 0.04	314 ± 2.2
BH	31	4.93 ± 0.15	296 ± 7.6
MS	83	4.91 ± 0.11	267 ± 5.3
RS	381	4.18 ± 0.04	300 ± 2.4
GS	35	2.99 ± 0.13	228 ± 18.7

2.2 Behavioural observations

One day after lambing lambs were taken out of the lambing pens for 10 minutes and held by a human handler at a distance of five meters from the ewe. Afterwards they were brought back to their mothers, and the ewes' behaviour was observed for an additional minute. Behaviour of the ewe was observed continuously and based on the entire observation session, one score per animal and behaviour category was given according to the below specifications:

Behaviour score during separation (BdS)

1 = ewe does not show any agitation

2 = ewe shows agitation and seeks for her offspring

3 = ewe shows agitation, climbs the fence of her box and is aggressive towards the handling person

Vocalisation score during separation (VdS)

1 = no vocalisation of the ewe

2 = vocalisation, interrupted by calm phases

3 = vocalisation is continuous and of high intensity

Behaviour score after separation (BaS)

2 = ewe does not show any interest in offspring

3 = ewe sniffs at and licks offspring

The entire procedure of handling lambs and observing the ewes was completed by one single person.

Table 3. Frequency of the observed behaviour scores in ewes separated from their lambs (BdS = Behaviour during separation, VdS = Vocalisation during separation, BaS = Behaviour after separation)

Score	Score level	Observations (n)	Frequency (%)

BdS	1 = No agitation	103	17.1
	2 = Agitation and seeking	432	71.8
	3 = Agitation and fence climbing	67	11.1
VdS	1 = No vocalisations	77	12.8
	2 = Interrupted vocalisations	278	46.2
	3 = Continuous vocalisations	247	41.0
BaS	1 = No interest in lamb(s)	23	3.8
	2 = Sniffing and licking	579	96.2

2.3 Statistical analysis

All statistical analyses were performed using SAS (Version 8.2). A linear model (GLM procedure) was used to calculate ewe behaviour scores with breed, sex of lambs and birth type as fixed effects.

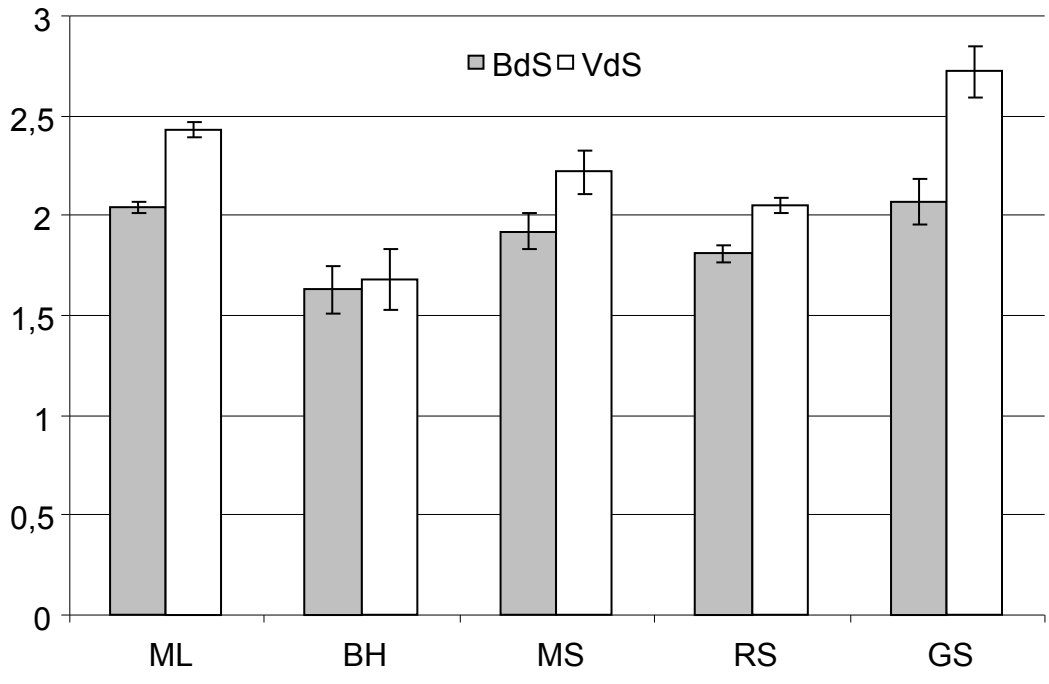
The following model was applied to the trait of birth weight:

$$y_{ijklm} = \mu + B_i + T_j + S_k + A_l + e_{ijklm}$$

where y_{ijklm} is the m-th observation, μ is the overall mean, B_i is the fixed effect of breed (i: ML, BH, RS, MS, HS), T_j is the fixed effect of birth type (j: single, multiple), S_k is the fixed effect of lamb sex (k: male, female), A_l is the fixed effect of ewe age (l: 1-2 years, 3-4 years, >4years) and e_{ijklm} is the random residual.

For the analysis of weight at weaning and daily weight gain birth weight within breed was used as covariable.

The C ...aily weigh...



3.

3.1

Most ...

mothers (71.8 %), and 87.2 % of the ewes vocalised during the separation from the lambs. Almost all ewes (96.2 %) sniffed and licked their offspring after they were brought back into the lambing pen. The breed of the ewes had a significant ($P < 0.0001$) effect on BdS and VdS (Figure 1). The GS ewes showed of all breeds the most intensive vocalisation (2.7) while being separated from their lambs. The ML ewes called more frequently and intensively when separated from their offspring than MS and RS ewes. The BH ewes showed the fewest vocalisations (1.7) during separation. However there was no significant difference ($P > 0.05$) between the breeds in BaS.

Fig.1 LS means (± SE) of maternal behaviour score (BdS) and vocalisation score (VdS,) in relation to breed (BdS: 1=no agitation; 2 =agitation and seeking; 3 = agitation and fence climbing; VdS: 1 = no vocalisations; 2 = interrupted vocalisations; 3 = continuous vocalisations)

Similarly, the age of the ewes at birth significantly affected BdS ($P = 0.0004$) and VdS ($P = 0.0023$), but did not affect BaS ($P = 0.5753$) (Figure 2). Ewes being between one and two years old at first birth had the lowest maternal behaviour and vocalisation scores (BdS: 1.77; VdS: 2.08) during separation. Highest scores during separation (BdS: 1.99; VdS: 2.29) were recorded for ewes being five years and older.

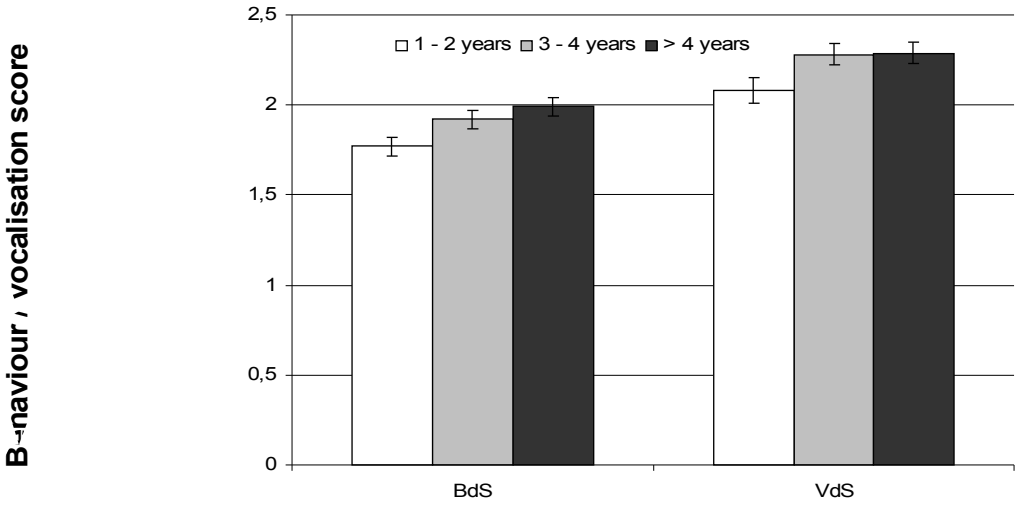


Fig.2 LS means (± SE) of maternal behaviour score (BdS, P < 0.001) and vocalisation score (VdS, P = 0.002) in relation to ewes age at birth (BdS: 1 = no agitation; 2 = agitation and seeking; 3 = agitation and fence climbing; VdS: 1 = no vocalisations; 2 = interrupted vocalisations; 3 = continuous vocalisations)

In contrast, BaS was significantly (P = 0.0046) affected by litter size. Ewes rearing one lamb scored on average 2.94 ± 0.02, whereas ewes raising two or more lambs scored on average 2.99 ± 0.02, though it remains questionable, whether this difference is biologically meaningful. No significant differences between litter sizes were observed in the other behaviour scores (BdS and VdS) (Figure 3). Sex of the lambs did not significantly (P > 0.05) affect any of the scores.

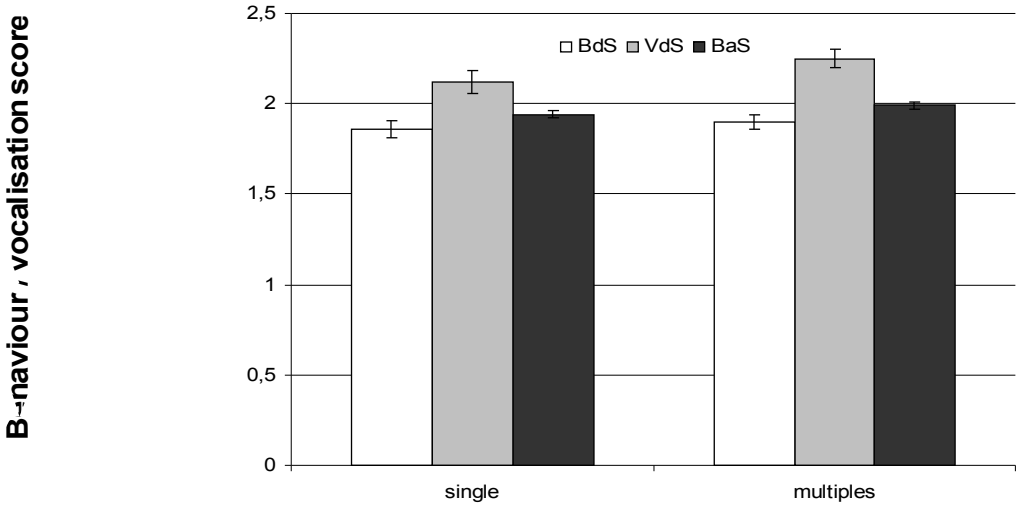


Fig.3 LS means of maternal behaviour score (BdS, P = 0.741), vocalisation score (VdS, P = 0.265), and behaviour after separation score (BaS, P = 0.005) in relation to littersize (BdS: 1=no agitation; 2 =agitation and seeking; 3 = agitation and fence climbing; VdS: 1 = no vocalisations; 2 = interrupted vocalisations; 3 = continuous vocalisations; BaS: 1 = no interest in lamb(s); 2 = sniffing and licking)

3.2 Mortality, body weight and daily weight gain

The mortality rate of lambs during the period from birth to weaning was 11.3 % (n = 113). Of these lambs 34.5 % died during the first week. BH had the highest (32.26 %; $P < 0.05$) and ML the lowest (5.7 %) total mortalities. No significant ($P > 0.05$) differences were found between MS (11.11 %), RS (10.37 %) and HS (11.43 %). Breeds differed significantly ($P < 0.0001$) with regard to birth weights and daily weight gains of the lambs until weaning at the age of 13 (Table 3). ML lambs had the highest ($P < 0.0001$) birth weights (5.16 kg $\pm$ 0.04) and daily weight gains (314 g $\pm$ 2.2) until weaning, whereas GS had lowest birth weights (2.99 kg $\pm$ 0.13) and daily weight gains (228 g $\pm$ 18.7). The age of the ewes at lambing also significantly ($P < 0.001$) influenced birth weights. Lambs from yearlings and two year old sheep showed lowest birth weights (4.07 $\pm$ 0.07 kg). Ewes at the age of three or four years produced lambs with an average birth weight of 4.56 kg $\pm$ 0.06. Ewes that were older than four years produced the heaviest lambs at birth (4.68 $\pm$ 0.06 kg).

Furthermore, the birth weights of single born lambs were significantly ($P < 0.0001$)

higher (4.82 kg ± 0.07) when compared to the birth weights of multiple born lambs (4.05 kg ± 0.05). The daily weight gain until weaning was also significantly ($P < 0.05$) higher in single born than in multiple born lambs (285 g ± 4.0 vs. 277 g ± 4.3). Birth weights (4.55 kg ± 0.06 vs. 4.32 kg ± 0.06) and daily weight gains (0.29 kg ± 0.004 vs. 0.28 kg ± 0.004) were significantly ($P < 0.0001$) higher in male lambs than in females. Birth weight as a co-variable had a significant ($P < 0.0001$) effect on daily weight gain.

3.3 Maternal behaviour and productivity in lamb

The lowest ($P < 0.01$) birth weights were recorded for lambs of mothers that showed no agitation (4.39 ± 0.95 kg) and/or no vocalisation (4.47 ± 0.94 kg) (scores 1), whereas the highest birth weights were associated with ewes showing agitation and fence climbing (4.77 ± 0.96 kg) and vocalisation at a high intensity (4.63 ± 1.07 kg) during the test (scores 3) (Table 4). The correlation between daily weight gain until weaning and birth weight was 0.58 ($P < 0.001$). However, unlike the birth weights, daily weight gain showed no significant ($P > 0.05$) relationship with ewes' behaviour during separation. Also, in contrast to BdS and VdS, lambs from ewes that showed no interest in the lamb after separation, had higher ($P < 0.01$) birth weights (5.05 ± 0.98 kg) and growth rates (0.33 ± 0.05 g) than lambs from ewes that licked and sniffed their lambs after reunification (4.51 ± 1.03 kg and 0.30 ± 0.05 g). The breed (BH) with lowest scores for BdS (1.63) and VdS (1.68) showed highest lamb mortality (32.26 %,), whereas ML had the lowest mortality rate (5.7 %) and together with GS ewes, highest behaviour scores (BdS: 2.04; VdS: 2.43).

Table 4. LS means of birth weight (BW) (kg ± SE) and daily weight gain (DWG) until weaning at an age of 13 weeks (g ± SE) in relation to maternal behaviour / vocalisation score during (BdS, VdS) and after separation (BaS) (n = number of lambs)

Ewe BdS		**Lamb**		**Lamb**
	n	**BW (kg ± SE)**	**n**	**DWG (g ± SE)**
1 No agitation	168	4.39 ± 0.08 [a]	158	298 ± 4.16 [a]
2 Agitation and seeking	721	4.52 ± 0.04 [b]	683	294 ± 2.00 [a]
3 Agitation and fence climbing	114	4.77 ± 0.10 [c]	114	311 ± 4.90 [b]
Ewe VdS				
1 no vocalisations	123	4.47 ± 0.09 [a]	115	302 ± 4.90
2 interrupted vocalisations	458	4.45 ± 0.05 [a]	427	295 ± 2.54
3 continuous vocalisations	422	4.63 ± 0.05 [b]	413	297 ± 2.58
Ewe BaS				
1 no interest in lamb(s)	28	5.05 ± 0.19 [a]	26	330 ± 10.2 [a]

2 sniffing and licking	975	4.51 ± 0.03 [b]	929	296 ± 1.71 [b]

Differences within tests: a, b, c = P < 0.05

4. Discussion

4.1 Maternal behaviour scores

4.1.1 Vocalisation during separation

Vocal behaviour between ewe and lamb may play an important role in establishing the ewe-lamb bond and enhancing lamb survival (Nowak, 1990, 1996), presumably also because it aids localisation and reunification of the partners when being separated. Therefore, through the VdS (in addition to the BdS score), an inference on the attempt of the ewe to retrieve her offspring can be made. In the present study vocalisation during separation was recorded in more than 85 % of the ewes. However, ewes of less artificially selected breeds like GS showed higher vocalisation frequencies during separation compared to highly selected sheep breeds like BH. These results are in accordance with the analysis of Dwyer et al. (1997), who found that high-pitched bleating is influenced by ewe breed and may reflect the evolutionary likelihood of separation of the ewe from the lamb. Breed differences were also described by Shillito-Walser et al. (1984) as a result of the selection process. However, these authors suggest that selection intensity of sheep has led to bleat "redundancy". In a prey species, natural selection would favour low vocal rates in the vulnerable new-born, however, domestication may have led to the re-emergence of more vocal behaviour in the neonate, particularly if this improves maternal-infant bonding (Nowak, 1990), as the selection against vocalisation by predators has largely been removed. Specific tests of ewe-lamb attachment are required to confirm that bleating serves bonding. This higher vocalisation rate, as well as higher behaviour scores, of older ewes was expected, as many authors have demonstrated that experience causes an improvement in the expression of maternal behaviour (e.g. Poindron et al., 1984; O'Connor et al., 1985, 1992) and a maturation of the neurophysiological processes underlying maternal behaviour (Kendrick et al., 1991; Lévy et al., 1992).

4.1.2 Behaviour during separation

In the present study, behaviour of the ewe has been assessed by looking at a composite measure of maternal behaviour during separation from her lamb. This

data acquisition of maternal behaviour in sheep differs from the methods described in literature (e.g. O'Connor et al., 1985; O'Connor, 1996), but the outcome of the different approaches to assess maternal ability is similar.

Most observed ewes showed high interest in their lambs during separation, as expressed by agitation and attempts to get to the lamb. However, comparable to the vocalisation scores, breed differences were found for the measured maternal behaviour traits. This is in agreement with the literature where genotype differences are described (Whateley et al., 1974; O'Connor et al., 1985; Alexander et al., 1990). In the present study, GS ewes, directly followed by ML ewes, were more agitated during separation when compared to RS ewes, whereas BH ewes showed lowest scores, maybe indicating a less intensive mother-lamb bond in the breeds with lower scores. Less artificially selected and feral breeds of sheep are generally considered to be superior mothers to more selected breeds (Shillito-Walser et al., 1984), and GS, for example, is an old-established German sheep breed mainly kept under extensive conditions. However, the response of individuals in the BdS score may reflect their underlying emotivity or temperament, as much as it measures their maternal behaviours (Le Neindre et al., 1998). In studies with Merino ewes, 'calm' ewes spent more time grooming their lambs than 'nervous' ewes, and bleated more frequently to their lambs (Murphy et al., 1998). Since temperament traits are to some extent heritable (Kilgour and Szantar-Coddington, 1995; Gauly et al., 2001), the observed breed differences in maternal behaviour may be related to underlying temperament. Also, the differences in behaviour seem to relate to some extend to the intensity of husbandry conditions the breeds have evolved under.

4.1.3 Behaviour after separation

Irrespective of age and breed, almost all ewes in the present study (96.2 %), showed great interest in their returning lambs, as expressed by sniffing and licking. However, ewes rearing two or more lambs had a higher BaS score than ewes with only one lamb. A possible explanation could be that a greater litter size has a higher attraction on the ewe, which would be expected, since each lamb presumably requires a set amount of attention from the dam to ensure bonding.

4.2 Mortality, body weight and daily weight gain

The average mortality rate of 11.3 % in this study reflects the situation under practical conditions (c.p. e.g. Kritas et al., 2006). This trait differed significantly between

breeds. Birth weights and daily growth rates of the lambs were also significantly different between the breeds. Considering the growth characteristics, the ML lambs were evidently superior to the other breeds. In addition, the daily weight gains of ML lambs were approximately 38 % higher than those of the GS lambs. Production rates of the different breeds and sex differences in production traits are in agreement with the literature (Mathiak et al., 1999; Quanz, 1995), and reflect the different growth potential of the different genotypes (Gauly et al., 2004; Reeg et al., 2005).

4.3 Maternal behaviour and productivity in lamb

Maternal traits have an important impact on the survival of the lambs, birth weight and growth rates (e.g. Lindsay et al., 1990; Gama et al., 1991; Yapi et al., 1992), as well as weaning weight (O'Connor et al., 1985; O'Connor, 1996). In the present study, breeds with highest behaviour scores lost on average fewer lambs, which is in agreement with earlier studies (Dalton et al., 1980; Hinch et al., 1983: O'Connor et al., 1985). Also, birth weights were significantly different between the levels of all behaviour scores. Animals which were more active during separation produced lambs with higher birth weights. Possibly, the individuals showing higher activity levels were the generally healthier individuals and therefore also had higher birth weights in their offspring. No differences were found for BdS and VdS in daily weight gains, indicating that maternal behaviour may be more influential early in the lamb's life. Contrary to the expectations, low interest in the returning lamb (BaS) was associated with higher birth weights and growth rates. A potential explanation could be that ewes of heavy and healthy lambs are not as anxious about their offspring, as there is less reason for concern. On the other hand, it is more likely that this result was based by the low number of animals (n = 28) in score level 1, whereas the great majority of animals (n = 975) showed high interest in their lambs (score level 2). Also, a more dispersed scale of categories in BaS might have given a more accurate picture of individual differences and therefore might have led to different results.

5. Conclusions

Distinct breed differences in the maternal behaviour traits vocalisation and agitation during separation could be observed, and they showed a positive correlation with production traits in lambs. Strong maternal behaviour was more prevalent in breeds evolved under more extensive rather than intensive environments, which could reflect

evolutionary adaptations to the differences in the social or physical circumstances between differing rearing environments (Dwyer and Lawrence, 2005). These evolutionary adaptations overrode the present circumstances the sheep lived under, as breed differences were present even though all animals lived in the same herd under the same environment, feeding and handling regimen. Therefore, genetic selection of animals with desirable maternal behaviour is possible, and will improve welfare and productivity of lambs.

Acknowledgement

The authors thank Prof. Dr. G. Erhardt for supporting the study by allowing us to use the animals at the Research Station Oberer Hardhof at the University of Giessen.

References

Alexander, G., 1988. What makes a good mother? Components and comparative aspects of maternal behaviour in ungulates. Proc. Aust. Soc. Anim. Prod. 17, 25-41.

Alexander, G., Stevens, D., Bradley, L.R., Barwick, S.A., 1990. Maternal behaviour in Border Leicester. Aust. J. Exp. Agric. 30, 27-38.

Burfening, P.J., Kress, D.D., 1993. Direct and maternal effects on birth and weaning weight in sheep. Small Ruminant Research 10, 153.

Dalton, D.C., Knight, T.W., Johnson, D.L., 1980. Lamb survival in sheep breeds on New Zealand hill country. N. Z. J. Agric. Res. 23, 167-173.

Dwyer, C.M., Lawrence, A.B., 1998. Variability in the expression of maternal behaviour in primiparous sheep: Effects of genotype and litter size. Appl. Anim. Behav. Sci. 58, 311-330.

Dwyer, C.M., McLean, K.A., Deans, L.A., Chirnside, J., Calvert, S.K., Lawrence, A.B., 1997. Vocalisation between mother and young in sheep: effects of breed and maternal experience. Appl. Anim. Behav. Sci. 58, 105-119.

Dwyer, C.M. , Lawrence, A.B., 2005. A review of the behavioural and physiological adaptions of hill and lowland breeds of sheep that favour lamb survival. Appl.

Anim. Behav. Sci. 92, 235-260.

Gama, L.T., Dickerson, G.E., Young, L.D., Leymaster, K.A., 1991. Effects of breed, heterosis, age of dam, litter size and birth weight on lamb mortality. J. Anim. Sci. 69, 2727-2743.

Gauly M., Mathiak H., Hoffmann K., Kraus M., Erhardt G. 2001. Estimating genetic variability in temperamental traits in German Angus and Simmental cattle. Appl. Anim. Beh. Sci., 74, 2, 109-119.

Gauly M., Reeg J., C. Bauer, Erhardt, G., 2004. Influence of production systems in lambs on the *Eimeria* oocyst output and weight gain. Small Ruminant Research, 55, 159 -167.

Hinch, G.N., Kelly, R.W., Owens, J.L., Crosbie, S. F., 1983. Patterns of lamb survival in high fecundity booroola flocks. Proc. N. Z. Soc. Anim. Prod. 43, 29-32.

Kendrick, K.M., Lévy, F., Keverne, E.B., 1991. Importance of vaginocervical stimulation for the formation of maternal bonding in primiparous and multiparous parturient ewes. Physiol. Behav. 50, 595-600.

Kilgour, R.J., Szantar-Coddington, M.R., 1995. Arena behavior of ewes selected for superior mothering ability differs from that of unselected ewes. Anim. Reprod. Sci. 37, 133-141.

Kritas, S.K., Govaris, A., Christodoulopoulos, G., Burriel, A.R., 2006. Effect of Bacillus licheniformis and Bacillus subtilis Supplementation of Ewe's Feed on Sheep Milk Production and Young Lamb Mortality. J. Vet. Med. A Physiol. Pathol. Clin. Med. 53, 170 – 173.

Le Neindre, P., Murphy, P.M., Boissy, A., Purvis, I.W., Lindsay, D., Orgeur, P., Bouix, J., Bibé, B., 1998. Genetics of maternal ability in cattle and sheep. In: Proceedings of the 6th World Congress on Genetic Livestock Production, vol. 27. pp. 23-30.

Lent, P.C., 1974. Mother infant relationships in ungulates. In: Geist, V.; Walther, F. (Eds.). The Behaviour of Ungulates and ist Relationship to Management. IUCN Publication No. 24, Morges, Switzerland, pp. 14-55.

Lévy, F., Kendrick, K.M., Keverne, E.B., Piketty, V., Poindron, P., 1992. Intracerebral oxytocin is important for the onset of maternal behaviour in inexperienced ewes delivered under peridural anesthesia. Behav. Neurosci. 106, 427-432.

Lévy, F., Lacatelli, A., Piketty, V., Tillet, Y., Poindron, P., 1995. Involvement of the main but not the accessory olfactory system in maternal behaviour of primiparous and multiparous ewes. Physiol. Behav. 57, 97-104.

Lévy, F., 2002. Neurobiological mechanisms involved in recognition of olfactory signature of the young in sheep. J. Soc. Biol. 196, 77-83.

Lindsay, D.R., Nowak, R., Putu, I.G., Mc Neill, D., 1990. Behavioural interactions between the ewe and her young at parturition: A vital step for the lamb. In: Reproductive Physiology of Merino Sheep. Concepts and Consequences. University of Western Australia, Perth, 191-205.

Mathiak, H., Gauly, M., Hoffmann, K., Erhardt, G., 1999. Züchterische Aspekte bei der Haltung von Wiederkäuern in peripheren Regionen – Rasse und Standort. Zeitschrift für Kulturtechnik und Landentwicklung 40, 263–268

Meurisse, M., Gonzalez, A., Delsol, G., Caba, M., Levy, F., Poindron, P., 2005. Estradiol receptor-alpha expression in hypothalamic and limbic regions of ewes is influenced by physiological state and maternal experience. Horm. Behav. 48, 34-43.

Murphy, P.M., Lindsay, D.R., Le Neindre, P., 1998. Temperament of merino ewes influences maternal behaviour and survival of lambs. In: Proceedings of the 32nd Congress of Int. Soc. Appl. Ethol. P. 131.

Nowak, R., 1990. Lamb bleats: Important for the establishment of the mother young bond? Behaviour 115, 14-29.

Nowak, R., 1996. Neonatal survival: contributions from behavioural studies in sheep. In: Appleby, M.C., Lawrence, A.B., Hughes, B.O. (Eds.), Behaviour and Welfare of Extensively kept Animals, Appl. Anim. Behav. Sci. 49, 61-72.

Nowak, R., Murphy, T.M., Lindsay, D.R., Alster, P., Andersson, R., Uvnäs Moberg, K., 1997. Development of a preferential relationship with the mother by the newborn lamb: importance of the sucking activity. Physiol. Behav. 62, 681-688.

Nowak, R., Porter, R.H., Lévy, F., Orgeur, P., Schaal, B., 2000. Role of mother young interactions in the survival of offspring in domestic mammals. Rev. Reprod. 5, 153-163.

O'Connor, C.E., Jay, N.P., Nicol, A.M., Beatson, P.R., 1985. Ewe maternal behaviour score and lamb survival. Proc. N. Z. Soc. Anim. Prod. 45, 159-162.

O'Connor, C.E., Lawrence, A.B., Wood-Gush, D.G.M., 1992. Influence of litter size and parity on maternal behaviour at parturition in Scottish Blackface sheep. Appl. Anim. Behav. Sci. 33, 345-355.

O'Connor, C.E., 1996. Ewe maternal behaviour score and lamb growth: ten years on. Proc. N. Z. Soc. Anim. Prod. 56, 107-109.

Poindron, P., Le Neindre, P., Raksanyi, I., Trillat, G., Orgeur, P., 1980. Importance of

the characteristics of the young in the manifestation and establishment of maternal behaviour in sheep. Reprod. Nutr. Dev. 20, 817-826.

Poindron, P., Le Neindre, P., Lévy, F., Keverne, E.B., 1984. The physiological mechanisms of the acceptance of the newborn among sheep. Biol. Behav. 9, 65-88.

Quanz, G., 1995. Einfluss von Rasse und Fütterung: Lammfleisch ist (k)eine Geschmacksfrage. Deutsche Schafzucht 26, 640-643

Reeg K.J., Gauly M., Bauer C., Mertens C., Erhardt G., Zahner H., 2005. Coccidial infections in housed lambs: Oocyst excretion, antibody levels and genetic influences on the infection. Vet. Parasitol., 127, 209–219.

Shayit, M., Nowak, R., Keller, M., Weller, A., 2003. Establishment of a preference by the newborn lamb for its mother: The role of opioids. Behavioral Neuroscience 117, 446-454.

Shillito, E.E., Hoyland, V.J., 1971. Observations on parturition and maternal care in Soay sheep. J. Zool. 63, 868-875.

Shillito-Walser, E.E., Walters, E., Ellison, J., 1984. Observations on vocalisation of ewes and lambs in the field. Behaviour 91, 190-203.

Whateley, J., Kilgour, R., Dalton, D.C., 1974. Behaviour of hill country sheep during farming routines. Proc. N. Z. Soc. Anim. Prod. 34, 243-245.

Yapi, C.V., Boylan, W.J., Robinson, R.A., 1992. Effect of genetic and environmental factors on lamb mortality. World Rev. Anim. Prod. 27, 35-41.

Effects of weaning lambs in two stages or by abrupt separation on their behavior and growth rate

C. Schichowski, E. Moors, M. Gauly *

Department of Animal Breeding and Genetics, Georg August University,
Albrecht Thaer Weg 3, 37075 Göttingen, Germany

(published in Journal of Animla Science 2008.86:220-225)

Abstract

A study was conducted to evaluate effects of age at weaning in combination with different weaning procedures on 2 breeds of lambs (Merinoland, Rhoenschaf). Lambs were either weaned at 8 or 16 wk of age in 2 stages or with the traditional method of weaning by abrupt separation. In the 2-stage treatment, lambs were prevented from nursing their dam for 1 wk (stage 1) before their separation (stage 2). Control animals were nursed by their dams until they were separated. Lamb BW and behavior (vocalization, agitation) were recorded before and after separation. After separation, lambs weaned at 8 wk of age had greater (P = 0.004) ADG compared with lambs weaned at 16 wk of age. Control lambs had greater (P < 0.001) agitation scores [1 = no agitation (normal behavior; i.e., feeding, resting, lying, standing, or play behavior) to 3 = high agitation (continuously moving, restlessness, or vocalization)] irrespective of weaning age and breed. On the day of separation, 2-stage lambs had scores from 1.17 to 1.35, whereas control lambs were scored from 1.70 to 1.79. After separation, lambs weaned in 2 stages vocalized up to 98.2% less (P = 0.001) than control animals. Furthermore, bleats were greater for Rhoenschaf lambs and at a weaning age of 8 wk (P < 0.05). Differences between treatments were greatest on the day of separation. Vocalization decreased continuously within the first 3 d of weaning to zero. Lambs weaned in 2 stages were less distressed than lambs weaned by the traditional method of abrupt separation based on behavioral data, but ADG until 12 and 16 wk of age did not differ (P > 0.05) for either treatment in this study.

Keywords: *behavior, lamb, productivity, sheep, weaning*

Introduction

Suckling is a major factor in the strength of the ewe-lamb bond (Hinch et al., 1990). With reduced milk production, the frequency and duration of suckling decrease (Gordon and Siegmann, 1991; Pryce, 1992). Therefore, progressive natural weaning has very little apparent negative consequences on social groups of ewes and lambs. In contrast, artificial weaning imposed by the breeder can induce an important stress for ewe and lamb (Orgeur et al., 1997). In cattle, behavioral responses to this event can be observed for several days or weeks (Veissier and LeNeindre, 1989). Both ewes and lambs express their distress by an increase in bleating and locomotion activity (Alexander, 1977; Torres-Hernandez and Hohenboken, 1979). Some stressors can induce a suppression on some aspects of the immune system having negative effects on animal health, welfare (Orgeur et al., 1997), and performance, because the release of glucocorticoid hormones coincides with a decrease in GH (Kuhn et al., 1990). An alteration in growth rate may also result from the decrease of the quantity of food ingested or from an impairment of digestive function caused by weaning stress (Dantzer and Mormède, 1979).

Haley et al. (2005) described effects of an alternative weaning procedure for beef calves. Preventing nursing between cow-calf pairs before separation of the mother and young decreased the degree of behavioral changes compared with imposing both restrictions, preventing nursing and separation, together. The authors stressed the possible benefits from this procedure and recommended it for practical use. Similar studies have not been done in sheep. Therefore, the aim of this study was to measure lamb behavior and ADG after 2 different weaning procedures including traditional weaning by abrupt separation of the mother-lamb pair and a modified 2-stage treatment previously described for cattle (Haley et al., 2001, 2005).

Materials and Methods

Experimental flock and design

This experiment was performed in accordance with the guidelines established by the Institutional Animal Care and Use Committee of the University of Göttingen based on the German Animal Welfare law. A total of 158 Merinolandschaf (German Merino) and Rhoenschaf (Rhoensheep) lambs were used in the study. Animals were weaned at either 8 or 16 wk. Weaning was done by 1 of 2 procedures. The traditional

weaning method was by abrupt visual and acoustical separation of the ewe and lamb. The second was a 2-stage method, in which lambs were first prevented from nursing their dam for 1 wk (stage 1) before their separation (stage 2). Nursing was prevented by covering the udder of the mother with a net that was fixed on the back of the animal (Figure 1).

A **B**

Figure 1: (A) Photograph of the udder net, which prevented nursing by providing a barrier between the mouth of the lamb and the teat of the ewe. (B) Photograph showing how the net was fixed over the back.

All lambs in the study were born as singles within a week. They were kept indoors and bedded on straw in groups of 30 to 60 ewes (1.5 m^2/ewe and lamb). All lambs had ad libitum access to hay, a standard concentrate (11.5 MJ of ME/kg, 19.5% CP), and water. At an average age of 6 or 14 wk, lambs and their mothers were randomly divided into 4 groups/breed (Table 1). At the time of weaning, groups of lambs (20 to 30 lambs) were separated from their mothers by moving them to a different barn with pens (1.0 m^2/lamb), prohibiting visual contact and vocal communication.

Table 1. Experimental design, number of animals per weaning method and weaning age used in the study

Weaning method [1]	Weaning age;wk	breed	n (males and females)
Traditional	8	German Merino	19 (8 and 11)
		Rhoensheep	20 (9 and 11)
	16	German Merino	22 (10 and 12)
		Rhoensheep	18 (10 and 8)
2-stage	8	German Merino	20 (9 and 11)
		Rhoensheep	21 (7 and 14)
	16	German Merino	20 (9 and 11)
		Rhoensheep	18 (11 and 7)

[1] Traditional = weaning by abrupt separation; 2-stage = preventing the lambs from nursing their dam for 1 wk (stage 1) before their separation (stage 2).

Behavioral observations

For identification, ewes and lambs were individually marked on the back with a color code (cattle color, Raidex, Dettingen, Germany). Lambs and ewes received the same color codes for correct allocation. Lambs were observed for 3 h/d (from 0900 to 1200). Observation began 4 d before weaning (at 1000) and was continued for 4 d after weaning. Scan sampling was used at 30-min intervals to count the total number of vocalizations (bleats) coming from each lamb for 1 min, on a rotating basis. At the beginning of each 30-min interval, scores for agitation were recorded for each lamb. Three scores were used: 1 = no agitation (normal behavior, i.e., feeding, resting, lying, standing, or play behavior); 2 = agitation (no normal behavior, i.e., moving around, head or leg moving); 3 = high agitation (continuously moving, restlessness, or vocalization).

Statistical analysis

All statistical analyses were performed using SAS (SAS Inst. Inc., Cary, NC). The GLM procedure was used to obtain least squares means for lamb ADG with breed, sex, age, and method of weaning as fixed effects and birth weight as the covariate.

The following model was used:

$y_{ijklm} = \mu + b_i + s_j + m_k + a_l + a_l \times m_k + e_{ijklm}$

where y_{ijklm} = the mth observation; μ = overall mean; b_i = breed; s_j = sex; m_k = weaning method; a_l = weaning age; $a_l \times m_k$ = interaction between weaning age and weaning method; and e_{ijklm} = random residual. For the analysis of birth weight, breed and sex as well as the interaction between them were set as fixed effects. The following model was used to analyze differences in the frequency of bleats

(bleats/min) using the MIXED procedure of SAS:

$y_{ijklmn} = \mu + b_i + a_j + m_k + d_l + a_j \times m_k \times b_i + a_j \times m_k \times b_i \times d_l + n_m + e_{ijklmn}$,

where yijklmn = nth observation; μ = overall mean; b_i = breed; a_j = weaning age; m_k = weaning method; d_l = day of observation; $a_j \times m_k \times b_i$ = interaction among weaning age, weaning method, and breed; $a_j \times m_k \times b_i \times d_l$ = interaction among breed, weaning age, weaning method, and day of observation; nm = random animal effect; and eijklmn = random residual. To analyze differences in the agitation score, a linear model (GLM) was used with weaning age, method, and breed as fixed effects. Frequencies of agitation scores were calculated with the FREQ procedure of SAS.

Results

BW and ADG

German Merino lambs had greater (P < 0.001) birth weights (5.51 ± 0.10 kg) compared with Rhoensheep lambs (4.41 ± 0.10 kg). Although ADG was different (P < 0.001) between breeds at wk 12 (329 vs. 281 g) and wk 16 of age (335 vs. 268 g), lamb sex had no influence (P = 0.10) on birth weight. Lambs weaned at wk 8 had greater (P = 0.004) ADG until wk 12 (317 vs. 294 g) and wk 16 (313 vs. 291 g) compared with lambs weaned at wk 16. However, neither the traditional nor the 2-stage weaning affected (P > 0.50) ADG at wk 12 and 16. An interaction between weaning age and weaning method influenced (P < 0.047) ADG (Table 2) at wk 12 and 16.

Table 2. Average daily gains of lambs weaned at 8 and 16 wk of age by traditional or 2-stage methods[1]

	Traditional		2-stage	
Item	8 wk	16 wk	8 wk	16 wk
ADG until wk 12, g/d	327.3[a] ± 8.2	288.0[b] ± 8.0	306.2 ± 8.5	299.1 ± 8.1
ADG until wk 16, g/d	319.6[a] ± 7.7	280.0[b] ± 7.5	305.5 ± 8.0	301.1 ± 7.6

[a,b] Row values within weaning procedure with different superscripts differ (P < 0.05).
[1] Traditional = weaning by abrupt separation; 2-stage = preventing the lambs from nursing their dam for 1 wk (stage 1) before their separation (stage 2).

Lamb Behavior

Animals weaned by abrupt separation showed greater (P < 0.001) scores of agitation compared with animals weaned in 2 stages. Development of the score levels in the different groups during the time of observation is shown in Figure 2.

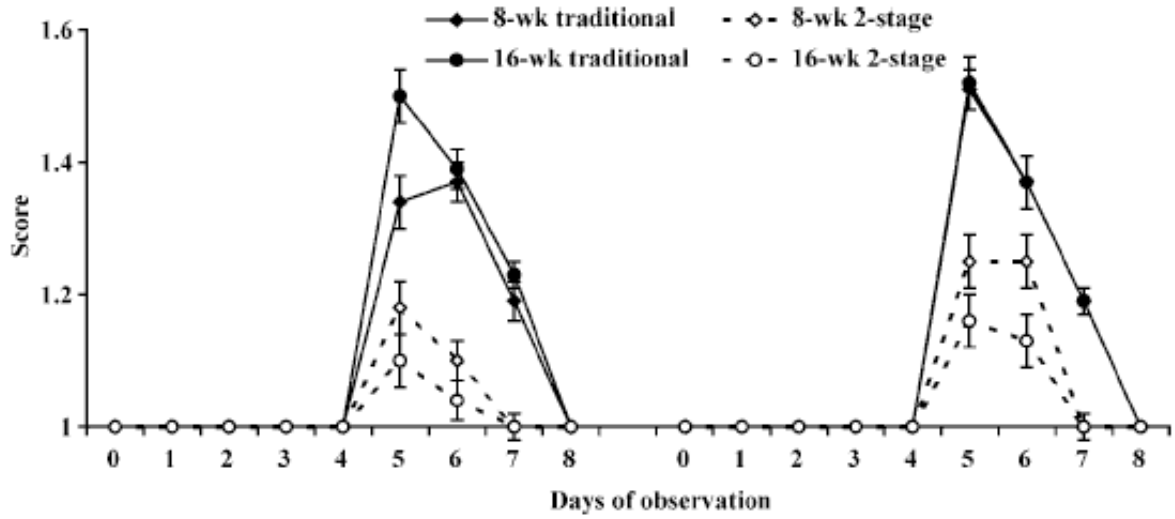


Figure 2. Agitation score (1 = no agitation; 2 = agitation; 3 = high agitation) before (d 0 to 3) and after (d 5 to 8) weaning (d 4) in relation to weaning age (8 and 16 wk) and weaning procedure (traditional weaning was by abrupt seperation and 2-stage weaning prevented lambs from nursing their dam for 1 wk before their separation) in German Merinoland (left) and Rhoensheep (right) lambs

All groups showed no agitation before weaning and at 4 d after weaning (score = 1). Agitation scores were not different between breeds (P > 0.05); however, animals weaned in 2 stages had lower (P < 0.001) agitation scores compared with traditionally weaned animals (Table 3).

Table 3. Average frequencies (%) of agitation scores in lambs during the observation period divided by breed, weaning age, and weaning method[1]

	German Merino				Rhoensheep			
	8 wk		16 wk		8 wk		16 wk	
Agitation score,[2] %	Traditional	2-stage	Traditional	2-stage	Traditional	2-stage	Traditional	2-stage
1	90.3[a]	96.9[b]	87.5[a]	98.3[b]	89.1[a]	94.4[b]	88.1[a]	96.8[b]
2	9.4[a]	3.1[b]	12.5[a]	1.67[b]	10.0[a]	5.6[b]	11.9[a]	3.2[b]
3	0.3	0.0	0.0	0.0	0.9	0.0	0.0	0.0

[a,b] Row values within breed and weaning age with different superscripts differ (P < 0.05).
[1] Traditional = weaning by abrupt separation; 2-stage = preventing the lambs from nursing their dam for 1 wk (stage 1) before their separation (stage 2).
[2] 1 = no agitation; 2 = agitation; 3 = high agitation.

The frequency of bleats (Table 4) was influenced by breed (P = 0.008), weaning age (P = 0.035), and procedure (P < 0.001). Although Rhoensheep lambs bleated more (P = 0.008) than German Merino lambs (2.10 vs. 1.83 ± 0.07), traditionally weaned lambs vocalized more (P < 0.001) than lambs weaned in 2 stages (3.15 vs. 0.78 ± 0.07).

Table 4. Least squares means (±SE) of bleats per minute in relation to weaning age, weaning method, and breed[1]

	German Merino				Rhoensheep			
	8 wk		16 wk		8 wk		16 wk	
Item	Traditional	2-stage	Traditional	2-stage	Traditional	2-stage	Traditional	2-stage
Bleats/min	2.62 ± 0.15[a]	1.01 ± 0.14[b]	3.30 ± 0.14[a]	0.39 ± 0.14[b]	3.67 ± 0.14[a]	1.00 ± 0.14[b]	3.01 ± 0.15[a]	0.72 ± 0.15[b]

[a,b] Row values within breed and weaning age with different superscripts differ (P < 0.001).
[1] Traditional = weaning by abrupt separation; 2-stage = preventing the lambs from nursing their dam for 1 wk (stage 1) before their separation (stage 2).

Number of bleats was greatest in lambs weaned in the traditional method at an age of 8 wk (Figure 3). No vocalization occurred on the days before weaning and after the second day of weaning. Bleat frequencies differed (P < 0.001) between the observation days and times within a day (Figure 4) and were greater on the day of weaning (3.71 ± 0.10/min, P < 0.001) compared with d 1 (2.86 ± 0.10/min) and 2 (1.29 ± 0.10/min) after weaning. On the day of weaning, the greatest mean bleat rate of 6.30 ± 0.25/min occurred 30 min after separation (1030). The frequency decreased until the second day after weaning to 0.84 ± 0.25 bleats/min at 1200.

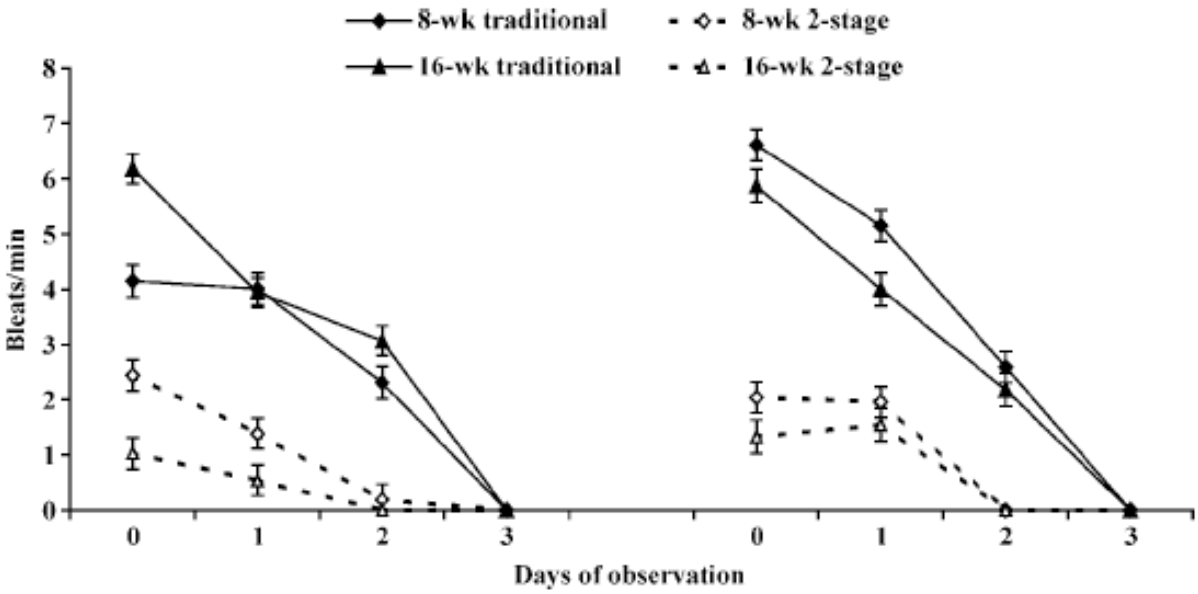


Figure 3. Least squares means (±SE) of bleats per minute after weaning (d 0) in relation to weaning age (8 and 16 wk) and weaning procedure (traditional weaning was by abrupt separation and 2-stage weaning prevented lambs from nursing their dam for 1 wk before their separation) in German Merinoland (left) and Rhoensheep (right) lambs

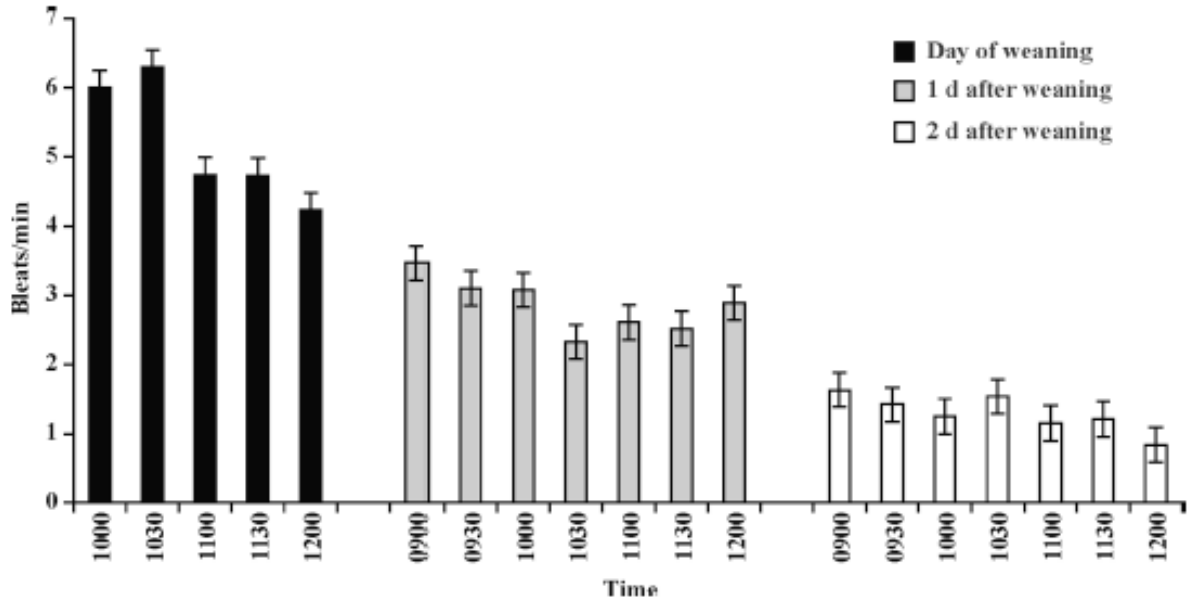


Figure 4. Bleats per minute (every 30 min from 0900 to 1200) during day of weaning as well as 1 and 2 d after the weaning procedure for all lambs in the study

Discussion

Considering birth weights and growth characteristics, German Merino lambs were evidently superior to Rhoensheep lambs, confirming earlier studies (Kraus et al., 1998; Mathiak et al., 1999; Seibert et al., 2004).

Daily growth rate may be reduced by stress, because the release of glucocorticoid hormones is accompanied by reduced GH production (Kuhn et al., 1990), which may lead to decreased feed intake. However, in this study, early weaned lambs (8 wk) had greater (P = 0.004) ADG compared with lambs weaned at an age of 16 wk. This is somewhat surprising, because laterweaned animals would have been expected to benefit from the additional milk received by the ewe. The availability of high-quality concentrates may have allowed early weaned lambs to compensate for the loss of maternal milk by increased feed intake, resulting in a greater total intake of energy.

Furthermore, traditional and 2-stage weaning did not differ regarding daily BW gains, confirming similar results found for calves (Haley et al., 2005). A punctuated loss in BW due to social disturbance like mother-young separation was probably transient and unnoticed because of the relatively long-term weighing intervals (Dantzer and Mormède, 1979). These results may have been different under conditions with disadvantageous nutritional management and shorter weighing frequencies. Poor feed conditions may increase BW gains by lambs weaned by the 2-stage method compared with an abrupt separation.

Clear behavioral perturbations were induced by weaning for all observed lambs, independent of genotype, age, or weaning procedure. But after only a few days, clear signs of habituation occurred, and behavior returned to preweaning levels, which is in agreement with results found by Orgeur et al. (1997).

As expected, results showed that younger lambs were more stressed by weaning procedures when compared with older lambs based on the observed behavioral parameters. This may be due to the stronger mother young bond. The relationship between the ewe and its lamb(s) disengages with age of the offspring and as the lambs become more autonomous (Orgeur et al., 1997). The intervals between suckling increase with age, indicating that 16-wk-old lambs are more accustomed to a separation from the mother than younger lambs. With age, the distance between mother and young becomes longer. Older lambs also move more frequently and further from the ewe than younger lambs, and they do not vocalize as much as younger ones. Increased vocalization rates in lambs occur after a stressor such as separation (Torres-Hernandez and Hohenboken, 1979; Cockram et al., 1993). Younger lambs show more activity, such as running around in the stable and searching for their dam. Therefore, to abate the separation stress for lambs at weaning, weaning should occur when lambs are as old as possible.

Vocalization was different (P = 0.008) between breeds, with Rhoensheep lambs bleating more than German Merino lambs if weaned abruptly at 8 wk of age. This could either indicate that the development of the Rhoensheep breed may be slower compared with the German Merino (Kraus et al., 1998) or that the mother bond is somehow stronger in this breed. Results of this study clearly demonstrate that lambs weaned with the 2-stage method vocalized less and showed less behaviors indicative of agitation after separation than animals weaned by the traditional method of abrupt separation. Similar results have been reported in horses (McCall et al., 1985), sheep (Orgeur et al., 1997), and calves (Haley et al., 2001, 2005). Although lambs weaned in 2 stages have to cope with a single stressor at a time, the denial of milk and the separation procedure, lambs weaned in the traditional way have to cope with both stressors at the same time, leading to greater stress levels expressed by more agitation and vocalization.

The greatest mean bleat rate was recorded on the day of weaning, followed by a continuous decline until 2 d after weaning. Similar results have been reported for sheep (Orgeur et al., 1997) and calves (Haley et al., 2005). Several studies indicate that separation of mother and young induced only a weak response of

glucocorticoids, provided that a visual and auditory contact exists (Levine et al., 1985; Hennessy and Moorman, 1989; Lefcourt and Elsasser, 1995). However, the behavioral response of separation can be different from the behavior shown before separation. This study showed that preventing lambs from suckling before the actual separation (2-stage method) can reduce stress for weaned lambs. However, the 2-stage weaning method is very time-consuming, particularly the attachment of the udder net. Therefore, this method is practical only for small herds. Nevertheless, because detailed information on the possible benefits of alternative weaning procedures are lacking, further investigations on modified systems are needed.

Acknowledgments

The authors would like to thank G. Erhardt and the staff of the Research Station Oberer Hardthof of the University of Giessen for their generous technical support.

Literature Cited

Alexander, G. (1977): Role of auditory cues in mutual recognition between ewes and lambs in Merino sheep. Applied Animal Ethology 3: 65-81.

Cockram, M.S.; Imlah, P.; Goddard, P.J.; Harkiss, G.D. & Waran, N.K. (1993): The behavioral, endocrine and leucocyte response of ewes to repeated removal of lambs before the age of natural weaning. Applied Animal Behaviour Science 38: 127-142.

Dantzer, R. & Mormède, P. (1979): Le stress en élevage intensif. In: Actualités scientifiques et agronomiques de l' INRA. Masson, Paris, p. 119.

Gordon, K. & Siegmann, M. (1991): Suckling behaviour of ewes in early lactation. Physiology & Behavior 50: 1079-1081.

Haley, D.B.; Bailey, D.W. & Stookey, J.W. (2005): The effects of weaning beef calves in two stages on their behavior and growth rate. Journal of Animal Science 83: 2205- 2214.

Haley, D.B.; Stookey, J.W.; Clavelle, J.L. & Watts, J.M. (2001): The simultaneous loss of milk and maternal contact compounds distress at weaning in beef calves. 35th International Congress. International Society Applied Ethology.

Hennessy, M.B. & Moormann, L. (1989): Factors influencing cortisol and behavioural response to maternal separation in Guinea pigs. Behavioral Neuroscience 103: 378-385.

Hinch, G.N.; Lynch, J.J.; Elwin, R.L. & Green, G.C. (1990): Long-term associations

between Merino ewes and their offspring. Applied Animal Behaviour Science 27: 93-103.

Kuhn, C.M.; Pauk, J. & Schanberg, S.M. (1990): Endocrine responses to mother-infant separation in developing rats. Developmental Psychobiology 23: 395-410.

Kraus, M.; Beuing, R.; Gauly, M. & Erhardt, G. (1998): Zum Zuchtziel beim Rhönschaf im Hinblick auf Mutterschafgewicht und Fruchtbarkeit unter dem Aspekt extensiver und intensiver Haltung. Arch. Tierzucht 41: 99-109.

Lefcourt, A.M. & Elsasser, T.H. (1995): Adrenal responses of Angus x Hereford cattle to the stress of weaning. Journal of Animal Science 73: 2669-2676.

Levine, S.; Johnson, D.F. & Gonzalez, C.A. (1985): Behavioural and hormonal responses to separation in infant Rhesus monkeys and mother. Behavioral Neuroscience 99: 399-410.

Mathiak, H.; Gauly, M.; Hoffmann, K. & Erhardt, G. (1999): Vergleich der Produktionsleistung von Schafrassen auf einem extensiv bewirtschafteten Mittelgebirgsstandort. Zeitschrift für Kulturtechnik und Landentwicklung 40: 1-6.

McCall, C.A.; Potter, G.D. & Kreider, J.L. (1985): Locomotor, vocal and other behavioral responses to varying methods of weaning foals. Applied Animal Behaviour Science 14: 27-35.

Orgeur, P.; Mavric, N.; Yvore, P.; Bernard, S.; Nowak, R.; Schaal, B. & Levy, F. (1997): Artificial weaning in sheep: consequences on behavioural, hormonal and immuno-pathological indicators of welfare. Applied Animal Behaviour Science 58: 87-103.

Seibert, B.; Gauly, M. & Erhardt, G. (2004): Productivity of different sheep breeds in extensive pasture management. Arch. Tierzucht 47: 147-152.

Pryce, C.R. (1992): A comparative systems model of the regulation of maternal motivation in mammals. Animal Behavior 43: 417-441.

Torres-Hernandez, G. & Hohenboken, W. (1979): An attempt to assess traits of emotionality in crossbred ewes. Applied Animal Ethology 5: 71-83.

Veissier, I. & le Neindre, P. (1989): Weaning in calves: its effect on social organization. Applied Animal Behavior 24: 43-54.

Influence of age of weaning on the effect of an experimental *Haemonchus contortus* infection on parasitological measurements, behaviour and performance

C. Schichowski, E. Moors, M. Gauly *

Department of Animal Science, Goerg August University,
Albrecht Thaer Weg 3, 37075 Göttingen, Germany

* Corresponding author Tel.: +49-551-395602; Fax: +49-551-395587;
E-Mail address: Mgauly@gwdg.de (M. Gauly)
(submitted to Applied Animal Behaviour Sciene on 24.09.2009)

Abstract

Four groups of 20 lambs each, differing in weaning age (6, 13 or 21 weeks of age) and infection with *Haemonchus contortus*, were observed and compared regarding the behaviour before, during and after these procedures. Furthermore the influence on performance, health, and welfare was estimated by examining average daily weight gain (ADW), haematocrit (HCT), and faecal egg count (FEC). The analysis demonstrates that the exposure through weaning is highest for the youngest lambs. Agitation was significantly higher in lambs that were weaned at the age of 6 weeks, when compared with animals weaned at 13 and 21 weeks of age.

Lambs which were weaned at 13 weeks of age, had significantly higher ADW until week 17 and 21 of age compared to lambs which were not weaned until this time, possibly because of a higher concentrate intake. Weaning and experimental infection at the same time did not influence ADW in lambs significantly. However, the combination of weaning and infection at the same time denotes a great intervention for the lambs, what is reflected in lower HCT values and a decreased resistance against an experimental infection with *H. contortus*.

The results show that weaning, age at weaning time, existence of another stressor, weight and health performance have an effect on the grade of infection. These aspects are important for the assurance of productivity in sheep breeding systems.

Keywords: *sheep, productivity, weaning, Haemonchus contortus*

1. Introduction

Worldwide *Haemonchus contortus* is the most important endoparasite in sheep and goat production causing economic damage by blood losses (Waller and Chandrawathani, 2005; Gauly et al., 2002), resulting in a potential anaemic status (Dargie and Allonby, 1975), reduced growth rate and weight loss. In cases of a small amount of blood loss the host might be able to compensate it and the infection stays subclinical. In heavier infections (up to 30000 worms), healthy sheep may die suddenly from severe haemorrhagic gastritis (hyperacute haemonchosis). The most often and most seriously affected animals are lambs and older sheep under massive stress (Demeler, 2005). Therefore the parasite presents worldwide a major constraint on livestock production and goes along with the increased costs associated with anthelmintic and management control measures (Coop et al., 1985; Waller and Chandrawathani, 2005). Many factors influence the severity of the disease. These are the number of worms present, general health and immunological status of the sheep, age of the sheep, environmental factors such as weather, pasture type, stabling systems, stocking rate and stress, e.g. induced by management procedures, poor diet or poor weather (Demeler, 2005). Weaning can also induce an important stress for ewes and lambs (Orgeur et al., 1997). In cattle and sheep behavioural responses to this event can be observed for several days or weeks (Veissier and LeNeindre, 1989; Schichowski et al., 2008). Both ewes and lambs express their distress by an increase in bleating and locomotion activity (Alexander, 1977; Torres-Hernandez and Hohenboken, 1979). Some stressors can induce suppression on some aspects of the immune system having negative effects on animal health, welfare (Orgeur et al., 1999), and performance, as the release of glucocorticoid hormones coincides with a decrease in growth hormones (Kuhn et al., 1990). An alteration in growth rate may also result from the decrease of the quantity of food ingested or from an impairment of digestive function caused by weaning stress (Dantzer and Mormède, 1983).

There are different ways for an animal to cope with a disease like behaviour, physiological responses, immunological responses or brain activity. Behaviour is an important way of adapting to disease. Selective pressures resulting from disease have had major consequences for the evolution of behaviour (Broom, 2005). Because in some production systems lambs are moved from barn to pasture directly after weaning and facing helminth infection for the first time the aim of this study was

to estimate the effects of weaning and an experimental infection with *H. contortus* infection in Merinoland sheep lambs on behaviour, performance and health.

2. Material and methods

2.1 Experimental flock and design

The experimental flock was located at the Research Station of the Institute of Animal Breeding and Genetics at the University of Giessen, Germany. A total of 80 pure single Merino lambs were used in the study. All lambs were born indoors. They were kept together with their dams in a barn on straw in two groups of about 40 ewes with lambs until and age of 4 weeks (1.5 m2 per ewe and lamb). At an age of 4 weeks the animals (lambs and ewes) were randomly divided into four groups of 20 lambs each. The number of male lambs in the groups ranged between 6 and 9.

Animals of group 1 (G 6/13) were weaned at the age of 6 weeks and infected with *H. contortus* at an age of 13 weeks. Animals of group 2 (G 0/13) were not weaned until the end of the experiment (week 21) but infected at an age of 13 weeks. Lambs of group 3 (13/13) were weaned and experimentally infected at an age of 13 weeks. Finally animals of group 4 (G 13/0) were weaned at 13 weeks of age but kept as uninfected controls.

Weaning was done by abrupt visual and acoustical separation of the ewe and lamb. The lambs were kept separately in their groups, whereas ewes were brought to another barn, prohibiting visual contact and vocal communication. Lambs of group 2 were kept together with their dams until the end of the experiment. They were weaned at an age of 21 weeks. Space allowance for animals of groups 1, 3 and 4 was reduced after weaning to 1.0 m^2 per lamb.

The lambs were given water ad libitum and were fed with hay and a standard pellet diet (ME 11.5 MJ/kg, 19.5% crude protein) ad libitum. No anthelmintic treatments were used in lambs during the study.

2.2 Behavioural observations

For identification, ewes and lambs were individually marked on the back with a colour code (cattle colour, Raidex, Dettingen, Germany) one week before the beginning of the observations. Lambs received the analogical colour code of the mother sheep, to allow an allocation between them.

The behaviour of all lambs was recorded before, during and after weaning and/or the experimental infection with *H. contortus* to quantify the behavioural alterations through weaning and/or infection in relation to the procedure.
The observations for all lambs began one week before weaning/infection (week 12) and were continued until one week after weaning/infection. Therefore animals of group 1 and 2 were observed 2 weeks longer, then animals of groups 3 and 4. During observation period all lambs were observed for 4 hours per day (from 0900 to 1300) using the scan sampling method at 15-min intervals on a rotating basis. At the beginning of each 15-min interval scores for agitation and vocalisation were given. Three scores were used to describe the level of agitation: 1 = no agitation (normal behaviour, i.e., feeding, resting, lying, standing, or play behaviour); 2 = agitation (no normal behaviour, i.e., moving around, head or leg moving); 3 = high agitation (continuously moving, restlessness). Furthermore three different scores for vocalisation were determined: 1 = no vocalisation; 2 = vocalisation; 3 = intensive and high frequent vocalisation.
In addition vocalisation rate per minute were noted for all lambs during 8 hours after weaning. Therefore every 15-min the total number of vocalizations (bleats) coming from each lamb were counted for 1 min.

2.3 Experimental infection, body weight and parasitological measurements

Each helminth-naive lamb of the groups 1, 2 and 3 was orally infected at 13 weeks of age with 5000 infective-stage larvae (L3) of the nematode *H.* contortus (Gauly et al., 2002).
In addition body weights were measured at the day of birth, at 13, 17 and 21 weeks of age with an electronical scale. Based on these measurements average daily weight gains (ADW) were calculated.
Blood samples were taken from the jugular vein at an age of 13, 17 and 21 weeks to measure the haematocrit values (HCT) by the microhaematocrit centrifugation technique. Furthermore individual faecal samples were collected at the age of 13, 17 and 21 weeks. Faecal egg counts (FEC) were determined using the modified McMaster technique (Whitlock, 1948). In this method 4 g faeces and 60 ml of a saturated NaCl solution (specific gravity of 1.2 kg/m^3) were used with a test sensitivity of 50 eggs per gram faeces.

2.4 Statistical analysis

Statistical analysis was performed by using SAS (Inst. Inc., Cary, NC) (version 8.2) (GLM procedure). The GLM procedure was used to obtain least squares means for lamb ADW, HCT, and log FEC with group, sex, birth type as fixed effects, and birth weight as the covariate.

3. Results

3.1 Behavioural observations

Infection with *H. contortus* alone had no impact on the measured behaviour parameters of the lambs as the comparison of early (group 1) and late (group 2) weaned animals is indicating (Table 1). In opposite weaning significantly ($p < 0.05$) influenced the agitation scores. Agitation was significantly higher in lambs that were weaned at the age of 6 weeks (group 1), when compared with animals only weaned at 13 weeks of age (group 4). Lambs that were weaned and infected at the age of 13 weeks (group 3) had in tendency ($p > 0.05$) higher scores then lambs which were only weaned at that age (group 4). The significantly lowest agitation scores showed lambs belonging to group 2 when weaned at an age of 21 weeks.

Table 1. LS means of agitation/vocalisation score in relation to weaning and infection (d 0)

time [d]	group I at weaning (6 weeks)	group I at infection (13 weeks)	group II at infection (13 weeks)	group II at weaning (21 weeks)	group III at weaning + infection (13 weeks)	group IV at weaning (13 weeks)
< -2	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
-2	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
-1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
0	1.81 / 1.92	1 / 1	1 / 1	1.36 / 1.49	1.78 / 1.76	1.53 / 1.69
1	1.40 / 1.51	1 / 1	1 / 1	1.16 / 1.13	1.35 / 1.46	1.26 / 1.37
2	1.33 / 1.41	1 / 1	1 / 1	1 / 1	1.29 / 1.35	1.18 / 1.29
3	1.21 / 1.20	1 / 1	1 / 1	1 / 1	1.06 / 1.06	1.07 / 1.08
4	1.12 / 1.13	1 / 1	1 / 1	1 / 1	1.04 / 1.05	1.03 / 1.03
5	1.09 / 1.01	1 / 1	1 / 1	1 / 1	1.01 / 1	1 / 1
6	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1
> 6	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1	1 / 1

The least square means of the recorded vocalisation score for all groups before, during and after weaning and/or infection is also given in table 1. The results are similar to those of the agitation score. The experimental infection with *H. contortus* had no significant effect on the vocalisation scores. Vocalisation scores were highest

in animals weaned at six weeks, followed by those weaned at 13 and 21 weeks ($p < 0.05$). Both scores were latest 5 days after weaning back to the normal values. In table 2 the influence of weaning and infection with *H. contortus* on the bleats per minute is presented from the first until the fourth hour after weaning/infection. There was no behavioural change in consequence of the infection. The significantly ($p < 0.05$) highest number of bleats was recorded for group 1 weaned at the age of six weeks followed by groups 3 and 4, respectively.

Table 2. Average vocalisation/min in relation of weaning and infection in the course of time (4 hours after event)

time [h]	group I at weaning (6 weeks)	group I at infection (13 weeks)	group II at infection (13 weeks)	group II at weaning (21 weeks)	group III at weaning + infection (13 weeks)	group IV at weaning (13 weeks)
0.5	8.66	0	0	3.26	6.23	4.76
1.0	8.31	0	0	3.08	5.46	4.52
1.5	7.85	0	0	2.79	4.29	3.10
2.0	7.59	0	0	2.34	4.12	3.05
2.5	7.23	0	0	1.96	3.87	2.57
3.0	6.97	0	0	1.73	3.54	2.52
3.5	6.53	0	0	1.22	3.23	1.67
4.0	5.74	0	0	0.78	2.85	1

3.2 Daily weight gain and parasitological measurements

ADW were significantly ($p < 0.05$) different between the groups until an age of 13 and 17 weeks with the highest values in animals weaned at 13 weeks (groups 3, 4) (Table 3). However, ADW until 21 weeks of age was only significantly different ($p < 0.05$) between group 2 and 3 (279 ± 9.53 g vs. 309 ± 9.24 g).

Table 3. LS means ($\pm$ SE) of ADW (g) until week 13, 17 and 21 in the four groups

Group	1 (6/13)	2 (0/13)	3 (13/13)	4 (13/0)
ADW wk 13	$314 \pm 10.1^{a,b}$	276 ± 10.1^{a}	332 ± 9.78^{b}	325 ± 9.78^{b}
ADW wk 17	302 ± 10.3^{a}	284 ± 10.4^{a}	326 ± 10.0^{b}	$305 \pm 10.0^{a,b}$
ADW wk 21	$306 \pm 9.50^{a,b}$	279 ± 9.53^{a}	309 ± 9.24^{b}	$293 \pm 9.23^{a,b}$

$^{a, b}$ significant differences between the groups ($p < 0.05$)

Table 4 shows the average log FEC and HCT of the four groups at an age of 13, 17

and 21 weeks. At an age of 13 weeks log FEC were zero for all animals. This was also the case for lambs from the uninfected group 4 at all times of sampling. There were no significant differences between the four groups in log FEC. In tendency animals from group 3 (infected and weaned at the same time) had highest log FEC at the age of 17 weeks. At the age of 21 weeks highest log FEC values were found in group 2.

At the age of 13 weeks the significantly ($p < 0.05$) lowest HCT values were found in group 4 (0.33 ± 0.01 l/l), whereas the significantly lowest HCT values at the age of 17 weeks could be measured in group 1 (0.28 ± 0.01 l/l).

Table 4. LS means of log FEC ($\pm$ SE) and haematocrit value (HCT $\pm$ SE) at the age of 13, 17 and 21 weeks

	Group Week	1 (6/13)	2 (0/13)	3 (13/13)	4 (13/0)
log FEC	13	0	0	0	0
	17	7.65 ± 0.23	7.71 ± 0.22	7.95 ± 0.22	0
	21	7.68 ± 0.24	7.83 ± 0.23	7.21 ± 0.23	0
HCT (l/l)	13	0.36 ± 0.01^{a}	0.35 ± 0.01^{ab}	0.36 ± 0.01^{a}	0.33 ± 0.01^{b}
	17	0.28 ± 0.01^{a}	0.30 ± 0.01^{b}	0.31 ± 0.01^{b}	0.36 ± 0.01^{c}
	21	0.33 ± 0.01	0.32 ± 0.01	0.31 ± 0.01	0.33 ± 0.01

[a, b] significant differences between the groups ($p < 0.05$)

4. Discussion

Infection with *H. contortus* alone had no impact on the measured behaviour of the lambs. In opposite weaning significantly ($p < 0.05$) influenced agitation and vocalisation scores as well as the bleating frequency. The effects of weaning decreased with age. Therefore the significantly lowest scores were found in lambs which were weaned at an age of 21 weeks. Weaning induced clear behavioural perturbations. This is in confirmation with earlier studies (Schichowski et al., 2008). The same authors have shown that younger lambs are more stressed by weaning procedures when compared with older lambs. They assume that this is due to the stronger mother-young bond. The relationship between the ewe and its lamb(s) disengages with age of the offspring and as the lambs become more autonomous (Orgeur et al., 1999). The intervals between suckling increase with age, indicating that 13 week old lambs are more accustomed to a separation from the mother than younger lambs. Increased vocalization rates in lambs occur after a stressor such as separation (Torres-Hernandez and Hohenboken, 1979; Cockram et al., 1993). In this

study only a few days, clear signs of habituation occurred, and behaviour returns to preweaning levels, which is in agreement with results found by Orgeur et al. (1999) and Schichowski et al. (2008). Some behaviour patterns may have be influenced in a longer term as it was shown already for other species (Gauly et al., 2007) In this study lambs which were weaned at 13 weeks of age (group 3 and 4) had significant higher ADW until week 17 and 21 of age compared to lambs which were not weaned until this age (group 2). The availability of high-quality concentrates may have allowed earlier weaned lambs to compensate for the loss of maternal milk by increased feed intake, resulting in a greater total intake of energy. A punctuated loss in body weight due to social disturbance like mother-young separation was probably transient and unnoticed because of the relatively long-term weighing intervals (Dantzer and Mormède, 1983). These results may have been different under conditions with disadvantageous nutritional management and shorter weighing frequencies.

When weaned at the same time (at week 13 in group 3 and 4) infection did not influence ADW in lambs significantly. Thus, weaning seems to have a higher influence on the weight of the lambs compared to a parasite infection.

The animals were kept in a helminth free environment as it is proven by the fact that log FEC were 0 at an age of 13 and for all animals at all time from uninfected group 4. Lambs are in general more susceptible to *H. contortus* than adult sheep (Benitez-Usher et al., 1977). The development of immunity is influenced by many factors as sex (Gauly et al., 2006), age, dietary protein content (Abott et al., 1988; Bown et al., 1991) and age at weaning (Spedding et al., 1963). In the present study, lambs that were infected and weaned at the same time (week 13) had the highest log FEC values at 17 weeks of age. Weaning and the absence of the milk of the ewe is a factor affecting the development of parasite resistance in lambs (Spedding et al., 1963). Milk is a significant source of nutrients and important for growth and immunologically active factors. Watson and Gill (1991) showed that suckling lambs developed earlier and higher serum antibody responses to parasite antigens of *H. contortus* than weaned lambs. In a comparative study of weaned and unweaned lambs infected with 5000 *H. contortus* larvae from eight weeks of age, by 12 weeks of age, the weaned group had twice the mean faecal egg count of the unweaned group, indicating that they had lower resistance to the parasites (Watson and Gill, 1991). A similar result was found in the present study when groups 2 and 3 are

compared. Furthermore, lambs that were weaned at the time of infection had also in tendency higher log FEC, when compared with lambs that are weaned earlier, at the age of six weeks, and infected at the age of 13 weeks. This indicates that weaning around infection has an effect on the grade of infection. This effect can still be seen after 6 weeks.

The normal range of haematocrit for sheep is between 0.29 and 0.40 l/l. In the present study the determined values lie within the limits, except one for group 1 at the age of 17 weeks (0.28 0.01 l/l). At the age of 17 weeks, lambs that were not infected (group 4) had significant ($p < 0.05$) higher HCT in comparison to the infected lambs in group 1, 2, and 3. The value seems to normalise after a few weeks, so that no significant differences ($p > 0.05$) in HCT could be found at week 21.

Haemonchosis can lead to anaemia. An adult worm consumes between 0.003 ml and 0.05 ml blood per day (Dargie and Allbony, 1975), so an animal which is infected with only 2000 worms loses in the worst case 5 – 7 % of its blood volume (Dargie, 1980), which may explain the minor effects.

5. Conclusions

This study shows that weaning and infection with a gastrointestinal parasite can have a stressing implication for Merino lambs. The effect however is depending on age at weaning and infection time. Differences between the groups that were exposed to different terms and conditions (see above) can be verified, but the impact on animal welfare is probably slight.

Acknowledgement

The authors thank Prof. Dr. G. Erhardt for making the study at the Research Station Oberer Hardthof, University of Giessen possible.

References

Abbott, E.M., Parkins, J.J., and Holmes, P.H., 1988. Influence of dietary protein on the pathophysiology of haemonchosis in lambs given continuous infections. Research in Veterinary Science 45, 41-49.

Alexander, G., 1977. Role of auditory and visual cues in mutual recognition between ewes and lambs in merino sheep. Appl. Anim. Ethol. 3, 65-81.

Benitez-Usher C., Armour J., Duncan, J.L., Urquhart G.M., and Gettinby, G., 1977. A study of some factors influencing the immunization of sheep against *Haemonchus contortus* using attenuated larvae. Veterinary Parasitology 3, 327-342.

Bown, M.D., Poppi, D.P., and Sykes, A.R., 1991. The effect of post-ruminal infusion of protein or energy on the pathophysiology of *Trichostrongylus colubriformis* infection and bodycomposition in lambs. Australian Journal for Agricultural Research 42, 253-267.

Broom, D.M., 2005. Behaviour and welfare in relation to pathology. Applied Animal Behaviour Science 97, 73-83.

Cockram, M.S., Imlah, P., Goddard, P.J., Harkiss, G.D., and Waran, N.K., 1993. The behavioural, endocrine and leucocyte response of ewes to repeated removal of lambs before the age of natural weaning. Appl. Anim. Behav. Sci. 38, 127-142.

Coop, R.L., Graham, R.B., Jackson, F., Wright, S.E., and Angus, K.W., 1985. Effect of experimental *Ostertagia circumcincta* infection on the performance of grazing lambs. Research in Veterinary Science 38, 282-287.

Dantzer, R. and Mormède, P., 1983. Stress in farm animals: A need for reevaluation. J. Anim. Sci. 57, 6-18.

Dargie, J.D. and Allonby E.W., 1975. Pathophysiology of single and challenge infections of *Haemonchus contortus* in Merino sheep: Studies on red cell kinetics and the “self-cure” phenomenon. International Journal for Parasitology 5, 2, 147-157.

Dargie, J.D., 1980. The pathogenesis of *Schistosoma bovis* infection in sudanese cattle. Transactions of the Royal Society Tropical Medicine and Hygiene 74, 560-562.

Demeler, J., 2005. The physiological site of action and the site of resistance to the macrocyclic lactone anthelmintics in sheep parasitic trichostrongyloid nematodes. Diss., TiHo Hannover, Germany.

Gauly, M., Kraus, M., Vervelde, L., van Leeuwen, M.A.W., and Gerhardt, G., 2002. Estimating genetic differences in natural resistance in Rhön and Merinoland sheep following experimental *Haemonchus contortus* infection. Veterinary Parasitology 105, 55-67.

Gauly, M., Schackert M., and Erhardt G., 2006. Influence of gender on the resistance of sheep lambs to an experimental *Haemonchus contortus* infection. Dtsch. Tierärztl. Wschr., 113, 178-181.

Gauly, M., Duss C., and Erhardt G., 2007. Influence of *Ascaridia galli* infections and anthelmintic treatments on the behaviour and social ranks of laying hens (*Gallus gallus domesticus*). Vet. Parasitol., 146, 271-280.

Kuhn, C.M., Pauk, J., and Schanberg, S.M., 1990. Endocrine responses to mother-infant separation in developing rats. Dev. Psychobiol. 23, 395-410.

Orgeur, P., Bernard, S., Naciri, M., Nowak, R., Schaal, B., and Lévy, F., 1999. Psychobiological consequences of two different weaning methods in sheep. Reprod. Nutr. Dev. 39, 231-244.

Schichowsk,i C., Moors, E., and Gauly, M., 2008. Effects of weaning lambs in two stages or by abrupt separation on their behavior and growth rate. J. Anim. Sci., 86, 220-225.

Spedding, C.R.W., Brown, T.H., and Large, R.V., 1963. The effect of milk intake on nematode infestation of the lamb. Proceedings of the Nutrition Society 22, 32-41.

Torres-Hernandez, G. and Hohenboken, W., 1979. Genetic and environmental effects on milk production, milk composition and mastitis incidence in crossbred ewes. J. Anim. Sci. 49, 410-417.

Veissier, I., and Le Neindre, P., 1988. Cortisol responses to physical and pharmacological stimuli in heifers. Reprod. Nutr. Dev. 28, 553-562.

Waller, P.J., Chandrawathani, P., 2005. *Haemonchus contortus*: Parasite problem No. 1 from Tropics - Polar Circle. Problems and prospects for control based on epidemiology. Trop. Biomed. 22, 131-137.

Watson, D.L. and Gill, H.S., 1991. The effect of weaning on antibody responses and nematode parasitism in Merino lambs. Research in Veterinary Science 51, 128-132.6.

6. Diskussion

In der vorliegenden Arbeit wurden die Einflüsse des mütterlichen Verhaltens, des Absetzalters, der Absetzmethode und einer Endoparasiteninfektion sowie ihre Interaktionen auf Sterblichkeit, Gesundheit, Vitalität, Gewichtsentwicklung und somit auf die Produktionsleistung der Lämmer untersucht.

6.1 Muttereigenschaften

Das mütterliche Verhalten der Schafe hat eine große Auswirkung auf das Überleben der Lämmer und ihre Wachstumsraten (DALTON ET AL., 1980; HINCH ET AL., 1983; LINDSAY ET AL., 1990; GAMA ET AL., 1991; YAPI ET AL., 1992; FOGARTY ET AL., 2000).
Die durchschnittliche Sterblichkeitsrate in der vorliegenden Untersuchung entspricht der Lämmersterblichkeit unter praktischen Bedingungen (KRITAS ET AL., 2006). Es konnte festgestellt werden, dass die Schafrasse einen signifikanten Einfluss auf die Sterblichkeit der Lämmer hat. Mutterschafe mit hohen Mütterlichkeitsnoten im Verhaltenstest verloren die wenigsten Lämmer. Dies konnte auch in früheren Studien festgestellt werden (DALTON ET AL., 1980; HINCH ET AL., 1983). Geburtsgewicht und tägliche Zunahmen der Lämmer zeigten signifikante Unterschiede zwischen den Rassen. Es konnte festgestellt werden, dass die meisten untersuchten Mutterschafe große Unruhe während der Trennung von ihren Lämmern zeigen. Die Schafe wurden indirekt darauf selektiert, lange Trennungen von ihrem Nachwuchs zu vermeiden und somit deren Überleben zu sichern.
Neben den tatsächlichen mütterlichen Eigenschaften einer Schafrasse spielen auch das Temperament und die individuelle Ängstlichkeit eines Mutterschafs eine wichtige Rolle bei der Ausprägung des mütterlichen Verhaltens (LE NEIDRE ET AL., 1998). Das Temperament der Mutterschafe beeinflusst die individuelle Qualität der mütterlichen Fürsorge. Ursprüngliche Schafrassen, wie z.B. die Graue Gehörnte Heidschnucke, die einer weniger starken Züchtung unterlagen, scheinen durchschnittlich bessere Mutterschafe zu sein (SHILLITO-WALSER ET AL., 1984), was auch in unserer Untersuchung bestätigt werden konnte.
Lautäußerungen sind von großer Bedeutung für die Entwicklung einer intensiven Mutterschaf-Lamm-Bindung, die sehr entscheidend für das Überleben der Lämmer ist. Mutterschaf und Lämmer bleiben mit Hilfe der Rufe in Kontakt und antworten sich gegenseitig (SHILLITO-WALSER ET AL., 1982). Die Frequenz und Intensität der

Lautäußerungen der Mutterschafe und Lämmer sind abhängig von der Schafrasse und scheinen der jeweiligen Domestikation zu entsprechen.
Die Lautäußerungen der Mutterschafe spiegeln die Muttereigenschaften wider, was sich auch in den Sterblichkeitsraten der Lämmer zeigt.
Das Verhalten und die Lautäußerungen der Mutterschafe während der Trennung von den Lämmern sind vom Alter und damit der Erfahrung der Schafe abhängig. Sowohl die Lautäußerungen als auch die gezeigte Unruhe steigen mit dem Alter der Mutterschafe. In Untersuchungen von POINDRON ET AL. (1984) und O'CONNOR ET AL. (1985, 1992) ist ebenfalls festgestellt worden, dass eine gesteigerte Erfahrung der Mutterschafe in der Aufzucht von Lämmern eine Verbesserung der Muttereigenschaften bedingt.
Das mütterliche Verhalten beeinflusst das Überleben und das Absetzgewicht der Lämmer (O'CONNOR ET AL. 1985, 1996).
Eine gesteigerte Selektion auf Produktionsmerkmale in der Schafzucht sollte nicht mit einer Abnahme im Ausdruck des mütterlichen Verhaltens einhergehen, da dies zu einer geringeren Mutterschaf-Lamm-Bindung und damit zu höheren Lämmersterblichkeiten, verringerter Lämmervitalität und -gesundheit und geringerer Gewichtsentwicklung führt.

6.2 Absetzen

Durch das Absetzen kommt es zu deutlichen temporären Verhaltensstörungen für alle Lämmer, unabhängig von Rasse, Absetzalter und Absetzverfahren. Nach ein paar Tagen kann jedoch eine Gewöhnung an die veränderte Situation beobachtet werden und das Verhalten normalisiert sich wieder, was auch durch die Untersuchung von ORGEUR ET AL. (1998) bestätigt wird.
Je früher der Absetzzeitpunkt gewählt wird, desto größer ist die Beeinträchtigung der Lämmer, da jüngere Tiere noch eine festere Bindung zum Mutterschaf haben. Die Verbindung zwischen Mutterschaf und Lamm löst sich mit dem Alter des Nachwuchses. Die Intervalle zwischen dem Säugen werden größer und die Lämmer werden mit der Zeit immer selbstständiger und benötigen das Mutterschaf immer weniger zur Sicherung der Nahrungsaufnahme und zum Schutz vor Gefahren.
Lautäußerungen sind als Konsequenz einer stressauslösenden Situation wie z.B. der Trennung vom Mutterschaf zu beobachten (TORRES-HERNANDEZ & HOHENBOKEN, 1979; COCKRAM ET AL., 1993). Lämmer, die früh abgesetzt werden, zeigen bei der Trennung

vom Mutterschaf starke Unruhe, Lautäußerungen hoher Frequenz und Intensität, Umherlaufen im Stall und Suchen nach dem Muttertier. Um den Stress für die Lämmer zu verringern, sollte das Absetzalter so hoch wie möglich für den Schafbetrieb gewählt werden.
Lämmer, die mit Hilfe eines Zwei-Stufen-Verfahrens abgesetzt werden, zeigen beim Absetzen geringere Unruhe und weniger Lautäußerungen, als Lämmer die traditionell, durch abrupte Trennung, abgesetzt werden. Im Fall des Zwei-Stufen-Verfahrens müssen sich die Lämmer mit nur einem Stressor auseinandersetzen, zunächst mit der Entwöhnung von der Muttermilch mit Hilfe des Euterschutzes und anschließend mit der Trennung vom Mutterschaf. Beim traditionellen Absetzverfahren kommen beide Ereignisse zeitlich zusammen, was zu einem höheren Stresslevel bei den Lämmern führt, gezeigt durch gesteigerte Unruhe und Lautäußerungen hoher Frequenz und Intensität.

Die Belastung der Lämmer kann durch ein höheres Absetzalter und ein zweistufiges Absetzverfahren verringert werden. Da das Anbringen des Euterschutzes sehr zeitaufwändig ist, scheint es für größere Betriebe nicht praktikabel zu sein, könnte seine Anwendung jedoch bei kleineren Schafherden und bei Milchschafbetrieben finden.

6.3 Absetzen und Parasitenresistenz

Die Untersuchung des Verhaltens der Lämmer beim Absetzen, ausgedrückt durch Unruhe und Lautäußerung, zeigt, dass das Absetzen großen Stress für alle Lämmer bedeutet. Abhängig ist der durch das Absetzen erfahrene Stress von Absetzalter, Vitalität, Gesundheitszustand und Gewicht der Lämmer.
Unruhe und Lautäußerung nehmen nach dem Absetzen beständig ab und pendeln sich spätestens sechs Tage nach dem Absetzen auf einem normalen Niveau wie vor dem Absetzen ein (Orgeur et al., 1998).
Die Infektion mit dem Magen-Darm-Parasiten *Haemonchus contortus* ist im Gegensatz zum Absetzen nicht verbunden mit Unruhe und Lautäußerung bei den Lämmern.
Lämmer sind im Allgemeinen anfälliger für eine Infektion mit *Haemonchus contortus* als erwachsene Schafe (Benitez-Usher et al., 1977) und der durch das Absetzen erfahrene Stress verstärkt diese Anfälligkeit weiter.
Die Entwicklung einer Immunität wird beeinflusst durch Geschlecht, Alter, Fütterung

(ABOTT ET AL., 1988; BOWN ET AL., 1991) und Absetzalter (SPEDDING ET AL., 1963) und ist von großer Bedeutung für die Gesunderhaltung der Tiere.

In der vorliegenden Untersuchung haben das Absetzverfahren und das Absetzalter keinen signifikanten Einfluss auf die Infektion mit *Haemonchus contortus*. Die Gewichtsentwicklung der Lämmer wird durch die Parasiteninfektion nicht beeinträchtigt. Der Hämatokrit der Lämmer fällt nicht unter den normalen, physiologischen Bereich von 0,29 und 0,40. Die Infektion führt also nicht zu einer Anämie. Die untersuchten Lämmer der Lehr- und Forschungsstation Oberer Hardthof der Justus-Liebig-Universität Giessen zeigen eine Toleranz gegenüber der künstlichen Parasiteninfektion, so dass diese zu keiner Beeinträchtigung führt.

Der stressauslösende Einfluss von Absetzen und Parasiteninfektion ist abhängig von Absetzalter, Zeitpunkt der Infektion, Fütterung, Anwesenheit weiterer Stressoren, Gesundheitszustand, Vitalität und Gewicht. Der Gesundheitszustand eines Tieres steht in direkter Verbindung mit der Gefahr zu erkranken (BROOM, 2005). Gute Haltungsbedingungen können die Lämmer vor Krankheiten bewahren (SACHSER, 2001; LUTGENDORF, 2001).

7. Zusammenfassung

Für jeden Schafbetrieb ist die Aufzucht gesunder, widerstandsfähiger Lämmer mit guter Gewichtsentwicklung das wichtigste Ziel. Grundlage dafür ist eine gute, natürliche Aufzucht durch die Mutterschafe, ein schonendes Absetzverfahren und eine mögliche Parasitenresistenz bzw. -toleranz, um Leistungseinbußen zu verhindern.

7.1 Muttereigenschaften

Fünf verschiedene deutsche Schafrassen, Merino Landschaf, Deutsches Schwarzköpfiges Fleischschaf, Weißes Deutsches Bergschaf, Rhönschaf und Graue Gehörnte Heidschnucke, wurden bezüglich ihrer Muttereigenschaften verglichen, um mögliche rassebedingte Unterschiede aufzuzeigen. Am Tag nach der Geburt wurden die Lämmer zur Identifikation, zum Wiegen und zur Nabeldesinfektion für ca. zehn Minuten vom Mutterschaf getrennt. In dieser Zeit wurde das Verhalten des Mutterschafes beobachtet und mit Hilfe eines Bewertungssystems aufgezeichnet. Es wurden für jedes Mutterschaf drei Noten vergeben, für das Verhalten während der Trennung, für die Lautäußerungen während der Trennung und das Verhalten nach der Trennung. Weiterhin wurde untersucht, ob die Mütterlichkeit einen Einfluss auf die Gewichtsentwicklung und damit auf die Produktivität der Lämmer hat.

Lämmersterblichkeit, Geburtsgewicht und tägliche Zunahmen der Lämmer wurden signifikant von der Schafrasse, dem Alter der Mutterschafe sowie dem Geschlecht der Lämmer und dem Geburtstyp beeinflusst.

Die Rasse und das Alter der Mutterschafe hatten einen signifikanten Einfluss auf das Verhalten und die Lautäußerungen der Mutterschafe während der Trennung.

Die Untersuchung konnte zeigen, dass mütterliches Verhalten eine Auswirkung auf die Gewichtsentwicklung der Lämmer hat. Je besser die Mütterlichkeit war, desto höher waren Geburtsgewicht und tägliche Zunahmen. Weiterhin war auch die Lämmersterblichkeit abhängig vom Verhalten der Mutterschafe bezüglich ihrer Lämmer.

Um die Anzahl der aufgezogenen Lämmer zu erhöhen und die Lämmerproduktivität zu steigern, ist es von großer Bedeutung, dass die Mutterschafe ein deutlich ausgeprägtes, natürliches Mutterverhalten zeigen, um eine gute Versorgung der Lämmer zu gewährleisten.

7.2 Absetzen

Da sich Stress negativ auf Wachstum, Entwicklung, Wohlbefinden und Gesundheit von Lämmern auswirkt, wurde der Einfluss von Schafrasse, Absetzalter und Absetzverfahren auf den durch das Absetzen erfahrenen Stress untersucht. Es wurden Lämmer der Rassen Merino Landschaf und Rhönschaf miteinander verglichen. Das Absetzen wurde im Alter von acht bzw. 16 Wochen vorgenommen. Zwei unterschiedliche Absetzmethoden, das abrupte Absetzen mit sofortiger Trennung vom Mutterschaf und das Zwei-Phasen-Absetzen mit vorherigem Entwöhnen der Lämmer vor der Trennung, wurden miteinander verglichen. Das Verhalten der Lämmer wurde vor, während und nach der Trennung aufgenommen. Zusätzlich wurde die Gewichtsentwicklung der Lämmer dokumentiert und Blutproben für jedes Tier entnommen.

Absetzmethode und Absetzalter hatten einen signifikanten Einfluss auf Unruhe und Lautäußerungen der Lämmer während der Trennung von den Mutterschafen. Die Rasse zeigte nur bezüglich der Lautäußerungen signifikante Unterschiede.

Die täglichen Gewichtszunahmen der Lämmer wurden signifikant von der Schafrasse beeinflusst, jedoch nicht durch Absetzalter und Absetzmethode.

Der durch das Absetzen erfahrene Stress kann mit Hilfe eines höheren Absetzalters und einer Zwei-Phasen-Absetzmethode verringert werden, was einen positiven Effekt auf Vitalität und Entwicklung der Lämmer hat. Der Einfluss auf die Gewichtsentwicklung der Lämmer kann durch hochwertige Fütterung minimiert bzw. ausgeglichen werden.

7.3 Absetzen und Parasitenresistenz

Vier Gruppen mit jeweils 20 Lämmern der Rasse Merino Landschaf, die sich in Absetzalter und Infektion mit *Haemonchus contortus* unterschieden, wurden bezüglich ihres Verhaltens vor, während und nach dem Eingriff untersucht, um die Auswirkungen einer Endoparasiteninfektion und des Absetzens auf die Lämmer bewerten zu können. Zusätzlich zu den Verhaltensbeobachtungen wurde für jedes Tier in regelmäßigen Abständen das Gewicht aufgezeichnet, sowie Blut- und Kotproben entnommen, um einen Einfluss auf Gesundheit und Wohlbefinden dokumentieren zu können.

Die Ergebnisse zeigen, dass das Absetzen und vor allem das Absetzalter verantwortlich sind für den erfahrenen Stress, den die Lämmer durch Unruhe und

gesteigerte Lautäußerungen zeigen, was wiederum zu verringertem Wachstum und schlechterem Gesundheitszustand führt. Dies sollte berücksichtigt werden, um die Lämmerproduktivität zu steigern. Das Absetzen, das Absetzalter, Gewicht und Gesundheitszustand der Lämmer haben einen großen Einfluss auf den Grad der Infektion mit *Haemonchus contortus*. Die Untersuchung zeigte jedoch auch, dass Lämmer mit hoher Vitalität, gutem Gesundheitszustand und ausreichend, hochwertigem Futterangebot eine künstliche Infektion mit *Haemonchus contortus* ohne Einbußen der Gesundheit kompensieren können.

8. Summary

The breeding of healthy, resistant lambs with good weight gain is most important for shepherds. Basis for this is a good, natural breeding by the ewe, a gentle weaning method and a potential parasite resistance respectively parasite tolerance to avoid losings of benefit.

8.1 Maternal Behaviour

Five different german sheep breed, German Merino, German Black Head Mutton, German White Mountain Sheep, Rhoensheep and German Grey Heath, were compared concerning their maternal behaviour to point out differences. On the day after birth the lambs were separated for about 10 minutes for identification, weighing and navel desinfection. In this period of time the behaviour of each ewe was observed and recorded by utilisation of a rating system. Three scores were given for each ewe for behaviour during separation, vocalisation during separation and behaviour after separation. The influence of maternal behaviour on weight gain and productivity of the lambs was analysed.

Lamb mortality, birth weight and daily weight gain are significantly influenced by breed and age of the ewe as well as by sex and birth type of the lambs.

Breed and age of the ewe has a significant influence on agitation and vocalisation during separation. The study shows that the behaviour of the ewe has a consequence on the weight gain of the lambs. Lamb mortality depends on the maternal behaviour.

To increase the number of fostered lambs and enhance lamb productivity it is of great importance that the ewes show distinctive natural maternal behaviour to guarantee best supply for the lambs.

8.2 Weaning

Given that stress has a negative effect on weight gain, growth, well being and health of lambs, the influence of breed, weaning age and weaning method on the through weaning experienced stress was examined. Lambs of the breed German Merino and Rhoensheep were compared. Weaning was carried out at the age of eight or 16 weeks. Furthermore two different weaning procedures, the abrupt weaning with direct separation of mother and young and the two-step-weaning with preventing the lambs

from nursing before the separation, were compared. Behaviour of the lambs was recorded before, during and after weaning. In addition weight gain of the lambs was documented and blood samples of each lamb were taken.
Weaning method had a significant influence on agitation and vocalisation of the lambs during separation from the ewes. The scores for agitation and vocalisation were significant higher for abrupt weaned lambs in comparison to the lambs weaned in the two-stage-procedure independent of the breed.
The examination of weaning age of the lambs showed a significant influence on agitation and vocalisation. Breed showed significant differences concerning vocalisation. Weaning age and weaning procedure in contrast to breed had no significant effect on daily weight gain.
The distress experienced through weaning could be reduced with help of higher weaning age and gentle weaning methods, which has a positive effect on vitality and productivity of the lambs. However corresponding deficits could be minimised or compensated through high quality feeding.

8.3 Weaning and parasite resistance

Four groups of 20 lambs of the breed German Merino differing in weaning age and infection with *Haemonchus contortus* were observed concerning their behaviour before, during and after the intervention to evaluate the effect of weaning distress and endoparasite infection on the lambs. Additionally to the behavioural observations weight was recorded and blood and faeces samples were taken in regular intervals for every lamb to determine possible effects on health.
The results show that weaning and especially weaning age is responsible for the experienced stress shown through agitation and vocalisation leading to reduced growth and worse health condition. This should be considered to increase lamb productivity. Weaning, weaning age, existence of another stressor, health and condition of the lambs have a great influence on the grade of infection with *Haemonchus contortus*. The study shows as well that lambs of high vitality, good health condition and adequate, high quality feeding can cope with an artificial infection with 5000 larvae of *Haemonchus contortus* without losing of health.

9. Literaturverzeichnis

ABBOTT, E.M.; PARKINS, J.J. & HOLMES, P.H. (1988): Influence of dietary protein on the pathophysiology of haemonchosis in lambs given continuous infections. Research in Veterinary Science 45: 41-49.

ALBERS, G.A.A.; GRAY, G.D.; PIPER, L.R.; BARKER, J.S.F., LE JAMBRE, L.F. & BARGER, I.A. (1987): The genetics of resistance and resilience to *Haemonchus contortus* infection in young Merino sheep. International Journal of Parasitology 17: 1355-1363.

ALEXANDER, G. (1958): Behaviour of newly born lambs In: HULET, C.V.; ALEXANDER, G. & HAFEZ, E.S.E. (1975): The behaviour of domestic sheep In: HAFEZ, E.S.E. (1975): The behaviour of domestic animals 3. Auflage, London, Baillière Tindall.

ALEXANDER, G. (1977): Role of auditory and visual cues in mutual recognition between ewes and lambs in merino sheep. Applied Animal Ethology 3: 65-81.

ALEXANDER, G. (1988): What makes a good mother? Components and comparative aspects of maternal behaviour in ungulates. Australian Society of Animal Production 17: 25-41.

ALEXANDER, G.; STEVENS, D.; BRADLEY, B. & BARWICK, S.A. (1990): Maternal Behaviour in Border Leicester, Glen Vale and Merino sheep. Australian Journal of Experimental Agriculture 30: 27-38.

BAKER, R.L.; MWAMACHI, D.M.; AUDHO, J.O.; ADUDA, E.O. & THORPE, W. (1999): Genetic resistance to gastro-intestinal nematode parasites in Red Massai, Dorper and Red Massai x Dorper ewes in the sub-humid tropics. Animal Science 69: 335-344.

BARGER, I.A. (1988): Resistance of young lambs to *Haemonchus contortus* infection and its loss following anthelmintic treatment. International Journal of Parasitology 18: 1107-1109.

BENITEZ-USHER C.; ARMOUR J.; DUNCAN, J.L.; URQUHART G.M. & GETTINBY, G. (1977): A study of some factors influencing the immunization of sheep against *Haemonchus contortus* using attenuated larvae. Veterinary Parasitology 3: 327-342.

BERIAJAYA & COPEMAN, D.B. (2006): *Haemonchus contortus* and *Trichostrongylus colubriformis* in pen-trials with Javanese thin tail sheep and Kacang cross Etawah goats. Veterinary Parasitology 135: 315-323.

BICKHARDT, K. & KÖNIG, G. (1985): Blutmesswerte von gesunden Mutterschafen der Merino- und Schwarzkopfrasse zur Zeit der Geburt (Referenzwerte). Deutsche Tierärztliche Wochenschrift 92: 319-322.

BISHOP, S.C. & STEAR, M.J. (1999b): Selecting sheep for resistance to gastrointestinal nematode parasites. Annual Meeting of the European Association for Animal Production (EAAP), Zürich, Switzerland, Session S4.2: Genetic resistance to disease and parasites.

BISHOP, S.C. & STEAR, M.J. (2001): Inheritance of faecal egg counts during early lactation in Scottish Blackface ewes facing mixed, natural nematode infections. Animal Science 73: 389-395.

BISSET, S.A.; VLASSOFF, A.; DOUCH, P.G.C.; JONAS, W.E.; WEST, C.J. & GREEN, R.S. (1996): Nematode burdens and immunological responses following natural challenge in Romney lambs selectively bred for low or high faecal worm egg count. Veterinary Parasitology 61: 249-263.

BOSTEDT, H. & DEDIÉ, K. (1996): Schaf- und Ziegenkrankheiten. Verlag Eugen Ulmer, Stuttgart, 2. Auflage.

BOUILHOL, M. & MAGE, C. (2001): Parasitism in organic sheep farming. Vortrag anlässlich des 5th NAHWOA Workshop, 11.-13.11.2001. Rødding, Dänemark.

BOUIX, J.; KRUPINSKI, J.; RZEPECKI, R.; NOWOSAD, B.; SKRZYZALA, I.; ROBORZYNSKI, M.; FUDALEWICZ-NIEMCZYK, W.; SKALSKA, M.; MALCZEWSKI, A. & GRUNER, L. (1998): Genetic resistance to gastrointestinal nematode parasites in Polish long-wool sheep. International Journal for Parasitology 28: 1797-1804.

BOWN, M.D.; POPPI, D.P. & SYKES, A.R. (1991): The effect of post-ruminal infusion of protein or energy on the pathophysiology of *Trichostrongylus colubriformis* infection and bodycomposition in lambs. Australian Journal for Agricultural Research 42: 253-267.

BROOM, D.M. (2005): Behaviour and welfare in relation to pathology. Applied Animal Behaviour Science 97: 73-83.

BÜRGER, H.-J. (1992): Parasitosen der Wiederkäuer – Helminthen. In: ECKERT,J.; KUTZER, E.; ROMMEL, M.; BÜRGER, H.-J. & KÖRTING, W.: Veterinärmedizinische Parasitologie. Paul Parey Verlag, Berlin und Hamburg, 4. Auflage.

BURFENING, P.J. & KRESS, D.D. (1993): Direct and maternal effects on birth and weaning weight in sheep. Small Ruminant Research 10: 153-163.

CAPPER, J.L.; WILKINSON, R.G.; MACKENZIE, A.M. & SINCLAIR L.A. (2006): Polyunsaturated Fatty Acid Supplementation during Pregnancy Alters Neonatal Behavior in Sheep. Nutrient Physiology, Metabolism, and Nutrient-Nutrient Interactions. American Society for Nutrition136: 397-403.

COCKRAM, M.S.; IMLAH, P.; GODDARD, P.J.; HARKISS, G.D. & WARAN, N.K. (1993): The behavioural, endocrine and leukocyte response of ewes to repeated removal of lambs before the age of natural weaning. Applied Animal Behaviour Science 38: 127-142.

COOP, R.L. & HOLMES, P.H. (1996): Nutrition and parasite interaction. International Journal for Parasitology 26: 951-962.

DALTON, D.C.; KNIGHT, T.W. & JOHNSON, D.L. (1980): Lamb survival in sheep breeds on New Zealand hill country. New Zealand Journal of Agricultural Research 23: 167-173.

DANTZER, R. & MORMÈDE, P. (1979) Le stress en élevage intensif. In : Actualités scientifiques et agronomiques de l' INRA. Masson, Paris, 119.

DEMELER, J.; SANGSTER, N.; GILL, J. & VON SAMSON, G. (2005): Site of resistance to the macrocyclic lactone anthelmintics in trichostrongyloids. Proceedings of the British Society for Parasitology, Nottingham.

DWYER, C.M. (2003): Behavioural development in the neonatal lamb: effect of maternal and birth-related factors. Theriogenology 59: 1027-1050.

DWYER, C.M. (2007): Genetic and physiological determinants of maternal behaviour and lamb survival: implications for low input sheep management. Journal of Animal Science.

DWYER, C.M. (2008): Individual Variation in the Expression of Maternal Behaviour: A Review of the Neuroendocrine Mechanisms in the Sheep. Journal of Neuroendocrinology 20: 526-534.

DWYER, C.M. & LAWRENCE, A.B. (1998): Variability in the expression of maternal behaviour in primiparous sheep: Effects of genotype and litter size. Applied Animal Behaviour Science. 58: 311-330.

DWYER, C.M. & LAWRENCE, A.B. (2000): Maternal behaviour in domestic sheep (*Ovis aries*): Constancy and change with maternal experience. Behaviour 137: 1391-1413.

DWYER, C.M.; LAWRENCE, A.B.; BISHOP, S.C. & LEWIS, M. (2003): Ewe-lamb bonding behaviour at birth is affected by maternal undernutrition in pregnancy. The British Journal of Nutrition 89: 123-136.

DWYER, C.M.; GILBERT, C.L. & LAWRENCE, A.B. (2004): Prepartum plasma estradiol and postpartum cortisol, but not oxytocin, are associated with interindividual and breed differences in the expression of maternal behaviour in sheep. Hormones and Behavior 46: 529-543.

EVERETT-HINCKS, J.M. & DODDS, K.G. (2007): Management of maternal-offspring behavior to improve lamb survival in easy care sheep systems. Journal of Animal Science.

EWBANK, R. (1967): Nursing and suckling behaviour amongst Clun Forest ewes and lambs. Animal Behaviour 15: 251-258.

FEINSTEIN, M.H. & THOMAS, E. (2003): Sheep may vocalize stress by altering timbre. Hampshire College.

FOGARTY, N.M.; HOPKINS, D.L. & VAN DE VEN, R. (2000): Lamb production from diverse genotypes. 1. Lamb growth and survival and ewe performance. Animal Science 70: 135-145.

GAMA, L.T.; DICKERSON, G.E.; YOUNG, L.D. & LEYMASTER, K.A. (1991): Effects of breed, heterosis, age of dam, litter size and birth weight on lamb mortality. Journal of Animal Science 69: 2727-2743.

GAULY, M. & ERHARDT, G: (2001): Genetic resistance to gastrointestinal nematode parasites in Rhön sheep following natural infection. Veterinary Parasitology 102: 253-259.

GAULY, M.; KRAUS, M.; VERVELDE, L.; VAN LEEUWEN, M.A. & ERHARDT, G. (2002): Estimating genetic differences in natural resistance in Rhön and Merinoland sheep

following experimental *Haemonchus contortus* infection. Veterinary Parasitology 106: 55-67.

GAULY, M.; SCHACKERT, M.; HOFFMANN, B. & ERHARDT, G. (2006): Influence of sex on the resistance of sheep lambs to an experimental *Haemonchus contortus* infection. Deutsche Tierärztliche Wochenschrift 113: 178-181.

GETACHEW, T.; DORCHIES, P. & JACQUIET, P. (2007). Trends and challenges in the effective and sustainable control of *Haemonchus contortus* infection in sheep. Parasite 14: 3-14.

GRAY, G.D. (1997): The use of genetically resistant sheep to control nematode parasitism. Veterinary Parasitology 72: 345-366.

GRAY, G.D.; BARGER, I.A.; LE JAMBRE, L.F. & DOUCH, P.G.C. (1992): Parasitological and immunological responses of genetically resistant Merino sheep on pastures contaminated with parasitic nematodes. International Journal for Parasitology 22: 417-425.

HALEY, D.B.; BAILEY, D.W. & STOOKEY, J.W. (2005): The effects of weaning beef calves in two stages on their behavior and growth rate. Journal of Animal Science 83: 2205-2214.

HIELSCHER, A.; BRANDT, H.; ERHARDT, G. & GAULY, M. (2006): Heterosis analysis of *Haemonchus contortus* resistance and production traits in Rhoen sheep, Merino Land sheep and crossbred lambs. Veterinary Parasitology 141: 279-284.

HINCH, G.N.; KELLY, R.W.; OWENS, J.L. & CROSBIE, S.F. (1983): Patterns of lamb survival in high fecundity Booroola flocks. New Zealand Society of Animal Production 43: 29-32.

HINCH, GN.; LYNCH, J.J.; ELWIN, R.L. & GREEN, G.C. (1990): Long-term associations between Merino ewes and their offspring. Applied Animal Behaviour Science 27: 93-103.

KENDRICK, K.M. & KEVERNE, E.B. (1991): Importance of progesterone and estrogen priming for the induction of maternal behavior by vaginocervical stimulation in sheep: effects of maternal experience. Physiology & Behavior 49: 745-750.

KRITAS, S.K.; GOVARIS, A.; CHRISTODOULOPOULOS, G. & BURRIEL, A.R. (2006): Effect of

Bacillus licheniformis and *Bacillus subtilis* supplementation of ewe's feed on sheep milk production and young lamb mortality. Journal of veterinary medicine. A: Physiology, pathology, clinical medicine 53: 170-173.

KUCHEL, R.C. & LINDSAY, D.R. (1999): Maternal behaviour and the survival of lambs in superfine wool sheep. Reproduction, Fertility and Development 11: 391-394.

KUHN, C.M.; PAUK, J. & SCHANBERG, S.M. (1990): Endocrine responses to mother-infant separation in developing rats. Developmental Psychobiology 23: 395-410.

LAMBE, N.R.; CONINGTON, J.; BISHOP, S.C.; WATERHOUSE, A. & SIMM, G. (2001): A genetic analysis of maternal behaviour score in Scottish Blackface sheep. Animal Science 72: 415-425.

LANE, S.F. & ALBRECHT, K.A. (1991): Growth and plasma metabolites of lambs weaned to legume pastures at 28 days of age. Journal of Animal Science 69: 305-317.

LENEINDRE, P.; MURPHY, P.M.; BOISSY, A.; PURVIS, I.W.; LINDSAY, D.; ORGEUR, P.; BOUIX, J. & BIBÉ, B. (1998): Genetics of maternal ability in cattle and sheep. In: Proceedings of the 6th World Congress on Genetic Livestock Production 27: 23-30.

LENT, P.C. (1974): Mother infant relationships in ungulates. In: Geist, V. & Walther, F. The Behaviour of Ungulates and its Relationship to Management. IUCN Publication No. 24, Morges, Switzerland: 14-55.

LÉVY, F.; LACATELLI, A.; PIKETTY, V.; TILLET, Y. & POINDRON, P. (1995): Involvement of the main but not the accessory olfactory system in maternal behaviour of primiparous and multiparous ewes. Physiology & Behavior 57, 97-104.

LÉVY, F. (2002): Neurobiological mechanisms involved in recognition of olfactory signature of the young in sheep. Journal de la Société de biologie 196: 77-83.

LINDSAY, D.R.; NOWAK, R.; PUTU, I.G. & MCNEILL, D. (1990): Behavioural interactions between the ewe and her young at parturition: a vital step for the lamb. In: Reproductive physiology of Merino sheep – concepts and consequences. Perth: University of Western Australia 191-205.

LÖER, A. (1998): Die Tiergerechtheit einer ganzjährigen Weidehaltung winterlammender Mutterschafe am Mittelgebirgsstandort. Dissertation Fachbereich Agrarwissenschaften, Universität Göttingen.

LUTGENDORF, S.K. (2001): Life, liberty and the pursuit of happiness: good welfare in humans. In: Broom, D.M.: Coping with Challenge: Welfare in Animals including Humans. Dahlem University Press, Berlin: 49-62.

MCCLURE, S.J. & EMERY, D.L. (2007): Trichostrongylus colubriformis and *Haemonchus contortus* infections in light bodyweight Merino lambs. Australian Veterinary Journal 85: 437-445.

MCKUSICK, B.C.; THOMAS, D.L. & BERGER, Y.M. (2001): Effect of Weaning System on Commercial Milk Production and Lamb Growth of Friesian Dairy Sheep. Journal of Dairy Science 84: 1660-1668.

MEURISSE, M; GONZALEZ, A.; DELSOL, G.; CABA, M.; LÉVY, F. & POINDRON, P. (2005): Estradiol receptor-α expression in hypothalamic and limbic regions of ewes is influenced by physiological state and maternal experience. Hormones and Behavior 48: 34-43.

MORRIS, C.A.; WATSON, T.G.; BISSET, S.A.; VLASSOFF, A. & DOUCH, P.G.C. (1995): Breeding sheep in New Zealand for resistance or resilience to nematode parasites. In: GRAY, G.D.; WOOLASTON, R.R. & EATON, B.T.: Breeding for resistance to infectious diseases in small ruminants. ACIAR, Canberra, Australien.

MUNRO, J. (1956): Observations on the suckling behaviour of young lambs. British Journal of Animal Behaviour 4: 34-36.

NAPOLITANO, F.; DE ROSA, G. & SEVI, A. (2008): Welfare implications of artificial rearing and early weaning in sheep. Applied Animal Behaviour Science 110: 58-72.

NEARY, M. (1992): Management of ewes and lambs at weaning. Purdue Sheep Day Proceeding.

NOWAK, R. (1996): Neonatal survival: contributions from behavioural studies in sheep. Applied Animal Behaviour Science 49: 61-72

NOWAK, R.; MURPHY, T.M.; LINDSAY, D.R.; ALSTER, P.; ANDERSSON, R. & UVNAS MOBERG, K. (1997): Development of a preferential relationship with the mother by the newborn lamb: importance of the sucking activity. Physiology & Behavior 62: 681-688.

NOWAK, R.; PORTER, R.H.; LEVY, F.; ORGEUR, P. & SCHAAL, B. (2000): Role of mother-

young interactions in the survival of offspring in domestic mammals. Reviews of Reproduction 5: 153-163.

NOWAK, R.; KELLER, M.; VAL-LAILLET, D. & LÉVY, F. (2007): Perinatal visceral events and brain mechanisms involved in the development of mother-young bonding in sheep. Hormones and Behaviour 52: 92-98.

O'CONNOR, C.E.; JAY, N.P.; NICOL, A.M. & BEATSON, P.R. (1985): Ewe maternal behaviour score and lamb survival. Proceedings of the New Zealand Society of Animal Production 45: 159-162.

O'CONNOR, C. E.; LAWRENCE, A. B. & WOOD-GUSH, D. G. M. (1992): Influence of litter size and parity on maternal behaviour at parturition in Scottish Blackface sheep. Applied Animal Behaviour Science 33: 351-355.

O'CONNOR, C.E. (1996): Ewe maternal behaviour score and lamb growth: 10 years on. Proceedings of the New Zealand Society of Animal Production 56: 107-109.

ORGEUR, P.; MAVRIC, N.; YVORE, S.; BERNARD, S.; NOWAK, R.; SCHAAL, B. & LEVY, F. (1998): Artificial weaning in sheep: consequences on behavioural, hormonal and immuno-pathological indicators of welfare. Applied Animal Behaviour Science 58: 87-103.

ORGEUR, P.; BERNARD, S.; NACIRI, M.; NOWAK, R.; SCHAAL, B. & LÉVY, F. (1999): Psychobiological consequences of two different weaning methods in sheep. Reproduction Nutrition Development 39: 231-244.

PETERS, H.F. & HEANEY, D.P. (1974): Factors influencing the growth of lambs reared artificially or with their dams. Can. Journal of Animal Science 54: 9-18.

POINDRON, P.; LENEIDRE, P.; RAKSANYI, I.; TRILLAT, G. & ORGEUR, P. (1980): Importance of the characteristics of the young in the manifestation and establishment of maternal behaviour in sheep. Reproduction Nutrition Development 20: 817-826.

POINDRON, P.; RAKSANYI, I.; ORGEUR, P. & LE NEIDRE, P. (1984): Maternal behaviour at lambing in primiparous and multiparous Romanov, Prealpes du Sud and Ile-de- France ewes. Genetics, Selection, Evolution, 16.4: 503-522.

POINDRON, P.; LÉVY, F. & KELLER, M. (2007): Maternal responsiveness and maternal selectivity in domestic sheep and goats: the two facets of maternal

attachment. Developmental Psychobiology 49: 54-70.

POLLOT, G.E.; KARLSSON, L.J.; EADY, S. & GREEFF, J.C. (2004): Genetic parameters for indicators of host resistance to parasites from weaning to hogget age in Merino sheep. Journal of Animal Science 82: 2852-2864.

PRYCE, C.R. (1992): A comparative systems model of the regulation of maternal motivation in mammals. Animal Behaviour 43: 417-441.

RENSING, S. (1985): Untersuchungen zur Merkmalsbeziehung zwischen Fruchtbarkeit und Vitalität beim Schaf. Dissertation Fachbereich Agrarwissenschaften, Universität Göttingen.

RIEDEL, E. (1993): Rund um die Lammzeit (2). Deutsche Schafzucht 8: 180-182.

ROMMEL, M.; ECKERT, J.; KUTZER, E.; KÖRTING, W. & SCHNIEDER, T. (2000): Veterinärmedizinische Parasitologie. Begr.: BOCH, J. & SUPPERER, R., Parey Verlag, Berlin, Deutschland, 5. Auflage.

SACHSER, N. (2001): What is important to achieve good welfare in animals? In: Broom, D.M. (Ed.), Coping with Challenge: Welfare in Animals including Humans. Dahlem University Press, Berlin: 31-48.

SCHLOLAUT & WACHENDÖRFER (1992): Handbuch Schafhaltung. DLG-Verlags-GmbH, Frankfurt am Main, Deutschland, 5. Auflage.

SCHNIEDER, T. (2000): Helminthosen der Wiederkäuer. In: ROMMEL, M.; ECKERT, J.; KUTZER, E.; KÖRTING, W. & SCHNIEDER, T.: Veterinärmedizinische Parasitologie, Parey, Berlin, Deutschland, 5. Auflage.

SEARBY, A. & JOUVENTIN, P. (2003): Mother-lamb acoustic recognition in sheep: a frequency coding. Proceeding of Biological Science 270: 1765-1771.

SHAYIT, M.; NOWAK, R.; KELLER, M. & WELLER, A. (2003): Establishment of a preference by the newborn lamb for its mother: The role of opioids. Behavioral Neuroscience 117: 446-454.

SHILLITO-WALSER, E.E.; WALTERS, E. & HAGUE, P. (1982): Vocal communication between ewes and their own and alien lambs. Behaviour 18: 140-151.

SHILLITO-WALSER, E.E.; WALTERS, E. & ELLISON, J. (1984): Observations on vocalization of ewes and lambs in the field. Behaviour 91: 190-203.

SINGER, D. (1998): Thermometry and calorimetry in the neonate: recent advances in

monitoring and research. Thermochim Acta 309: 39–47.

SMITH, F. V.; VAN-TOLLER, C. & BOYES, T. (1966): The 'critical period' in the attachment of lambs and ewes. Animal Behaviour 14: 120-125.

SPEDDING, C.R.W.; BROWN, T.H. & LARGE, R.V. (1963): The effect of milk intake on nematode infestation of the lamb. Proceedings of the Nutrition Society 22: 32-41.

SRÉTER, T.; KASSAI, T. & TAKÁS, E. (1994): The heritability and specificity of responsiveness to infection with *Haemonchus contortus* in sheep. International Journal for Parasitology 24: 871-876.

TORRES-HERNANDEZ, G. & HOHENBOKEN, W.D. (1979): An attempt to assess traits of emotionality in crossbred ewes. Applied Animal Ethology 5: 71-83.

VEISSIER, I. & LENEIDRE, P. (1989): Weaning in calves: its effect on social organization. Applied Animal Behaviour 24: 43-54.

WALSER, E.S. & ALEXANDER, G. (1980): Mutual recognition between ewes and lambs. Reproduction Nutrition Development 20: 807-816.

WHATELEY, J.; KILGOUR, R. & DALTON, D.C. (1974): Behaviour of hill country sheep during farming routines. New Zealand Society of Animal Production 34: 243-245.

WOLLNY, C. & FESSER, F. (1986): Gute Muttereigenschaften sind wichtig für die Aufzucht. Deutsche Schafzucht 3: 48-50.

WOOLASTON, R.R. (1992): Selection of Merino sheep for increased and decreased resistance to *Haemonchus contortus*: peri-parturient effects on faecal egg counts. International Journal for Parasitology 22: 947-953.

WOOLASTON, R.R. & EADY, S.J. (1995): Australian research on genetic resistance to nematode parasites. In: Breeding for resistance to infectious diseases in small ruminants. Hrsg.: GRAY, G.D.; WOOLASTON, R.R. & EATON, B.T.; ACIAR, Canberra, Australien.

WOOLASTON, R.R. & PIPER, L.R. (1996): Selection of Merino sheep for resistance to *Haemonchus contortus*: genetic variation. Animal Science 62: 451-460.

YAPI, C.V.; BOYLAN, W.J. & ROBINSON, R.A. (1992): Effect of genetic and environmental factors on lamb mortality. Journal of Agricultural Science 100: 539-551.

Danksagung

An dieser Stelle möchte ich mich bei all denen bedanken, die mich während der Jahre meiner Doktorarbeit begleitet und unterstützt haben.

Mein besonderer Dank gilt Herrn Prof. Dr. M. Gauly für die Überlassung des Themas sowie die Unterstützung und die freundliche Zusammenarbeit bei der Erstellung dieser Doktorarbeit.

Prof. Dr. G. Erhardt möchte ich danken, dass er die Untersuchungen auf der Lehr- und Forschungsstation Oberer Hardthof der Justus-Liebig-Universität Gießen ermöglicht und das zweite Gutachten übernommen hat.

Frau Dr. E. Moors danke ich herzlich für jegliche Hilfe und Unterstützung bezüglich meiner Doktorarbeit, vor allem bei der statistischen Auswertung der Ergebnisse.

Danken möchte ich außerdem Frau Dr. Uta von Borstel für die großartige Unterstützung bei der Veröffentlichung.

Mein Dank gilt den Mitarbeitern der Lehr- und Forschungsstation Oberer Hardthof für die gute und herzliche Zusammenarbeit, insbesondere den Schäfermeistern, Herrn G. Gasch und Herrn R. Zartner, für die hervorragende Betreuung des Schafbestandes, die wundervolle Zusammenarbeit und die Möglichkeit an ihrer langjährigen Erfahrung der Schafhaltung teilhaben zu können und dabei sehr viel zu lernen.

Ich widme diese Doktorarbeit meinem Sohn Jonas, meinem Lebensgefährten Florian Uhle, meiner Mutter Brigitte Schichowski und meiner Schwester Yvonne Schichowski und danke ihnen von ganzem Herzen für die uneingeschränkte Unterstützung und ihre Liebe.

Eidesstattliche Erklärung

Hiermit erkläre ich eidesstattlich, dass die vorgelegte Dissertation selbständig und ohne unerlaubte fremde Hilfe und nur mit den Hilfen, die ich in der Dissertation angegeben habe, angefertigt wurde. Alle Textstellen, die wörtlich oder sinngemäß aus veröffentlichten oder nicht veröffentlichten Schriften entnommen sind, und alle Angaben, die auf mündlichen Auskünften beruhen, sind als solche kenntlich gemacht.

Ich erkläre eidesstattlich, dass diese Arbeit weder in gleicher noch in ähnlicher Form bereits anderen Prüfungsbehörden vorgelegen hat.

Weiter erkläre ich, dass ich mich an keiner anderen Hochschule um einen Doktorgrad beworben habe.

Göttingen, den .....

.....
(Christina Schichowski)

Lebenslauf

Persönliche Daten

Name:	Christina Schichowski
Geburtsdaten:	21. April 1978 in Lahn-Gießen
Anschrift:	Crednerstraße 18 35392 Gießen
Telefon:	0641 / 87780323 0162 / 3060831
E-Mail:	christinaschichowski@web.de
Familienstand:	ledig
Kinder:	Jonas Darwin 12.01.2008
Staatsangehörigkeit:	deutsch

Schulbildung

1984 – 1988	Grundschule Wilhelm-Leuschner-Schule Heuchelheim
1988 – 1990	Förderstufe Wilhelm-Leuschner-Schule Heuchelheim
1990 – 1997	Gymnasium Herderschule Gießen
25.06.1997	Abschluss allgemeine Hochschulreife

Studium

WS 1997–WS 2003	Biologie Justus-Liebig-Universität in Gießen Studienschwerpunkte: Tierphysiologie, Zoologie, Ökologie Diplomarbeit: „Vergleichende Untersuchungen zum Sozialverhalten verschiedener Schafrassen“
19.12.2003	Abschluss: Diplom-Biologin (Note: 1,3)
seit WS 03/04	Promotionsstudium „Untersuchungen verschiedener Einflussfaktoren auf Gesundheit und Produktivität beim Schaf“ Institut für Tierzucht und Haustiergenetik Georg-August-Universität in Göttingen

Berufserfahrung

seit Juli 2004	wissenschaftliche Hilfskraft im Institut für Veterinär-Virologie, Justus-Liebig-Universität Gießen