Aus dem Department für Nutztierwissenschaften
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Untersuchungen zur Erfassung und Genetik von Verhaltensmerkmalen beim Schwein unter Praxisbedingungen

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1. Referent: Prof. Dr. Dr. Matthias Gauly

2. Korreferent: Dr. Lars Schrader

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Zusammenfassung

Durch das öffentliche und politische Interesse an der Tierhaltung und den daraus resultierenden Gesetzen werden sich die Haltungssysteme von Schweinen zukünftig ändern. Das Wohlbefinden der Tiere soll dadurch gesteigert werden. Dies kann z. B. durch die Gruppenhaltung der Tiere in verschiedenen Produktionsabschnitten erreicht werden. Neben den positiven Effekten für die Tiere führt das Halten von Schweinen in Gruppen aber zwangsläufig zu agonistischen Interaktionen innerhalb der Gruppe und damit zu Stress für die Tiere. Bei den wachsenden Bestandsgrößen ist ebenso eine gute Umgänglichkeit der Schweine wichtig, um Stress für Mensch und Tier beim Handling zu vermeiden. Die Zucht auf gruppentaugliche und umgängliche Schweine könnte dazu beitragen, die Probleme in diesen Bereichen zu reduzieren. Für eine Eingliederung von „Umgänglichkeit“ und „Aggressivität“ in Zuchtprogramme müssen zunächst Methoden gefunden werden, die zum Zielmerkmal korrelierte Merkmale erfassen, was bei einem vertretbaren Aufwand an einer großen Anzahl an Daten erfolgen kann. Außerdem müssen Zusammenhänge zu anderen ökonomisch wichtigen Zuchtmerkmalen analysiert und berücksichtigt werden.

Ziel dieser Arbeit war es, Verhaltenstests zu entwickeln und deren Eignung als Selektionskriterium in Zuchtprogrammen zu überprüfen. Auf die Durchführung der Verhaltenstests unter praxisnahen Bedingungen und die Umsetzbarkeit zur Erfassung einer großen Anzahl an Verhaltensbeobachtungen wurde dabei besonders beachtet.

Als erstes wurde der Einfluss des Haltungssystems auf das Verhalten der Tiere untersucht. Mit Hilfe von unterschiedlichen Verhaltenstest (Novel Object Test, Novel Arena Test, Wiegetest) sowie der Beurteilung der Anzahl und Schwere der Hautläsionen wurden 126 Mastschweine aus zwei unterschiedlich strukturierten Aufzuchtställen (10er Gruppen mit Trockenfutterautomaten vs. 30er Gruppen mit Trockenfutterautomaten und Breifutterautomaten) verglichen. Dadurch sollte aufgezeigt werden, in welchem Ausmaß das Verhalten der Tiere bereits durch kleine Veränderungen der Umwelt und der Gruppengröße beeinflusst wird. Während die Beobachtungen beim Novel Arena Test keine signifikanten Unterschiede aufwiesen, waren Schweine aus der angereicherten Umwelt deutlich aktiver z.B. beim Verhalten

auf der Waage ($p < 0,0001$) und hatten auch weniger Hautläsionen ($p = 0,0074$) als die Tiere aus den 10er Gruppen (Kapitel 3).

Des Weiteren wurde die Eignung von Hautläsionen als Indikator für individuelle Aggressivität überprüft. Dabei wurden Zusammenhänge zwischen dem agonistischen Verhalten beim Zusammenstallen von Sauen und deren Anzahl an Hautläsionen 10 Wochen nach der Gruppierung untersucht. Die Ergebnisse zeigten keinen Zusammenhang zwischen Anzahl der Initiierung von agonistischen Interaktionen bei der Gruppierung und der Anzahl an Hautläsionen beim Ausstallen aus der Gruppenhaltung ($p > 0,1$). Aber die häufiger attackierten Sauen hatten signifikant mehr Hautläsionen ($p = 0,0435$). Daher scheinen Anzahl und Schwere von Hautläsionen nicht als Merkmal für individuelle Aggressivität beim Schwein geeignet zu sein. Die aggressiveren Sauen hatten die besseren Fruchtbarkeitsleistungen (z.B. Häufigkeit der Initiierung von agonistischen Interaktionen vs. gesamt geborene Ferkel: $r_p = 0,20$) und umgekehrt hatten die Sauen mit vielen Hautverletzungen schlechtere Fruchtbarkeitsleistungen (Score für Hautläsionen vorderes Körperdrittel vs. gesamt geborene Ferkel: $r_p = –0,28$). Hier zeigte sich eine ungünstige Beziehung zwischen Aggressivität und Fruchtbarkeit (Kapitel 4).

Im Weiteren wurden Zusammenhänge zwischen Backtest, Wiegeverhalten, Hautläsionen sowie Tageszunahmen analysiert. Dafür wurden sowohl genetische Parameter geschätzt als auch phänotypische Korrelationen berechnet. Verhaltensbeobachtungen von 976 Mastschweinen wurden über einen Zeitraum von der Geburt bis zum Schlachten der Tiere erfasst. Die geschätzten Heritabilitäten der Verhaltensmerkmale lagen in den meisten Fällen in einem züchterisch nutzbaren Bereich (z.B. Backtest 2: $h^2 = 0,36 \pm 0,08$; Verhalten von Schlachtschweinen auf der Waage: $h^2 = 0,20 \pm 0,07$). Die Ergebnisse zeigten aber, dass nur zwischen dem Backtest 1 und Backtest 2 ($r_p = 0,30$; $r_g = 0,84 \pm 0,11$) sowie zwischen Backtest 2 und dem Verhalten von Läufern auf der Waage ein Zusammenhang besteht ($r_p = 0,13$; $r_g = 0,57 \pm 0,21$). Aufgrund der vergleichsweise geringen Korrelationen zum Wiegenverhalten sowie den fehlenden Korrelationen zu weiteren Verhaltensmerkmalen, aber auch durch den hohen Zeit- und Arbeitsaufwand für die Durchführung, erscheint der Backtest insgesamt als Selektionsmerkmal ungeeignet. Weitere Zusammenhänge zwischen den verschiedenen Verhaltensmerkmalen konnten basierend auf den genetischen und phänotypischen Korrelationen nicht festgestellt werden. Die Tiere reagieren in den verschiedenen Situationen unterschiedlich, sodass kaum eine Konsistenz/Konstanz im Verhalten der Schweine bei unterschiedlichen Verhaltenstests beobachtet werden konnte. (Kapitel 5).

Anhand der vorliegenden Ergebnisse, u.a. der Heritabilitäten, bleibt festzuhalten, dass die Integration von Verhaltensmerkmalen in Zuchtprogramme insgesamt möglich ist. Der erste wichtige Schritt ist die Auswahl eines Merkmals das in direkter Beziehung zu den Zielmerkmalen, Umgänglichkeit oder aggressiven Verhalten, steht. Sowohl der Backtest als auch die Hautläsionen sind nicht mit aggressiven Verhalten oder nur geringfügig mit Umgänglichkeit verbunden und sind somit nicht als Indikatormerkmale für eine Zucht auf Verhalten beim Schwein geeignet. Andere Merkmale, die z.B. beim Wiegetest oder bei der direkten Beobachtung des agonistischen Verhaltens erfasst werden, scheinen besser geeignet zu sein. Die positiven Korrelationen von Aggressivität zu Tageszunahmen und Fruchtbarkeit zeigen aber, dass ungünstige Beziehungen zwischen diesen ökonomisch wichtigen Merkmalen und ruhigem, friedlichem Verhalten bestehen.

Summary

Public and political concern for livestock increases and due to new laws housing systems of pigs will change in the future. It is desired to increase well-being of animals, for example, by group housing of pigs at the different stages. However, beside the positive effects for animal welfare group housing of animals also leads to agonistic interactions within the group resulting in stress. Furthermore, due to structural changes herd sizes increase and the handleability of pigs gains importance under these conditions to reduce levels of stress at handling for stockmen and animals. The breeding of less-aggressive and calm pigs might be a solution for these problems. The selection for handleability and aggressiveness in breeding programmes requires methods for recording traits related to handleability and aggressiveness under commercial farm conditions to collect large sample sizes. Furthermore, associations with other relevant traits have to be investigated.

The aim of the present study was the development of behaviour tests and checking the ability of these tests for use in breeding programmes. Especially the feasibility of the tests under commercial conditions for recording large sample sizes was tested.

First of all, the environment effect of housing was investigated. Therefore, the behaviour of 126 rearing pigs housed in different rearing housing systems (10 pigs per pen, dry feeder vs. 30 pigs per pen, dry feeder and wet dry feeder) were compared using different behaviour tests (novel arena test, novel object test, weighing behaviour) as well as skin lesions to show effects of marginal environmental enrichment on behaviour. Behaviour patterns in the novel arena test were not different between pigs reared in the different environments, but the enriched housed pigs showed significantly more activity, for example, on the scale ($p < 0.0001$) and less skin lesions ($p = 0,0074$) compared to barren housed animals (chapter 3).

The use of skin lesions as an indicator for individual aggressiveness was investigated. Therefore, associations among agonistic behaviour of sows post mixing and skin lesions recorded 10 weeks post mixing were analysed. Our results showed that there was no association between the frequency of being aggressor of agonistic interactions post mixing and skin lesions ($p > 0.1$). However, sows being receivers of agonistic interactions had more skin lesions ($p = 0.0435$). Number and severity of skin lesions seem not to be useful as an indicator for individual aggressiveness.

Furthermore, more aggressive sows had better reproductive performances (e.g. being aggressor of agonistic interaction vs. total born piglets: r_p = 0.20) and sows with higher scores for skin lesions had reduced reproductive performances (skin lesion scores front vs. total born piglets: r_p = –0.28). An unfavourable association between aggressive behaviour and reproduction is shown (chapter 4).

Finally, associations among backtest, weighing behaviour, skin lesions, and daily gains were analysed. Therefore, genetic parameters were estimated as well as phenotypic correlations were calculated. Behaviour observations from birth to slaughtering of 976 fattening pigs were recorded. The estimated heritabilities were in the most cases useful for breeding purposes (e.g. backtest 2: h^2 = 0.36 ± 0.08; finishing pig scale score: h^2 = 0.20 ± 0.07). However, associations were only found between backtest 1 and backtest 2 (r_p = 0.30; r_g = 0.84 ± 0.11) and between backtest 2 and rearing pigs scale score (r_p = 0.13; r_g = 0.57 ± 0.21). Due to comparably weak associations towards weighing behaviour, the lack of further associations towards other behaviour traits as well as the high labour and time input for the procedure, the backtest seems not to be useful for breeding issues. There were also no further relationships between the other behaviour traits based on the overall low genetic and phenotypic correlations. The individual reaction of animals appears to be strongly affected by the situation (test) and there was little consistency across contexts in behaviour of pigs.

Regarding the results of the present study (e.g. heritabilities), the integration of behaviour traits into breeding programmes is overall possible. First of all, the selection of behaviour traits related to aggressiveness or handleability is important. Backtest as well as skin lesions are not related to aggressiveness or only marginally to handleability and therefore are not useful as indicators for breeding calm and less-aggressive pigs. For example, weighing behaviour or direct observations of agonistic interactions seem to be more appropriate. However, positive correlations among aggressions and weight gain as well as reproductive performance show unfavourable associations towards economically important traits.

KAPITEL 1

Allgemeine Einleitung

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Zuchtprogramme beim Schwein berücksichtigen vor allem ökonomisch wichtige Merkmale wie z.B. Wurfgröße, Wachstum oder Muskelfleischanteil. In diesen Merkmalen konnte in den letzten Jahrzehnten beachtliche Leistungssteigerungen erzielt werden. Beispielsweise ist die Anzahl lebend geborener Ferkel bei Deutsche Landrasse Sauen von 1990 bis 2010 um 6,6 lebend geborene Ferkel gestiegen (ZDS, 1991, 2011). In der Selektion unberücksichtigt blieben aber funktionale Merkmale wie z.B. das Verhalten oder die Fitness der Tiere. Durch Veränderungen in der Schweineproduktion werden sich vor allem die Haltungssysteme in den nächsten Jahren deutlich wandeln. Die Ursachen dieser Veränderungen sind vielfältig. Zunächst beeinflussen sowohl gesellschaftliche als auch politische Rahmenbedingungen die Produktion von Schweinefleisch. Das Interesse des Verbrauchers an der Tierproduktion ist gestiegen und Forderungen nach Verbesserungen des Tierwohls und des Tierschutzes im gesamten Produktionsablauf werden gestellt (Arey and Edwards, 1998; McGlone, 2001; Brown et al., 2009). Gleichzeitig sind in Gesetzen und Richtlinien bereits Forderungen formuliert. Beispielsweise wird in der EU-Richtlinie 2008/120/EG die Gruppenhaltung von tragenden Sauen ab dem 01.01.2013 vorgeschrieben. Aber auch durch das Wachstum der ökologischen Landwirtschaft steigt die Bedeutung von gruppentauglichen Schweinen, da hier die Gruppenhaltung von Sauen bereits vorgeschrieben ist (VO (EG) 889/2008) und auch ferkelführende Sauen in Gruppen gehalten werden. Weitere Veränderungen sind auf den Strukturwandel in der Landwirtschaft zurückzuführen. Die Anzahl der schweinehaltenden Betriebe ist rückläufig, die Tierbestände der verbleibenden Betriebe wachsen dafür aber deutlich (Statistisches Bundesamt, 2012). Die größeren Bestände führen dazu, dass von einem Tierhalter mehr Tiere versorgt werden müssen und die Haltungstechnik dementsprechend weiterentwickelt wird. Es werden z.B. Gruppen von bis zu 400 Schweinen in Ställen mit automatischer Fütterung und Sortierung gehalten (Hoy, 2005). Insgesamt führt dies zu einer abnehmenden Gewöhnung der Tiere an den Menschen (Le Neindre et al., 1996).

Durch diese Veränderungen der Haltungssysteme gewinnt sowohl das Verhalten der Tiere gegenüber Artgenossen als auch das Verhalten der Tiere gegenüber dem Menschen an Bedeutung. Vermehrter Stress hervorgerufen durch agonistische

Interaktionen oder Handlingmaßnahmen beeinflusst das Tierwohl und führt zu reduzierten Leistungen der Tiere (Varley and Stedman, 1994; Kongsted, 2004; von Borell et al., 2007).

Die Reaktion eines Tieres in bestimmten Situationen wird teilweise von genetischen Faktoren bestimmt (z.B. Grandinson, 2005; Løvendahl et al., 2005; Turner et al., 2009; Velie et al., 2009). In bisherigen Zuchtprogrammen war die Berücksichtigung von Verhaltensmerkmalen aufgrund der bis dato gebräuchlichen Haltungssysteme nicht zwingend notwendig. Aber durch die oben beschriebenen Veränderungen werden Verhaltenscharakteristika in Zukunft an Bedeutung gewinnen. Um diese Charakteristika in Zuchtprogrammen zu integrieren, ist zunächst eine praxistaugliche, standardisierte Erfassung dieser Merkmale notwendig. Für die unterschiedlichen Verhaltenstests werden im folgenden Text die englischen Begriffe verwendet, wenn dies zu einem besseren Verständnis beiträgt.

Häufig genutzte Methoden zur Erfassung von Verhaltensmerkmalen sind, neben der direkten Beobachtung des Verhaltens der Tiere, der Backtest (z.B. Hessing et al., 1993; van Erp-van der Kooij et al., 2000; Cassady, 2007), der Wiegetest (z.B. Holl et al., 2010; Yoder et al., 2011) sowie die Hautläsionen als Indikatoren für agonistische Interaktionen (z.B. Turner et al., 2006; Stukenborg et al., 2011). Hessing et al. (1993) zeigten individuelle Verhaltensunterschiede bei Ferkeln anhand des Backtests und in einem sozialen Konfrontationstest mit mehreren Ferkeln. Auch Turner et al. (2006) konnten individuelle Unterschiede feststellen, indem die Anzahl der Hautläsionen und Verletzungen als Indikator für Aggressionen beurteilt wurden. Für dieses Merkmal konnten Erblichkeiten von $h^2 = 0.22$ geschätzt werden (Turner et al., 2006). Die Heritabilität für das Verhalten beim Wiegen war $h^2 = 0.23$ (Holl et al., 2010). Insgesamt zeigen die Ergebnisse früherer Studien, dass individuelle Verhaltensunterschiede feststellbar sind (z.B. Hessing et al., 1993; D'Eath, 2002; Turner et al., 2006) und diese Merkmale niedrige bis moderate Erblichkeiten aufweisen (z.B. Turner et al., 2006; D'Eath et al., 2009; Holl et al., 2010). Die Integration von Verhaltensmerkmalen in Zuchtprogramme ist demzufolge möglich. Besonders die Hautläsionen sind ein einfach und schnell zu erfassendes Merkmal für Aggressivität. Diese kommen daher als Zielmerkmal in Frage, um Zusammenhänge zwischen den angewandten Verhaltenstests und Aggressivität herzustellen. Insbesondere die Korrelationen zwischen Aggressivität und Backtest sind von Bedeutung, da der Backtest üblicherweise in den ersten Lebenswochen durchgeführt wird. Folglich wären schon sehr früh Informationen zu den einzelnen Tieren vorhanden, die für eine Selektion genutzt werden könnten.

In der vorliegenden Arbeit sollte überprüft werden, inwieweit die Integration von Verhaltenscharakteristika (Aggressivität und Umgänglichkeit) in Zuchtprogramme beim Schwein möglich ist. Dazu müssen zuerst praxistaugliche und standardisierte Verhaltenstests oder Indikatoren für Verhalten entwickelt und die Zusammenhänge der erfassten Parameter zu Aggressivität und Umgänglichkeit überprüft werden. Anschließend müssen auch die Korrelationen zu anderen Zuchtzielen (z.B. Tageszunahmen, Wurfgröße) analysiert werden. Daher sind eine Reihe von unterschiedlichen Verhaltenstests (z.B. Novel Object Test, Wiegetest) sowie Indikatoren für Verhalten (Backtest, Hautläsionen) in den Arbeitsablauf eines Betriebes integriert worden. Aber auch das agonistische Verhalten der Tiere beim Zusammenstallen wurde beobachtet. In einem ersten Versuch wurde aber zunächst ermittelt, welchen Einfluss das Haltungssystem auf das Verhalten in bestimmten Testsituationen hat (Kapitel 3). Anschließend wurden Zusammenhänge zwischen agonistischen Verhalten beim Zusammenstallen von Sauen und deren Anzahl an Hautläsionen 10 Wochen nach der Gruppierung untersucht sowie die Korrelationen zur Fruchtbarkeitsleistungen überprüft (Kapitel 4). Abschließend wurden genetische Parameter für Backtest, Wiegeverhalten, Hautläsionen und Tageszunahmen geschätzt sowie phänotypische Korrelationen zwischen den Merkmalen berechnet, um deren Zusammenhänge untereinander zu klären (Kapitel 5). In der abschließenden Diskussion werden die Möglichkeiten und Probleme bei einer Integration der untersuchten Merkmale in Zuchtprogramme beim Schwein diskutiert (Kapitel 6).

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KAPITEL 2

Literaturübersicht

2.1 Schweineproduktion in Deutschland

Deutschland ist mit ca. 27,7 Millionen gehaltenen Schweinen, der größte Schweineerzeuger innerhalb der EU. Während der Schweinebestand in Deutschland seit Jahren wächst, sinkt die Betriebsanzahl kontinuierlich (Abb.1). Folglich stieg die Anzahl gehaltener Schweine auf durchschnittlich 921 Schweine pro Betrieb im Jahr 2012 an. Dieser Strukturwandel setzt sich weiter fort (Statistisches Bundesamt, 2012). Vor allem im Bereich der Zuchtsauen wird aufgrund der sich ändernden gesetzlichen Anforderungen (tragende Sauen müssen ab dem 01.01.2013 in Gruppen gehalten werden (2008/120/EG)) der Strukturwandel forciert. Viele Betriebe werden die notwendigen Investitionen nicht tätigen und aus der Produktion ausscheiden. Die abnehmende Zahl an Sauen zur Ferkelerzeugung führt aber gleichzeitig auch dazu, dass die Nachfrage der Mäster nach großen, einheitlichen Ferkelpartien nur noch durch Exporte, vor allem aus den Niederlanden und Dänemark, gedeckt werden kann (Hortmann-Scholten, 2010).

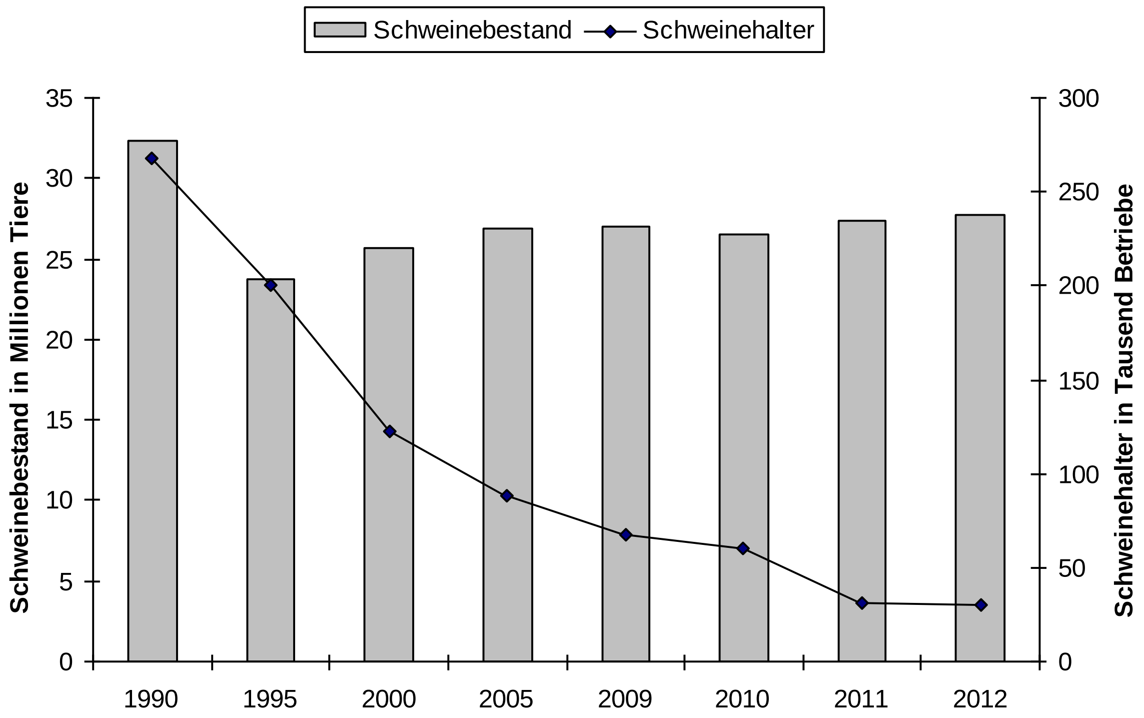

Abbildung 1. Entwicklung der Schweineproduktion in Deutschland von 1990 bis 2012 (ab 2010 nur noch Betriebe mit mindestens 50 Mastschweinen oder 10 Zuchtsauen) (Statistisches Bundesamt, 2012).

Außerdem lässt sich innerhalb Deutschlands eine starke regionale Konzentration der Produktion erkennen. In den Bundesländern Nordrhein-Westfalen und Niedersachsen werden über die Hälfte des gesamten deutschen Schweinebestandes gehalten (Statistische Ämter des Bundes und der Länder, 2011). Die im Zeitraum von 1995 bis 2011 gewachsene Produktion von Schweinefleisch hat aber auch dazu geführt, dass der Selbstversorgungsgrad in Deutschland von 77 % auf 115 % angestiegen ist (ZMP, 1995; AMI, 2012). Ein erheblicher Teil der Produktion muss auf dem Weltmarkt verkauft werden. Deshalb müssen die Landwirte mit größeren Preisschwankungen rechnen. Zusätzlich führt die starke Konzentration der Schlacht- und Verarbeitungsbetriebe dazu, dass die Erzeuger, trotz wachsender Bestandsgrößen, wenig Einfluss auf die Preisbildung ausüben können (Holst und von Cramon-Taubadel, 2011).

Neben den strukturellen Entwicklungen hat auch das gewachsene Interesse der Gesellschaft und Politik am Wohlbefinden von landwirtschaftlichen Nutztieren einen Einfluss auf die künftige Entwicklung der Schweineproduktion. In den letzten Jahren sind entsprechend in der Tierschutz-Nutztierhaltungsverordnung (letzte Änderung durch BGBL Nr. 66 am 01.10.2009) neue, weitergehende Anforderungen an die Haltung vorgeschrieben worden. Im Schweinebereich hat vor allem die Diskussion über den Verzicht auf das betäubungslose Kastrieren von männlichen Ferkeln und deren Alternativen zu weiteren Druck auf politische Entscheidungsträger geführt. Das Land Niedersachsen arbeitet gegenwärtig unter Einbeziehung aller maßgeblich Beteiligten an einem Tierschutzplan zur Umsetzung von Verbesserungspotentialen im Tierschutz. Die Umsetzung soll bis zum Jahr 2018 erfolgt sein.

2.1.1 Haltungsverfahren

In der Verordnung zum „Schutz landwirtschaftlicher Nutztiere und anderer zur Erzeugung tierischer Produkte gehaltener Tiere bei ihrer Haltung“ (Tierschutz-Nutztierhaltungsverordnung) werden Anforderungen für die Haltung von Nutztieren formuliert. Abschnitt 5 dieser Verordnung enthält besondere Anforderungen für Schweinehalter. In der Tabelle 1 sind die Punkte zusammengefasst, die für die Gruppenhaltung besonders relevant sind.

Tabelle 1. Wesentliche Anforderungen an die Gruppenhaltung von Schweinen (Tierschutz-Nutztierhaltungsverordnung).

Kennzeichen	**Altersklasse**	**Anforderungen**
Gruppenhaltung	Absatzferkel	Gesamte Zeitraum, Umgruppierungen vermeiden Min. 5 kg Durchschnittsgewicht und max. 20 % Abweichung vom Durchschnittsgewicht bei Neugruppierung Uneingeschränkt nutzbare Bodenfläche: Von 5 bis 10 kg Durchschnittsgewicht: 0,15 m² je Tier Über 10 bis 20 kg Durchschnittsgewicht: 0,2 m² je Tie Über 20 kg Durchschnittsgewicht: 0,35 m² je Tier Rationierte Fütterung ein Fressplatz pro Tier Tagesrationierte Fütterung ein Fressplatz für zwei Tiere Ad libitum Fütterung ein Fressplatz für vier Tiere Max. 12 Tiere pro Selbsttränke
	Zuchtläufer Mastschweine	Gesamte Zeitraum, Umgruppierungen vermeiden Uneingeschränkt nutzbare Bodenfläche: Von 30 bis 50 kg Durchschnittsgewicht: 0,5 m² je Tier Über 50 bis 110 kg Durchschnittsgewicht: 0,75 m² je Tie Über 110 kg Durchschnittsgewicht: 1,0 m² je Tier Min. 50 % der Fläche muss Liegebereich sein
	Sauen Jungsauen	Im Zeitraum von vier Wochen nach Decken bis eine Woche vor dem voraussichtlichen Abferkeltermin (ab 01.01.2013) Kranke, verletzte Tiere sowie Tiere von Betrieben mit weniger als 10 Sauen müssen nicht in Gruppen gehalten werden Uneingeschränkt nutzbare Bodenfläche: Bis 5 Tiere pro Gruppe: 1,85 m² je Jungsau; 2,5 je Sau 6 bis 39 Tiere pro Gruppe: 1,65 m² je Jungsau; 2,25 je Sau Ab 40 Tiere pro Gruppe: 1,5 m² je Jungsau; 2,05 je Sau Davon min. 0,95 m² je Jungsau und 1,3 m² je Sau Liegefläche
	Alle	Nicht gruppentaugliche Tiere dürfen einzeln gehalten werden Von Futterstelle räumlich getrennte zusätzliche Tränken
Beschäftigungs-material	Alle	Gesundheitlich unbedenkliches, bewegliches und veränderbares Material in ausreichender Menge

Wie aus der Tabelle 1 deutlich wird, ist eine Einzelhaltung von Schweinen zukünftig nur noch im Deckzentrum und im Abferkelbereich erlaubt sowie für kranke oder gruppenunverträgliche Tiere. Ausnahmen sind nur noch für sehr kleine Betriebe möglich. Ein weiterer wichtiger Aspekt für die Gruppenhaltung ist die ausreichende

Bereitstellung von Beschäftigungsmaterial, damit sich die Tiere nicht ständig mit ihren Gruppenpartner auseinandersetzen aus Mangel an anderen Beschäftigungsmöglichkeiten (Kelly et al., 2000, Scott et al.; 2006).

Die Gruppenhaltung von Sauen ist aber auch sowohl im Deckzentrum als auch im Abferkelbereich möglich. In einigen Betrieben werden die Sauen im Deckzentrum in Gruppen mit Selbstfangfressständen gehalten. Wobei sich die Gruppenhaltung hier besonders negativ auf die Fruchtbarkeitsleistung der Sauen auswirken kann, da die Einnistung der befruchteten Eizellen in die Gebärmutterschleimhaut im Zeitraum vom 10. Tag bis 24. Tag nach der Besamung stattfindet. Agonistische Interaktionen während dieser Zeit führen daher zu vermehrten Verlusten von Föten und die Zahl an umrauschenden Sauen steigt im Vergleich zur Einzelhaltung der Sauen (Hoy et al.; 2006; Spoolder et al., 2009). Im Abferkelbereich gestaltet sich eine Umstellung auf Gruppenhaltung schwieriger. In konventionellen Abferkelbuchten wird die Bewegungsfreiheit der Sau durch den Ferkelschutzkorb stark eingeschränkt, da sonst vor allem in den ersten Tagen nach der Geburt der Ferkel vermehrte Erdrückungsverluste vorkommen (Kunz und Ernst, 1987; Marchant et al., 2000; Andersen et al., 2005). Dieses Verfahren könnte sich in den nächsten Jahren deutlich ändern und die Fixierung der Sau während der gesamten Säugezeit könnte verboten werden (Baxter et al., 2011). In den nach EU-Öko-Richtlinien wirtschaftenden Betrieben darf die Sau bereits nicht mehr fixiert werden (VO (EG) 889/2008). Der nächste Schritt wäre dann auch hier die Gruppenhaltung von ferkelführenden Sauen, die ebenfalls in einigen ökologisch-wirtschaftenden Betrieben schon praktiziert wird.

Die Gruppenhaltung hat viele Vorteile für die argerechte Haltung der Tiere, die gekennzeichnet ist durch Bewegungsfreiheit und ausgeprägtes Sozialverhalten. Andererseits ergeben sich auch betriebswirtschaftliche Vorteile. Automatische Fütterungssysteme können effizient genutzt werden und der Platzbedarf für Ställe sinkt bei zunehmender Gruppengröße (Hoy, 2005). Dies trägt dazu bei, dass die Bestandgrößen deutlich wachsen können. Insgesamt bleibt aber auch festzuhalten, dass die Anforderungen an das Management sowohl durch die zunehmende Gruppenhaltung als auch durch die wachsenden Tierzahlen deutlich steigen.

2.2 Funktionale Merkmale

Funktionale Merkmale haben keinen direkten quantitativen Einfluss auf das eigentliche Produkt (z.B. Wachstum, Milchleistung), sondern führen vor allem zu Kosteneinsparungen auf der Input-Seite der Produktion. Außerdem können diese Merkmale zu einer besseren Vermarktbarkeit der Produkte beitragen (Groen et al., 1997). Swalve (2003) definiert funktionale Merkmale als nur indirekt mit der Produktion zusammenhängende, kosteneinsparende Merkmale. Insgesamt kommt diesen Merkmalen eine zunehmende wirtschaftliche Bedeutung zu. Wichtige Komplexe sind die Gesundheit, die Vitalität und das Verhalten der Tiere. So werden beispielsweise bei Rindern der Rasse Deutsche Holsteins funktionale Nutzungsdauer, Eutergesundheit (Somatische Zellzahl) und Kalbeeigenschaften mit einer Gewichtung von jeweils 20 %, 7 % sowie 3 % im Zuchtprogramm deutlich berücksichtigt (Deutscher Holstein Verband, 2012). Auch in der Schweinezucht werden mittlerweile Merkmale wie Muttereigenschaften als Zuchtziele ausgegeben (Grandinson et al., 2003). Die Veränderungen in den Haltungssystemen für Schweine bewirken außerdem, dass auch die Exterieurmerkmale an Bedeutung gewinnen. Entsprechend der oben genannten Definition zählt das Temperament zu den funktionellen Merkmalen und wirkt sich nur indirekt auf die Produktion aus. Ruhige und friedliche Schweine führen zu weniger agonistischen Interaktionen innerhalb der Gruppe und zu weniger Stress bei Handlingmaßnahmen. Beides wirkt sich positiv auf die Leistungen der Tiere aus, aber auch für den Tierbetreuer wird die tägliche Arbeit erleichtert (Forkman et al., 2007).

2.2.1 Temperament

Das Temperament beschreibt die Aktion/Reaktion eines Individuums (Verhalten) in einer bestimmten Situation (Bates, 1986). Dementsprechend wird Temperament in den Nutztierwissenschaften als Verhaltensantwort des Tieres auf den Umgang durch den Menschen beschrieben (Fordyce et al., 1988; Grandin, 1993a). Kilgour (1975) definiert das Temperament als physische, hormonelle und nervale Konstitution eines Individuums, durch die ein bestimmtes Verhalten hervorgerufen wird. Das Verhalten der Tiere variiert von ruhig und friedlich bis zu ängstlich und aggressiv und kann sich in Nervosität, Fluchtversuchen, Vermeidungsreaktionen sowie Aggressionen äußern (Burrow, 1997; Burrow und Dillon, 1997).

2.2.2 Aggressive Verhaltensweisen

Die Rangordnung innerhalb einer Gruppe wird bei Schweinen durch Kämpfe gebildet. Diese soziale Ordnung ist notwendig, damit innerhalb der Gruppe nicht ständig neue Auseinandersetzungen um Futter oder Partner ausgetragen werden müssen (Arey und Edwards, 1998; D'Eath und Turner, 2009; von Borell, 2009). Dementsprechend erfolgen Rangkämpfe nach dem Zusammenstallen von untereinander unbekannten Tieren (Meese und Ewbank, 1973; Arey und Edwards, 1998). Im gegenwärtigen Produktionsablauf der konventionellen Schweineerzeugung wird die Neugruppierung von Schweinen durchaus häufiger praktiziert. Die Anzahl und Intensität von agonistischen Interaktionen kann reduziert, aber nicht vollständig unterbunden werden. Wobei vor allem die agonistischen Interaktionen nach der Ausbildung einer Rangordnung interessant sind, da diese zu ständiger Unruhe und Stress innerhalb der Gruppe führen (Simmins, 1993; Hoy, 2009; Spoolder et al., 2009). Neben der individuellen Aggressivität der Tiere spielt hier die Umwelt eine große Rolle, viele Faktoren, wie z. B. Gruppengröße oder Platzangebot, beeinflussen das Auftreten von agonistischen Interaktionen (Arey und Edwards, 1998).

2.3 Erfassung von Verhaltensmerkmalen

Das Verhalten von Schweinen wurde bisher mit Hilfe einer Reihe von unterschiedlichen Verfahren und Indikatoren erfasst. In Tabelle 2 wird ein kurzer Überblick über verschiedene Verhaltenstests und Indikatoren gegeben. Dabei spielen sowohl Verhaltenstests eine Rolle, die einen stark experimentellen Charakter aufweisen und dementsprechend sehr aufwendig sind, als auch Tests die sich einfach in den täglichen Arbeitsablauf integrieren lassen. Die Verfahren sind in Erfassung von Temperament oder Umgänglichkeit, agonistischen Verhalten sowie Indikatoren aufgeteilt. Die große Anzahl an unterschiedlichen Verhaltenstests sowie die Variationen in der Durchführung und Dauer der Tests führt aber zu einer fehlenden Standardisierung bei der Erfassung von Verhaltensmerkmalen (Forkman et al., 2007).

Tabelle 2. Verhaltenstests und Indikatoren.

Kategorie	Test	Erfassung	Alter	Dauer	Literaturangabe
Temperament/Umgänglichkeit	Novel Arena/Environment Test	Reaktion des Tieres auf eine unbekannte Umgebung (z.B. Dauer von Verhaltensweisen wie Erkunden, Stehen usw.)	35 d 70 d/168 d	10 min 10 min	De Jong et al., 2000 Ruis et al., 2000
	Novel Object Test	Reaktion des Tieres auf einen unbekannten Gegenstand (z.B. Dauer bis zum ersten Kontakt, Anzahl der Kontakte)	30-49 d/70-84 d Mastschweine 161 d	5 min 2 h 3 min	Van Erp-van de Kooij et al., 2002 Bracke und Spoolder, 2008 Brown et al., 2009
	Open Door Test	Dauer bis ein Tier seinen Stall bei offener Tür verlässt	30-49 d/70-84 d 161 d	5 min 3 min	Van Erp-van de Kooij et al., 2002 Brown et al., 2009
	Human Approach Test	Reaktion des Tieres auf eine (fremde) Person (z.B. Dauer bis zum ersten Kontakt, Anzahl der Kontakte)	70 d/98 d 147 d 161 d	5 min 5 min 3 min	Hemsworth et al. ,1996 Velie et al., 2009 Brown et al., 2009
	Wiegetest	Verhalten des Tieres beim Treiben auf die Waage und in der Waage (z.B. Aktivität)	154 d 185 d	–	Holl et al., 2010 Yoder et al., 2011
Agonistisches Verhalten	Beobachtungen beim Gruppieren	Agonistische Interaktionen zwischen den Tieren (z.B. Dauer oder Anzahl der Verwicklung in Kämpfe)	Sauen 30 d Sauen	1 h 3 h 48 h	Mount und Seabrook, 1993 Bolhuis et al., 2005 Borberg und Hoy, 2009
	Resident Intruder Test	Zu einem in gewohnter Umgebung gehaltenen Tier (Resident) wird ein fremder Artgenosse (Intruder) gesetzt. Gemessen wird (Dauer bis zum ersten Angriff des Residents auf Intruder)	49 d/77 d 49 d 31-51 d/38-60 d	3,5 min 5 min 3 min	Erhard und Mendl ,1997 D'Eath, 2002 Velie et al., 2009
Indikatoren	Hautläsionen	Beurteilung der Anzahl und Schwere von Hautläsionen	80 d 56 d 28 d/68 d	–	Turner et al., 2006a, 2006b Brown et al., 2009 Stukenborg et al., 2011
	Backtest	Tiere werden auf den Rücken gedreht und anschließend deren Reaktion erfasst (z.B. Anzahl der Befreiungsversuche, Dauer der Befreiungsversuche)	1-21 d 3 d/10 d/17 d 6-10 d/13-17 d 7-14 d/14-21 d	1 min 1 min 1 min 1 min	Heesing et al., 1993 Van Erp-van de Kooij et al., 2002 Cassady, 2007 Velie et al., 2009

Häufig werden die Verhaltensweisen der Tiere in den Testverfahren mit Hilfe eines Notensystems eingeteilt. Beispielsweise bedeutet Score 1, dass ein Tier in der Testsituation ruhig ist, während der Score 3 ein sehr unruhiges, aufgeregtes Tier beschreibt. Dabei muss aber beachtet werden, dass die Vergabe eines Verhaltensscores durch den Beurteiler beeinflusst werden kann. In bisherigen Untersuchungen wurde aber auch gezeigt, dass die von verschiedenen Personen vergebenen Scores stark miteinander korrelieren (z.B. Waiblinger et al., 2007; Brown et al., 2009; Clouard et al., 2011).

Ein weiteres Problem bei der Beurteilung des Verhaltens anhand eines Bewertungssystems ist, dass die Daten häufig nicht einer Normalverteilung entsprechen und nicht kontinuierlich verteilt sind (Bennewitz, 2010). Eine statistische Auswertung dieser Daten und deren Nutzung in Zuchtprogrammen erweist sich deshalb als schwierig. Daher sind besonders Verhaltenstests von Bedeutung, bei denen lineare Daten erfasst werden können. Dies ist z.B. bei der direkten Beobachtung der Aggressionen nach dem Zusammenstallen möglich (z.B. Meese und Ewbank, 1973; Jensen, 1980; Turner et al., 2006a; 2006b). Dabei können die von einem Tier initiierten agonistischen Interaktionen als Merkmal für Aggressivität erfasst werden. Gleiches gilt für den Backtest, bei dem die Anzahl der Befreiungsversuche aus einer Rückenlage gezählt werden (Hessing et al., 1993). Zusätzlich sind diese Daten bereits zu einem frühen Zeitpunkt vorhanden, da der Backtest innerhalb der ersten 4 Lebenswochen durchgeführt wird. Entscheidend ist aber, dass Korrelationen zwischen den Ergebnissen des Backtests und den Zielmerkmalen Aggressivität oder Umgänglichkeit bestehen (Validität). In bisherigen Untersuchungen konnten diesbezüglich keine einheitlichen Ergebnisse erzielt werden. Hessing et al. (1993) teilten Ferkel anhand der Ergebnisse beim Backtest in drei Klassen ein (weniger als zwei Befreiungsversuche, zwei Befreiungsversuche und mehr als zwei Befreiungsversuche). Ferkel mit mehr als zwei Befreiungsversuchen beim Backtest waren auch die aggressiveren in einem sozialen Konfrontationstest und umgekehrt waren Ferkel mit weniger als zwei Befreiungsversuchen die friedlicheren Tiere (Hessing et al. 1993). Zu ähnlichen Resultaten gelangten Ruis et al. (2000). Ferkel mit mehr als vier Befreiungsversuchen verhielten sich bei der Futteraufnahme deutlich aggressiver als Ferkel mit maximal zwei Befreiungsversuchen (Ruis et al., 2000). In einer anderen Studie konnte dagegen keine Zusammenhänge zwischen den Beobachtungen beim

Backtest und beim Resident Intruder Test gezeigt werden (Cassady, 2007). Auch van Erp-van de Koij et al. (2002) konnten keine signifikanten Zusammenhänge zwischen dem Backtest und anderen Verhaltenstests (Human Approach Test, Novel Object Test, Open Door Test) finden. Zu beachten sind auch Korrelationen zwischen Verhaltensmerkmalen für Umgänglichkeit und Aggressivität. Bisher konnten Hinweise gefunden werden, dass zwischen den beiden Eigenschaften Zusammenhänge bestehen (z.B. Thodberg et al., 1999; Ruis et al., 2000; D'Eath et al., 2009). Häufig wird die fehlende Konsistenz/Konstanz im Verhalten der Tiere darauf zurückgeführt, dass die unterschiedlichen Verhaltenstests auch unterschiedliche Verhaltensmuster der Tiere messen (van Erp-van de Koij, 2002). Dies trifft wahrscheinlich vor allem auf Verhaltenstests zu, die sich sehr stark in Durchführung und den gemessenen Parametern unterscheiden. Zwischen vergleichbaren Testverfahren (Human Approach Test, Novel Object Test, Open Door Test) wurden niedrige bis moderate Korrelationen gefunden. Beispielsweise war die Korrelation zwischen einem Human Approach Test und einem Novel Object Test r_p = 0,44 ($p < 0,05$) (van Erp-van de Koij, 2002). Einige Ergebnisse zum Backtest weisen zwar einen Zusammenhang zu Aggressivität auf (Hessing et al., 1993; Ruis et al., 2000), diese konnte aber in aktuelleren Studien (van Erp-van de Koij, 2002; Cassady, 2007) nicht bestätigt werden.

Ein weiterer wichtiger Punkt, um Verhaltenstest in ein Zuchtprogramm zu integrieren, ist die Praxistauglichkeit der unterschiedlichen Tests. Diese sollten sich ohne übermäßigen Aufwand in bestehende Produktionsabläufe integrieren lassen, damit eine routinemäßige Erfassung von Verhaltensmerkmalen durchgeführt werden kann. Dazu sind besonders Verhaltensbeobachtungen während Handlingmaßnahmen (z.B. beim Wiegevorgang) geeignet. Die Integration in vorhandene Arbeitsabläufe ist einfach durchzuführen und es können große Tierzahlen untersucht werden (Holl et al., 2010). Die hier erfassten Verhaltensmerkmale stellen vor allem die Umgänglichkeit der Tiere bzw. deren Aktivität in einer bestimmten Situation dar. Die Erfassung von Verhaltenmerkmalen, die im Zusammenhang mit Aggressivität stehen (Direkte Beobachtung, Resident Intruder Test), ist für eine regelmäßige Beobachtung aufwendiger. Wobei die direkte Beobachtung der Tiere über einen längeren Zeitraum mit Hilfe von Videotechnik erfolgen kann. Aber insgesamt bleibt der Arbeitsaufwand sowohl für die Echtzeit-Beobachtung als auch für das Analysieren der Videos hoch. Ähnliches gilt für den Resident Intruder Test, der einen sehr experimentellen

Charakter hat. Ein vielversprechendes Indikatormerkmal für aggressives Verhalten, dass mit einem deutlich geringeren Erfassungsaufwand verbunden ist, sind daher die Anzahl und Schwere von Hautläsionen (Turner et al., 2006a; 2006b; 2009; Stukenborg et al., 2011).

2.4 Einflussfaktoren auf das Verhalten

Die Ausprägung des Verhaltens wird sowohl von umweltbedingten als auch von genetischen Einflussfaktoren sowie deren Interaktionen bestimmt.

2.4.1 Umweltbedingte Einflussfaktoren

Umweltfaktoren beeinflussen das Verhalten der Tiere am stärksten (Grandin 1993a). Dabei spielen vor allem der Umgang mit den Tieren, das soziale Umfeld, Lebenserfahrung, Alter und das Haltungssystem eine wichtige Rolle (Sambraus und Brummer, 1978; Naguib, 2006; von Borell, 2009). In früheren Untersuchungen konnte gezeigt werden, dass Schweine durch einen ruhigen und guten Umgang weniger Angst vor Menschen haben (Pearce et al., 1989; Tanida et al., 1994; Day et al., 2002). Auch das Alter und die Erfahrung sind für das Verhalten von Schweinen bedeutend. Docking et al. (2008) zeigten, dass Schweine verschiedener Altersstufen die Möglichkeit zur Beschäftigung (u.a. Stroh, Seile) unterschiedlich nutzten. Beispielsweise waren Absetzferkel insgesamt aktiver als Mastschweine, aber Mastschweine näherten sich schneller unbekannten Objekten an als Absetzferkel oder Saugferkel (Docking et al., 2008). Die bedeutsamsten Einflussfaktoren auf das Verhalten der Tiere sind unter den gegenwärtigen Produktionsbedingungen das soziale Umfeld sowie das Haltungssystem. Beide werden durch die Veränderungen in der Schweinehaltung stark beeinflusst (z.B. Zunehmende Gruppenhaltung, Beschäftigungsmaterialien) und führen wiederum zu Veränderungen im Verhalten der Tiere. Sowohl Futteraufnahme als auch Fressgeschwindigkeit von Schweinen, die in 20er Gruppen gehalten wurden, waren signifikant höher im Vergleich zu Artgenossen mit maximal 15 Buchtenpartnern (Nielsen et al., 1995). Außerdem führt die Gruppenhaltung von Schweinen zu Rangkämpfen um eine Hierarchie innerhalb der Gruppe zu bilden (Meese und Ewbank, 1973; Arey und Edwards, 1998). Wobei aber eine zunehmende Gruppengröße nicht zwangsläufig zu mehr Kämpfen führen muss (Turner et al., 2001; Schmolke et al., 2004). Viele Studien beschäftigten sich mit Haltungssystemen für Schweine (z.B. Beattie et al., 1996; Hill et al., 1998; van de Weerd und Day, 2009). In diesem Zusammenhang wird häufig von der Anreicherung der Umwelt gesprochen. Die Haltungsumwelt soll mit verschiedenen Möglichkeiten besser den Bedürfnissen der gehaltenen Tiere angepasst werden (Markowitz und Line, 1990; Poole, 1992). In früheren Studien konnte beispielsweise gezeigt werden, dass agonistische Interaktionen in mit Stroh eingestreuten Ställen deutlich reduziert und das Erkundungsverhalten stärker ausgeprägt ist im Vergleich zu konventionell gehalten Schweinen (Kelly et al., 2000). Aber auch schon kleinere Veränderungen im Haltungssystem führen bereits zu Veränderungen im Verhalten der Tiere (Bracke und Spoolder, 2008; van de Weerd und Day, 2009).

2.4.2 Genetische Einflussfaktoren

Die genetischen Einflussfaktoren sind die Rasse und das Geschlecht der Tiere (Sambraus und Brummer, 1978; Naguib, 2006; von Borrel, 2009). In verschiedenen Untersuchungen konnten Unterschiede im Verhalten zwischen den Rassen gezeigt werden (z.B. Hoppe et al., 2008; Yoder et al., 2011). Beispielsweise konnten für Large White Jungsauen mehr aggressive Verhaltensweisen beobachtet werden als für Pietrain Jungsauen (Appel et al., 2011). Dagegen stimmen die Literaturangaben beim Einfluss des Geschlechts nicht überein. Zwischen männlichen und weiblichen Ferkeln konnten beim Backtest oder Resident Intruder Test keine signifikanten Unterschiede festgestellt werden (Cassady, 2007) und auch weitere Studien kamen zu diesem Ergebnis (z.B. Erhard und Mendl, 1997; D'Eath und Lawrence, 2004; Ishiwata et al., 2004). Dagegen waren in anderen Untersuchungen weibliche Tiere aggressiver als männliche (z.B. Stookey und Gonyou, 1994; D'Eath und Pickup, 2002; Ishiwata et al., 2002). Außerdem sind Eber insgesamt aktiver und aggressiver als Börge (Cronin et al., 2003; Rydhmer et al., 2006; Pauly et al., 2009).

2.4.3 Heritabilitäten

Die Zucht auf ein bestimmtes Merkmal setzt voraus, dass dieses Merkmal sowohl eine Variation innerhalb der Population als auch eine Erblichkeit besitzt. Die

Heritabilität/Erblichkeit ist das Verhältnis der additiv genetischen Varianz zur phänotypischen Varianz (Falconer, 1984). Dementsprechend ist die vernünftige Merkmalserfassung (Phänotyp) die Grundvoraussetzung für die Tierzucht. Wie bereits im dritten Abschnitt „Erfassung von Verhaltensmerkmalen“ angesprochen, sind zahlreiche unterschiedliche Versuche durchgeführt worden um das Verhalten der Tiere zu beschreiben. Die Vergleichbarkeit der Ergebnisse wird aber durch fehlende Standardisierung der Verhaltenstests erschwert (Forkman et al., 2007). In der Tabelle 3 sind daher hauptsächlich Ergebnisse von Verhaltenstest aufgeführt, die für die vorliegende Arbeit relevant erscheinen. Die Heritabilitäten schwanken von 0,05 bis 0,75. Hohe Heritabilitäten sind vor allem für den Backtest und für Merkmale des agonistischen Verhaltens und niedrige für das Verhalten beim Wiegevorgang geschätzt worden. Insgesamt erscheint aber eine Selektion auf Verhalten anhand der Ergebnisse früherer Studien möglich.

2.4.4 Alternativen zur Zucht

Neben einer möglichen Selektion auf Verhaltensmerkmale können die wachsenden Anforderungen an die Haltungssysteme der Tiere können auch durch Maßnahmen erfüllt werden, die vor allem die Haltungsumwelt der Tiere betreffen. Eine Möglichkeit ist die bessere Strukturierung der Buchten in Ruhe- und Aktivitätsbereich (Olesen et al., 1996) oder auch das Bereitstellen von Beschäftigungsmaterialien, besonders während einer Neugruppierung (Kelly et al., 2000). Des Weiteren können Probleme beim Umgang mit den Tieren durch die richtige Ausrüstung beim Handling (Kabuga und Appiah, 1992; Grandin, 1993b) und durch ruhiges Verhalten des Menschen selbst vermieden werden (Pearce et al., 1989; Tanida et al., 1995; Day et al., 2002). Es sind also weitere Möglichkeiten vorhanden um das Verhalten von Schweinen so zu beeinflussen, dass die negativen Auswirkungen auf das Wohlbefinden der Tiere vermindert werden können. Aber dennoch erscheint die Zucht auf ruhige und friedliche Tiere sinnvoll, weil diese Tiere genetisch besser an ihre zukünftige Haltungsumwelt (mehr Gruppenhaltung, weniger Kontakt zu Menschen) angepasst sind ohne aufwendige haltungstechnische Maßnahmen zu ergreifen.

Tabelle 3. Heritabilitäten (h² ± SE) von Verhaltensmerkmalen beim Schwein.

Verhaltensmerkmal	Genetik	n	Väter (n)	Mütter (n)	Sex	Alter	h² ± SE	Literaturangabe
Befreiungsversuche (Backtest)	4 QAF Linien	680	47	116	beide	14 d	0,35 ± 0,15	Bunter und Landsdowne, 2004
							0,75 ± 0,10	
Befreiungsversuche (Backtest)	Landrasse x Large White	766	31	95	beide	7-14 d	0,53 ± 0,10	Velie et al., 2009
Dauer der Befreiungsversuche (Backtest)							0,49 ± 0,18	
Wiegescore	Duroc, Large White, Landrasse	2.186			beide	156 d	0,23	Holl et al., 2010
Eintrittsscore	Chester White	1.076	49	251	beide	185 d	0,05	Yoder, 2010
Wiegescore							0,22	
	Duroc	1.832	71	343			0,06	
							0,09	
	Landrasse	941	43	193			0,06	
							0,09	
	Yorkshire	925	45	203			0,05	
							0,10	
Eintrittsscore	Yorkshire,	1.663	86	251	beide	157 d	0,16 ± 0,02	D'Eath et al., 2009
Wiegescore	Yorkshire x Landrasse						0,10 ± 0,02	
Initiator von einseitigen Aggressionen (Dauer)						70 d	0,34 ± 0,03	
Empfänger von einseitigen Aggressionen (Dauer)							0,12 ± 0,03	
Verwicklung in Kämpfe (Dauer)							0,47 ± 0,03	
Score für Hautläsionen	Large White, Landrasse	1.132	47	244	beide	80 d	0,22 ± 0,07	Turner et al., 2006b
Initiator von einseitigen Aggressionen (Dauer)	Yorkshire,	1.184	85	250	beide	70 d	0,31± 0,04	Turner et al., 2009
Empfänger von einseitigen Aggressionen (Dauer)	Yorkshire x Landrasse						0,08 ± 0,03	
Verwicklung in Kämpfe (Dauer)							0,43 ± 0,04	
Hautläsionen anterior (3 Wochen nach Mischen)		1.660	85	250		90 d	0,43 ± 0,04	
Hautläsionen central (3 Wochen nach Mischen)							0,35 ± 0,03	
Hautläsionen caudal (3 Wochen nach Mischen)							0,19 ± 0,02	

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KAPITEL 3

Effect of marginal environmental and social enrichment during rearing on pigs' reactions to novelty, conspecifics and handling

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Effect of marginal environmental and social enrichment during rearing on pigs' reactions to novelty, conspecifics and handling

Björn Tönepöhl [a], Anne K. Appel [a], Stephan Welp [a], Barbara Voß [b], Uta König von Borstel [a], Matthias Gauly [a]

[a] Department of Animal Science, Livestock Production Systems, Georg August University Göttingen, 37075 Göttingen, Germany
[b] BHZP GmbH, 21368 Dahlenburg-Ellringen, Germany

Abstract

The rearing environment of farmed animals can affect their behaviour when handled, and therefore needs to be taken into account when selecting for traits such as docility. Therefore, 126 German Landrace and Pietrain x German Landrace pigs were reared in two different production environments (barren (n = 47) or slightly enriched (n = 79)), both corresponding to commercial conditions. The marginal enrichment included the provision of more toys, an additional feeder type, and a larger number of conspecifics, while space allowance per pig remained equal. Pigs' responses to (a) a novel arena test (NAT), (b) a novel object test (NOT), and (c) weighing, were compared, together with the number of skin lesions (an indicator of aggressiveness). While the differences in behaviour in the NAT were not significant ($p > 0.1$), the differences in the other tests were significant. In the NOT enriched housed pigs contacted the novel object more frequently ($p = 0.0124$) and showed a tendency for a greater total duration of manipulating the novel object ($p = 0.0641$). Furthermore, the pigs housed in enriched environment were calmer at loading onto the scale ($p = 0.0008$), but more agitated on the scale ($p < 0.0001$). Barren housed pigs had more severe skin lesions ($p = 0.0074$). Correlations between scores from the behaviour tests and the daily weight gain were not significant. However, correlations between the behaviour patterns measured in the tests revealed that pigs which showed more activity in the NAT were also more active in the other tests. Results indicate that marginal changes in the housing environment affect the behaviour of the pigs. Overall, the activity of barren housed animals seemed to be reduced, as revealed by the behaviour tests. Therefore, the housing environment must be taken into consideration carefully when evaluating the behaviour or indicator traits such as skin lesions for selection purposes in pigs. In addition, results of the present study have implications for animal welfare, showing that marginal enrichment of rearing environment leads to changes in behaviour that may partially be related to improved cognitive and/or physical development of the pigs.

Keywords: Environmental enrichment; Pigs; Behaviour test, Handling, Skin lesions, Housing

Introduction

Environmental enrichment is the improving of a barren captive-environment to advance the species-specific behaviour (Newberry, 1995; van de Weerd and Day, 2009). Due to the EU Directives 2001/93/EC in present-day livestock farming considerable importance is presently attributed to the species-specific behaviour of pigs, especially the exploratory behaviour. Accordingly there are many studies about environmental enrichment and whose effects on the behaviour of pigs (e.g. Beattie et al., 1996; Bracke and Spoolder, 2008). The well-being of confined animals depends on the one hand on the absence of pain, distress and behavioural abnormalities and on the other hand on the possibility for fulfilling physiological and ethological needs (Markowitz and Line, 1990; Poole, 1992). Pigs housed in barren environment show less normal behaviour (Beattie et al., 1996; de Jonge et al., 1996). If given the opportunity, the normal behaviour of domestic pigs varies not greatly from their wild conspecifics (Stolba and Wood-Gush, 1989). Exploration, foraging, play and social interactions are regarded as normal behaviour patterns of pigs (Hoy, 2009) and enrichment should increase the occurrence of such behaviours bouts (van de Weerd and Day, 2009). In contrast passiveness and abnormal behaviour is a result of barren environments in which the animals could not show their species-specific behaviour sufficiently (Wood-Gush and Beilharz, 1983; Mason, 1991a, 1991b; Poole, 1992). However the intensive production systems have to balance economic necessity and welfare of pigs. This led to numerous studies examining the potential for environmental enrichment to improve pig husbandry under commercial conditions (van de Weerd and Day, 2009). Bracke and Spoolder (2008) used the novel object test (NOT) for detecting minor differences in environmental enrichment. Further investigations have been done about objects for investigation and manipulating (e.g. van de Weerd et al., 2003; Scott et al., 2006, 2007, 2009; Trickett et al., 2009). Kelly et al. (2000) demonstrated that pigs housed in systems based on straw litter show more behaviour patterns associated with animal welfare than pigs housed in fully perforated floors.

Many methods have been developed to measure the behaviour of pigs. These include tests which give a numerical score for responses to typical handling procedures of livestock farming (Fordyce et al., 1988; Boivin et al., 1992; Grandin, 1993; Le Neindre et al., 1995); or response to novel environments (e.g. the open field test or novel environment/novel arena test (NAT) and NOT) (Hoy, 2009). Other methods include the backtest (Hessing et al., 1993; van Erp-van der Kooij et al., 2000; Cassady, 2007) or resident intruder test (Erhard and Mendl, 1997; Cassady, 2007). The results of studies using these methods show individual behavioural characteristics are partly under genetic control (e.g. Hessing et al., 1993; Erhard and Mendl, 1997; van Erp-van der Kooij et al., 2000; Cassady, 2007; Holl et al., 2010; Yoder et al., 2011), but Forkman et al. (2007) have criticized the absence of standardization and robustness of such tests.

Furthermore, investigations about the interaction between environment and handling yielded contrasting results. Geverink et al. (1999) reported that the stockman spent more time to move pigs housed in large straw-bedded pens into a vehicle than barren housed pigs. The time to weigh a group of pigs housed in barren or enriched pens was not significantly different (Hill et al., 1998). Day et al. (2002) could not show an effect on pigs' handling while moving between barren and enriched housed pigs. However, in both studies the enrichment was only done with additional objects (Hill et al., 1998; Day et al., 2002). The results of Grandin's study (1989) supported these studies partly, but there was evidence that in some cases the previous experience with humans and objects made the pigs easier to handle while in other cases there were no effects of previous experience on test-results/handling-ease. Nevertheless, van de Weerd and Day (2009) suggested an interaction between the type of handling and the type of enrichment.

Considerable knowledge exists regarding the interaction between housing systems and animal welfare of pigs (e.g. Stolba and Wood-Gush, 1989; Beattie et al., 1996; Kelly et al., 2000). However, there is limited information about the influence of the environment on the behaviour of the pigs while handling. Such information could be important, because on the one hand farmers get more information about impacts of their pig housing systems and on the other hand the effect of pigs rearing environment on behaviour could be accounted for when including such behaviour tests in breeding programmes for calm and accessible animals. Therefore, the aim of the study was to measure differences in the individual behaviour of finishing pigs reared in barren or slightly enriched housing systems.

Material and methods

Animals and housing conditions

One hundred twenty-six fattening pigs with an average body weight (± standard deviation) of 39.7 ± 8.1 kg and an average age (± standard deviation) of 86.6 ± 8.4 days were used for the tests. Among them were 100 Pietrain x German Landrace crossbred (47 barrows and 53 females) and 26 German Landrace purebred (14 barrows and 12 females) pigs. These pigs were randomly selected from 300 animals to include, whenever possible, from each litter two males and two females in the tests. If there were less than two animals of one gender, the missing animals were not replaced by animals of the opposite gender (n = 40 litters). They descended from 40 sows and 14 boars.

The animals were housed under commercial conditions at the University of Göttingen research farm. After weaning at the age of 4 weeks the piglets were taken into the flat-deck (rearing quarters) with slatted floor and housed together with animals of the same age. Depending on the pen size of 3.58 (n = 12 pens) and 11 m² (n = 6 pens) the group sizes were 10 or 30 animals, respectively. Thus, space allowance per animal was about 0.36 m². The total number of observed animals housed in groups of 10 animals was n = 47 and in groups of 30 animals n = 79. Water and feed was available ad libitum. For investigation and manipulation activities either a plastic star on a chain or a piece of wood on a chain was available per every 10 animals in the pens. The feeding system in the small pens included one dry feeder and two drinking nipples. In the larger pens were one dry feeder, one wet dry feeder and four drinking nipples installed. The feed ingredients from 8 to 25 kg live weight were 38 % wheat, 38 % barley, 14.5 % high protein soybean meal, 7.5 % supplementary and mineral feed and 2 % soybean oil. When the animals in a pen reached an average of 25 kg live weight the diet was switched for all pigs of that pen simultaneously to a feed that was composed of 50.5 % wheat, 27 % barley, 16.5 % high protein soybean meal, 5.5 % supplementary and mineral feed and 0.5 % soybean oil. Regarding to the equipment and the group size the two different systems were classified into barren and enriched environment (Table 1). However, the environmental enrichment was only marginal, we used the term, because even minor changes in environment were described by this term (e.g. only additional objects) (van de Weerd and Day, 2009) and for an easier differentiation of the environments. Production information (average daily weight gain) was obtained from the farm log book.

Test facilities and procedures

All behaviour observations were recorded when the animals were moved from the flat-deck into the finishing barn. In the alley leading to the finishing barn a 2.5 m x 4 m test arena was installed. In the arena, no visual contact to other pigs was possible. Behind the test arena a scale was placed. Two men carried a group of pigs into a forecourt of the finishing barn. After identification via the ear tag pigs were tested separately one at a time. One observer took live observations of the pig in the test arena while simultaneously reporting the observations to a second researcher who collected the data on a test protocol.

Table 1

Group size, total space and equipment of barren or enriched environment.

Environment	Group size	Total space (m²)	Toys	Feeding system	Drinking system
Barren	10	3.58	1	Automatic dry feeder	2 drinking nipples
Enriched	30	11	3	Automatic dry feeder Automatic wet feeder	4 drinking nipples

The NAT was always conducted first. The pig entered the test arena and the pig was observed for 120 s. Observed behaviour patterns were divided into the categories exploring, standing, walking, running and lying (Table 2), and using a stopwatch, the total time the pigs showed the specific behaviour patterns was measured. In addition, the frequency of urine and faeces excretion of the animals was recorded.

Following the NAT, the NOT started in the same area. The stimulus was a yellow plastic ball with a diameter of 30 cm and a weight of 800 g (Schippers GmbH, Kerken, Germany). The ball was curled into the middle of the pen, and the pig was given 300 s to examine the ball. The number of contacts and the duration of every contact were observed (Table 2).

Table 2

Definition of observed behaviour patterns in the novel arena test (NAT) and the novel object test (NOT) (adapted from Thodberg et al., 1999).

Test	Behaviour	Definition
NAT	Standing	Standing without any movements
	Lying	Lying in a ventral or sternal position
	Walking	Slow movements without exploring surroundings
	Running	Fast movement without exploring surroundings
	Exploring	Sniffing or manipulating floor or wall
NOT	Contact to novel stimulus	Sniffing or manipulating the novel stimulus
	Duration of every contact	Time from first contact until the release of the ball

Table 3

Definition of scores for handling (adapted from Grandin, 1993, Yoder et al., 2011) and aggressiveness (adapted from Turner et al., 2006, Brown et al., 2009).

Behaviour category	Score	Definition
Handling (load score)	1	The pig enters the scale without hesitation
	2	The pig hesitates briefly before entering
	3	The pig refuses to enter; tries to escape
Handling (scale score)	1	Calm; no/very little movements
	2	Excited; slow movements
	3	Very excited; fast movements
Aggressiveness (skin lesions)	1	No lesions
	2	Several lesions (i.e. less than 5 scratches)
	3	Many distinct lesions (i.e. 5–10 scratches)
	4	Wounds, lesions all over the body

After these two tests each pig was weighed in the adjacent scale. During handling the behaviour of each pig was scored twice: (a) while the handler placed the pig onto the weighing scale and (b) during its first 60 s on the scale. Both scores rated the pig's agitation from low (1) through to high (3) (Table 3). The number of vocalizations and excretion of urine and faeces were also recorded while the pig was on the scale.
Finally, the intensity of pigs' skin lesions was evaluated using a score from 1 to 4 before regrouping the pigs in the finishing area (Table 3). Overall, the treatment period lasted about 10–15 min per animal regarding to the individual behaviour at moving.

Statistical analysis

The collected data of the behaviour tests were analysed with the Statistical Analysis System (SAS 9.2; software SAS Institute Inc., Cary, NC; 2002-2008). Data from the NAT, and NOT were analysed for agreement with a normal distribution with the Kolmogorov-Smirnov test. When the recorded data did not follow approximately a normal distribution, data was transformed to approximate normal distribution (total time standing: log10 x; total time exploring: x^2; duration of contacts to novel stimulus: log10 x). Due to the large number of zeros for total time walking in NAT the values were transformed into binary data (i.e. walking/no walking). In addition each of the three influential dependent variables (exploring, standing, walking) of the NAT and both dependent variables (number of contacts, total duration occupied with the ball) of the NOT were analysed with a mixed model. Not enough observations for the behaviour categories running and lying were present to allow for further statistical analysis of these traits. Furthermore, urination, defecation and vocalisation (recorded at NAT, weighing) did not affect any variables and therefore not included in the mixed model. The mixed model was also used for analysis of the handling scores, the skin lesion score and the performance data. Mixed model analysis is able to accommodate unbalanced data and is at the time robust against deviation from normality (Littell et al., 2006). The traits recorded in the presented study can be reasonably assumed to possess an underlying distribution as the expression of the behaviour patterns can vary on a continuous scale. It is only the limitations of the recording method that reduce the distribution to just a few scores. Therefore, both from a biological and a statistical point of view it is reasonable and common practices (e.g. Hellbrügge et al., 2008; Hoppe et al., 2008; Meaghar et al., 2011) to use parametric statistics for data deviating from normality. The mixed procedure was used for analysing all variables with the exception of the parameter walking (PROC GLIMMIX).

The model included the fixed factors gender (female or castrated male), breed (German Landrace or Pietrain x German Landrace) and environment (barren or enriched). Furthermore the age of the pigs was included as a covariate in the model. Animal nested within pen was considered as a random factor. Thus the final model, with y being the respective dependent variable and e the random error, was:

$$y_{ijklmn} = sex_i + breed_j + environment_k + age_l + \mathit{pig(pen)}_m + e_{ijklmn}$$

Pearson correlations were used to calculate phenotypic correlations between the behaviour and production traits.

Results

Novel arena test

The parameters exploring and standing took the largest proportion of time of the 120 s. The mean (± standard deviation) for barren environment was 82.6 ± 31.0 s and 36.0 ± 31.8 s, respectively, and the mean for enriched environment was 80.5 ± 25.5 s and 33.6 ± 25.5 s, respectively. The parameter walking had a mean value of 1.2 ± 4.2 s (barren) and 6.0 ± 8.5 s (enriched). Running was shown only once and the pigs did not lie during the NAT. The measured values of exploring and standing ranged from 0 to 120 s.

The analysis of the traits exploring and standing revealed that the pigs did not show any significant differences for these behaviour patterns regardless of gender, breed, environment and age.

The parameter walking was only significantly affected by the rearing environment ($F_{1,103}$ = 10.52; p = 0.0016). Animals housed in barren environment showed the trait walking less frequently compared to their fellows in enriched environment.

Novel object test

The reaction of the pigs to the novel, yellow ball differed considerably between individuals. Some animals have not touched the ball at all and other animals touched to the ball up to 101 s of the test time. The mean frequency of contacts (± standard deviation) was 3.8 ± 2.6 and the mean value of total duration of playing with the ball was 22.6 ± 21.0 s.

The number of contacts was significantly affected by the environment the pigs were kept ($F_{1,103} = 6.48$; $p = 0.0124$). Barren housed animals showed only 2.9 ± 0.4 touches of the ball (LS-mean ± standard error of the parameter estimate) while the enriched housed pigs touched the novel stimulus 4.2 ± 0.2 times (Fig. 1).

Analogous results were found for total duration of playing with the ball. There was a tendency for an environment effect ($F_{1,92} = 3.51$; $p = 0.0641$). The total duration of barren housed pigs was 13.0 ± 3.5 s and of enriched housed pigs 19.5 ± 2.5 s. The rest of the variables (gender, breed, age) did not affect the parameters of NAT.

Handling tests

The load score was only significantly affected by the environment ($F_{1,103} = 11.92$; $p = 0.0008$). The moving of barren housed pigs onto the scale was judged with higher scores (i.e. animals were more agitated and refused to enter the scale) than the enriched housed animals (Fig 2.).

The environment had a significant effect on scale score, too ($F_{1,103} = 18.00$; $p < 0.0001$). Pigs in the barren environment were less active and excited in the scale than their fellows housed in enriched environment (Fig. 2). The rest of the variables (gender, breed, age) did not affect the load score or the scale score.

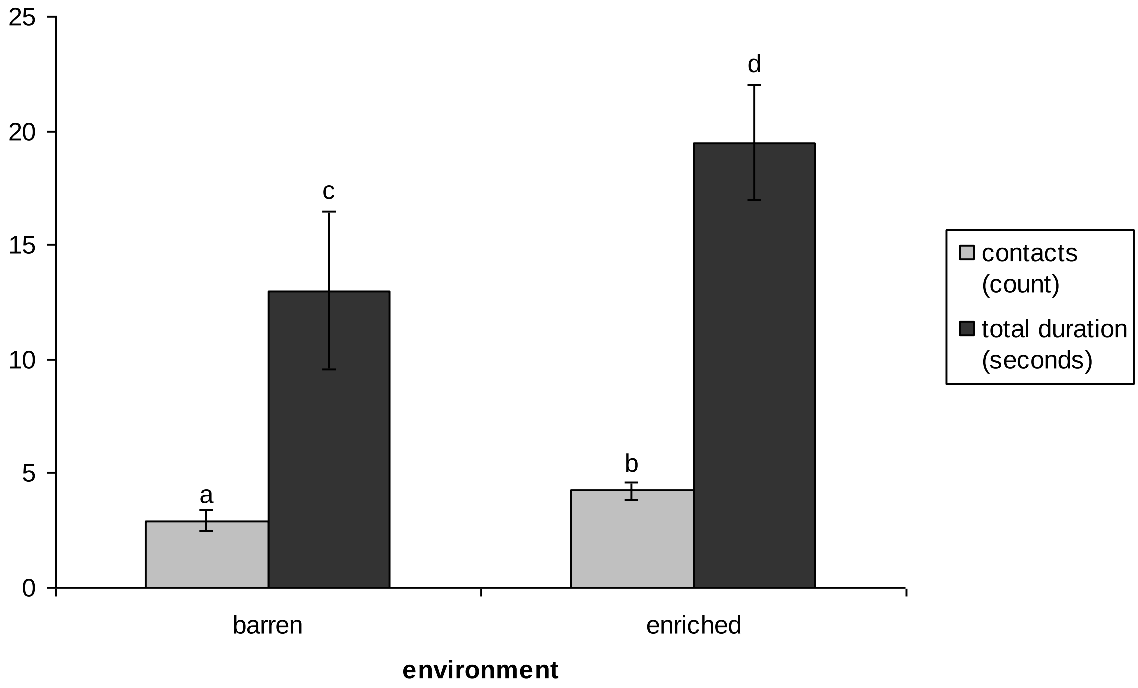

Figure 1. LS-means ± SE for number of contacts and total duration of contact with the novel stimulus according to the rearing environment of the pigs. Different letters (a, b) indicates significant differences for number of contacts between the environments at $p < 0.01$. Different letters (c, d) indicates tendencially differences for total duration between the environments at $p < 0.1$.

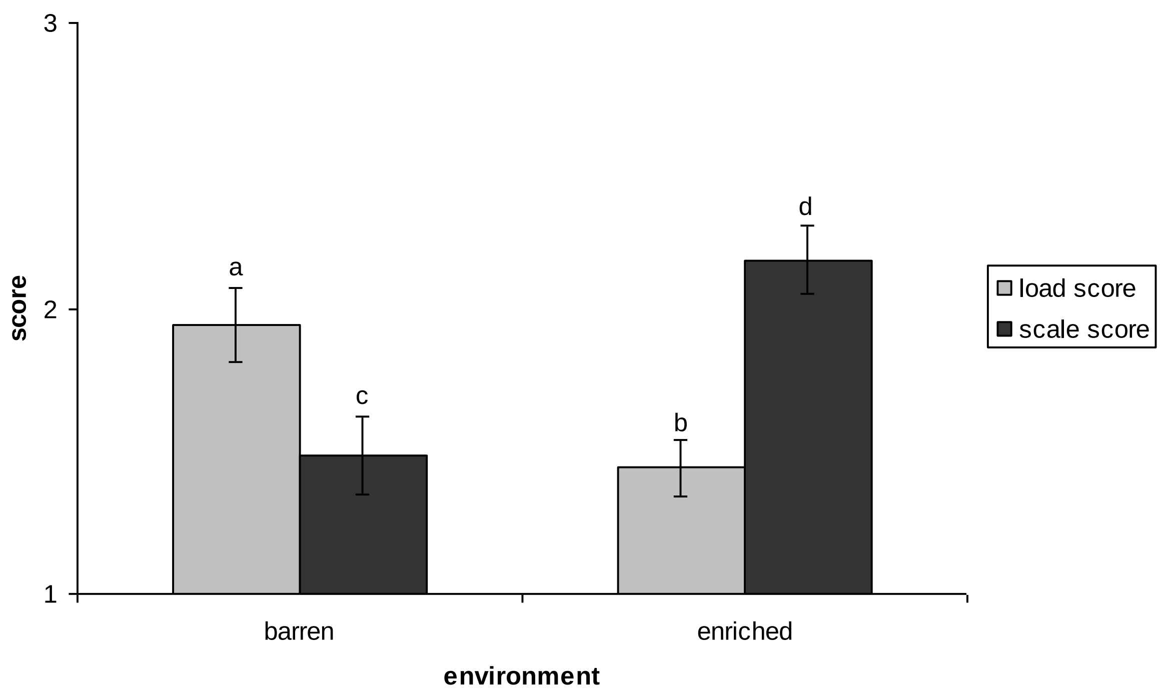

Figure 2. LS-means ± SE for loading score and scale score according to the environment of the pigs. Different letters indicates significant differences for load (a, b) and scale (c, d) score between the environments at $p < 0.001$.

Aggressiveness

The aggressiveness was measured indirectly by evaluating the skin lesions of the pigs before relocating them into the finishing barn. Scores are shown as LS-mean ± standard error of the parameter estimate. The environment effect was significant ($F_{1,103}$ = 7.48; $p < 0.0074$) and higher skin lesion scores were found for the barren environment (barren: 2.2 ± 0.1; enriched 1.8 ± 0.1) Another effect for the skin lesion score was the breed of the animals ($F_{1,103}$ = 6.49; $p < 0.0123$). Purebred German Landrace (1.8 ± 0.2) had a lower skin lesion score than the crossbred pigs (2.2 ± 0.1). Furthermore, there was a tendency for barrows (2.1 ± 0.1) to have higher numbers of skin lesions compared to female pigs (1.9 ± 0.1), but it was not significant ($F_{1,103}$ = 3.61; $p = 0.0786$).

Correlations

No significant correlations were found between the behaviour patterns of NAT and NOT and daily weight gain. The same applied to the load score and the scale score. Only between the skin lesion score and daily weight gain in the flat-deck period a low significant correlation existed (r_p = 0.18, $p = 0.0448$). However, the estimated average daily weight gain (LS-mean ± standard error of the parameter estimate) of the pigs housed in the barren environment was 558 ± 14 g and the enriched housed pigs gained 501 ± 15 g ($F_{1,103}$ = 8.56; $p = 0.0042$).
The analysis showed correlations between the results of NAT and NOT and the scores for handling and aggressiveness (Table 4). The correlation between the parameters exploring and standing was almost r_p = –1. A high positive correlation (r_p = 0.7, $p < 0.001$) was found between contacts to the ball and total duration of playing with the ball. Furthermore the correlation between the parameter walking and scale score was r_p = 0.4 ($p < 0.001$). The rest of the correlation values were low, but there were some interesting tendencies for correlations between the tests. It seems that animals which showed less movement in the NAT were also less active during the other tests. The other way round pigs which showed more movement (exploring and walking) in the NAT were also more active during the other tests. Another interesting correlation existed between the handling scores (r_p = –0.19, $p < 0.05$). Pigs more difficult to move were less active and excited on the scale.

Table 4

Pearson correlations intra and inter the behaviour tests (n = 126).

Test		NAT			NOT		HAN		AGG
		Exp	Wal	Sta	Con	Dur	LoS	ScS	LeS
NAT	Exp		–0.04	–0.96	0.27	0.19	–0.03	0.18	0.12
	Wal	n.s.		–0.24	0.09	0.17	–0.12	0.40	–0.19
	Sta	***	**		–0.28	–0.23	0.07	–0.29	–0.07
NOT	Con	**	n.s.	**		0.67	0.15	0.07	–0.12
	Dur	*	n.s.	*	***		0.13	0.08	–0.14
HAN	LoS	n.s.	n.s.	n.s.	n.s.	n.s.		–0.19	0.10
	ScS	*	***	***	n.s.	n.s.	*		–0.10
AGG	LeS	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.	

NAT: novel arena test; NOT: novel object test; HAN: handling test; AGG: aggressions; Exp: exploring; Wal: walking; Sta: standing; Con: contacts; Dur: duration; LoS: load score; ScS: scale score; LeS: skin lesion score.

n.s.: not significant.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

Discussion

Novel arena test

During the novel arena test, the most frequently shown behaviour patterns of the pigs were exploring and standing, but there was no significant difference in these behaviour patterns between the rearing environments. Only the variable walking indicated that the barren housed pigs walked less frequently than pigs of the other group. Potentially, the overall activity of the animals housed in the more barren environment decreased due to reduced stimulation by fewer pen-mates, fewer manipulating objects and less total space, and this general decrease in activity also transferred to the test situation. In a study by Wiegand et al. (1994) pigs housed in the smaller pens (0.356 m² per pig) spent more time standing than pigs in larger pens (0.396 m² per pig) measured by instantaneous sampling of each pen at 10-min intervals. Beattie et al. (1996) studied the effect of environmental enrichment and space allowance per animal on the behaviour. For behavioural observations two focal animals (boar, gilt) were continuously observed twice per week for 10 min over 6 weeks. Pigs housed in enriched pens with greater floor space demonstrated more locomotory behaviour (Beattie et al., 1996). By using a similar method for behavioural observation as Beattie et al (1996), enriched housed pig spent more time active and in exploratory behaviour (Beattie et al., 2000). The area per pig translates into far more space available for running around in the bigger groups. However, even though the space allowance in our study was invariably 0.36 m^2 per pig and the group sizes differed, the results showed a similar trend. Potentially, the mere availability of a larger area stimulates the pigs to move about more, resulting in a training effect that enables the animals to also walk more during other situations such as the NAT. On the other hand, pigs housed in small pens could have compensated their need for movement in the test area. The exploration behaviour in the NAT was not significantly different between the enriched and the barren housed groups. By using a novel environment test de Jong et al. (2000) could also not observe differences in exploring behaviour of piglets previously housed in barren or in enriched environment. Combined with the results for walking, these findings support the speculations about a physical training effect, while the interest in novel environments or cognitive abilities regarding the processing of information remained unchanged by the different rearing environments. However, this contrasts partly with findings from the literature, suggesting that housing in barren environments not only leads to increased passiveness (Wood-Gush and Beilharz, 1983), but also to higher psychological distress and increased incidences of abnormal behaviour patterns such as stereotypies (Mason, 1991a, 1991b; Poole, 1992). On the other hand, the barren environment in our present study corresponded to commercial housing conditions including an enrichment-toy, and our “enriched” housing conditions embodied only marginal additional enrichment by means of an additional feeder type, a larger area and additional social partners, effects on cognitive function may not have been as large as in previous studies comparing considerably larger differences in environmental conditions. In the study of Beattie et al. (2000) the barren housing during the rearing period was similar to our barren housing regarding the floor, space allowance and pigs per pen. In contrast the enriched environment was divided in five areas (rooting, straw, sleeping, feeding, defecating) and had a space allowance of 1.75 m^2 per pig with a constant group size (Beattie et al., 2000). Compared to the present study, the results vary regarding the exploratory behaviour, but not regarding the activity of the different housed pigs. The straw as a rootable substrate and the rooting area leads probably to more exploratory behaviour of the pigs. The cognitive development of piglets is affected by the early environment. Held et al. (2002) suggested that outdoor reared piglets have better-developed social and general cognitive skills than intensively indoor reared pigs. Similar results were found by de Jonge et al. (1996) and de Jong et al. (2000). A relatively barren environment leads to impaired long-term spatial memory abilities (de Jong et al., 2000) and affected the social skills of the piglets negatively (de Jonge et al., 1996) compared to enriched environments. However, results of our study suggested that the effects of the simple enrichment were only indicated in the NAT. Further behaviour tests are necessary to show an effect of the simple enrichment.

Novel object test

The differences in behaviour of pigs housed in barren and enriched pens were considerable in the NOT. The barren housed pigs showing less interest in or higher fear of the ball (Fig. 1). Bracke and Spoolder (2008) used the NOT to measure differences in environmental enrichment and concluded that the NOT can detect marginal differences in housing conditions. These results match our observations perfectly. In addition pigs’ reaction to novel stimulus is affected by previous exposure to other novel stimuli (Hemsworth et al., 1996). Although the pen size (14 m²) and the group size (eight pigs per pen) of the study of Hemsworth et al. (1996) differ to our housing, this could indicate that pigs housed in enriched environments were more familiar with the exploring of novel objects, because more equipment in the pen and therefore more possibilities for exploring and manipulating objects were available. In a study by Sneddon et al. (2000) the learning abilities of pigs were investigated. In an operant task the pigs had to learn to push a panel for a reward and in a maze test the spatial learning was tested. The results of the investigation show that the enriched housed pigs learned both tests more rapidly than their fellows housed in barren environment. However, in the present study, environment also encompassed additional social partners. Potentially, the opportunity to interact socially with a larger number of individuals and not just the number of available objects also alters the pigs’ response to novel objects: Pigs having more experience in social interactions may also be more confident in interactions with objects. In contrast to these findings, Pearce and Paterson (1993) found that barren housed pigs spent more time interacting with a novel object than pigs reared with toys such as chains, bars or tyres. This could indicate again that barren housed pigs compensated their need for activity in the test situation. However, the pigs reared with toys were housed under space restriction in groups of seven animals and only male pigs were used for the investigation (Pearce and Paterson, 1993). Regarding our results the additional objects during rearing seem to be not the main factor for more contacts and spending more time with the novel object, but the feedings system or the greater number of conspecifics including more total space allowance.

Handling tests

The scores for handling the pigs during the weighing process were significantly different between pigs reared in the barren and marginally enriched housing system. While the load scores for barren housed pigs were higher than the scores for enriched pigs, the results for the scale score followed the opposite trend. In some earlier studies the environmental enrichment only with additional objects seems to have no effect on the ease of handling (Hill et al., 1998; Day et al., 2002). Beattie et al. (1995) rated gilts from enriched environment using a scale from one to five for the parameter ease of movement with higher scores than their barren housed conspecifics (the easier the movement the lower the score). These findings are contrary to our results. A potential reason for the disagreement is the different type of enrichment including marginal additional enrichment by means of an additional feeder type, a larger area and additional social partners. It seems to be that this combination of enrichment affects the pigs' reaction while handling. In an earlier experiment by Grandin et al. (1986) 42.5 kg Landrace sired pigs were observed for the effect between environment and handling. The enrichment was three different treatments (three rubber hoses; 10 min quiet petting per week; driving 50 m once a week) and the behaviour observations were done when the pigs entered and crossed a chute. The result was that the enriched housed pigs were less excited and the expense for driving the animals was reduced. However, a general increase in passiveness of barren housed animals (Wood-Gush and Beilharz, 1983; Mason, 1991a, 1991b; Poole, 1992) could lead to handling scores indicating lower activity of the pigs.

Aggressiveness

The aggressiveness of the pigs was estimated by evaluating skin lesions (Turner et al., 2006). The lesion scores of pigs housed in barren environment were higher than the lesion scores of enriched housed pigs. Likely, the relative absence for manipulation leads to more frequent interactions with their conspecifics, as an alternative. Schaefer et al. (1990) used time-lapse video recordings for 24 h behavioural observations of pigs housed in pens with a car tyre on a chain or no device. Aggressive acts in the enriched pen were reduced compared to the control group (Schaefer et al., 1990). Contrary to this results, pigs from enriched housing tended ($p < 0.1$) to show more aggressive behaviour than barren housed pigs investigated by using 2 min instantaneous scan sampling over 8 h per week (Bolhuis et al., 2006). Further investigations found reduced aggressions for enriched housed pigs compared to their counterparts housed in a barren environment (e.g. Schaefer et al., 1990; Ishiwata et al., 2004), but there are also some results that show more aggressions for enriched housed pigs (e.g. Bolhuis et al., 2006). Melotti et al. (2011) examined the influence of the environment pre- and post-weaning. Pre-weaning enrichment increased aggressiveness of the piglets after weaning whereas post-weaning enrichment reduced aggressions between the pigs (Melotti et al., 2011). Therefore, the enrichment of the flat-deck leads to fewer interactions between the fellows. In our study the enriched housed animals have on the one hand more possibilities for manipulating (more toys, additional feeder type) and on the other hand a larger space to avoid aggressions.

Correlations

In the present study, there were no important phenotypic correlations between the daily weight gain and behaviour traits although the mean daily weight gain of barren housed pigs was significantly higher. The results of further investigations vary. Beattie et al. (2000) could not find an effect of the environment on the growth rate for pigs at the age of 0 to 14 weeks, but in the stage of 15 to 21 weeks-old pigs the daily growth rate of enriched housed individuals was 130 ± 14 g higher than of barren housed pigs ($p < 0.001$). Enrichment only with additional objects such as chains or balls shows no effect on performance (e.g. Pearce and Paterson, 1993; Day et al., 2002). Likewise, the enrichment with straw bedding seems not to lead to differences in the average daily weight gain (Bolhuis et al., 2006). In a study by Oostindjer et al. (2010) piglets housed in enriched pens had a greater growth in the first 2 weeks after weaning compared to barren housed piglets. The results of our study were not consistent with the results of these investigations, but the type of enrichment differed considerably between this previous and the present study. The combination of enrichment factors could be a reason for disagreement. Apart from enrichment with toys the different feeding system or the larger group size and total space allowance including more activity behaviour could lead to lower average daily weight gain. The effect of the group size on the average daily weight gain of pigs varies between different studies. In some cases the growth rate of pigs from smaller groups were higher (e.g. Gonyou and Stricklin, 1998; Wolter et al., 2000), while in other cases there were no significant differences in growth rate between pigs of different group sizes (e.g. McGlone and Newby, 1994; Turner et al., 2000; O'Connell et al., 2004). The different feeder type might be another possibility for the difference in the daily weight gains. However earlier investigations could not show a significant effect of the feeder type installed in the flat-deck on the weight gain (Nielsen et al., 1996; O'Connell et al., 2002; Magowan et al., 2008).

Conclusions

With the exception of the NAT there were significant differences in the results of the behaviour tests between marginally enriched and barren housed pigs. Especially the results of the NOT indicated the impaired general cognitive skills of barren housed pigs. The barren environment probably leads to more passive pigs, which have less distinct abilities to cope with unknown situations. The moving of these pigs onto the scale was more difficult. This result shows that the passiveness of the pigs may lead to problems when moving pigs and thus increased labour costs, although this may in turn be compensated by advantages due to the greater passiveness during weighing. Finally, the skin lesions suggested that barren housed pigs were more aggressive than pigs housed in enriched environment. Therefore, only marginal enrichments may improve animal welfare. The type of pigs' housing should be considered when the behaviour of pigs is evaluated, e.g. for selection purposes.

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KAPITEL 4

Interaction between aggressiveness post mixing and skin lesions recorded several weeks later

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Interaction between aggressiveness post mixing and skin lesions recorded several weeks later

Björn Tönepöhl [a,*], Anne K. Appel [a], Barbara Voß [b], Uta König von Borstel [a], Matthias Gauly [a]

[a] Department of Animal Science, Livestock Production Systems, Georg August University Göttingen, 37075 Göttingen, Germany

[b] BHZP GmbH, 21368 Dahlenburg-Ellringen, Germany

Abstract

Group housing of pigs leads inevitably to more or less serious agonistic interactions during the establishment of the social rank order of the group. In order to reduce the number of severe agonistic interactions and thus the negative effects on well-being and performance, the use of genetic selection of calm sows maybe a possible strategy. Therefore, in this study the behaviour of 112 German Landrace sows was observed after the animals were brought together in a group of 10–20 sows. After this initial period, the sows were integrated into a large dynamic group in the dry sow area where the animals were housed for 71 days. Before moving the sows into the farrowing area, skin lesions scores for three body regions (front/middle/rear) on both sides were recorded using a scoring system from 1 (no lesions) to 4 (wounds, lesions all over the body area). After farrowing, sows' reaction towards the separation from their litter was recorded to analyse relationships between aggressiveness and handling. Earlier research suggests that skin lesions recorded shortly after mixing are associated with agonistic interactions at mixing and might therefore be a useful indicator for the evaluation of recent aggressiveness of animals. However, results of the present study show that an individuals' frequency of being initiator of agonistic interactions post mixing do not affect ($p > 0.1$) the extent of skin lesion recorded 10 weeks later. Conversely, animals being attacked frequently were evaluated with higher scores in the anterior region ($p = 0.0435$). These findings indicate that a higher skin lesion score does not represent generally more aggressive sows under commercial housing systems, but it is still an indicator for overall aggressiveness within pens or groups. Between the different groups significant differences in the extent of skin lesions were found (e.g. skin lesion score front: $p = 0.0228$). A negative relationship was found between skin lesion score in caudal region and sows' reaction towards stockperson when handling their piglets ($r_p = -0.28$, $p < 0.01$). Furthermore, behaviour traits related to aggressiveness correlated with later reproductive performance. While sows recorded frequently as aggressors post mixing gave birth to more total and live born piglets, sows with higher skin lesion scores had a lower reproductive performance (e.g. skin lesion score front vs. total born piglets: $r_p = -0.28$, $p < 0.01$). Taken together, these results suggest that more severe skin lesions are indicative of low-ranking and less vital sows, but skin lesions are not useful to identify the generally more aggressive individuals.

Keywords: Aggressiveness; Skin lesions; Indicator trait; Individual behaviour; Sow; Reproductive traits

Introduction

Due to considerable changes in pig housing systems (McGlone, 2001; Hoy, 2005), the behaviour of pigs towards human-beings and conspecifics becomes more important and the need for calm and docile pigs increases. Especially the group housing of pigs previously housed individually or in small groups will increase due to animal welfare issues. However, group housing of animals implies the establishment of a hierarchy by fighting to avoid permanent conflicts for feed or partners in the social group (Arey and Edwards, 1998; D'Eath and Turner, 2009; von Borell, 2009). Under commercial pig housing conditions unacquainted pigs form a social hierarchy within 48 h post mixing (Meese and Ewbank, 1973; Arey and Edwards, 1998). The presence of very aggressive animals could extend the time for establishing the hierarchy (Erhard et al., 1997). The resulting, repeated initiation of aggressive behaviour and restlessness in the group, especially for lower-ranked animals, will increase stress (Simmins, 1993; Hoy, 2009; Spoolder et al., 2009), which may reduce animal welfare and performance (Varley and Stedman, 1994; Kongsted, 2004; von Borell et al., 2007). Earlier results showed that sows housed individually during gestation had better reproductive performances (e.g. less mummified or stillborn piglets) compared to sows housed in groups (Broom et al. 1995, Cronin et al. 1996).

One possibility to enhance animal welfare is the direct breeding for calm and less-aggressive pigs to reduce agonistic interactions (Erhard et al., 1997; D'Eath et al., 2009). Results of genetic studies on this subject reported evidence of moderate heritabilities of traits related to aggressiveness (e.g. Grandinson, 2005; Løvendahl et al., 2005; Turner et al., 2009; Velie et al., 2009). Prerequisite for a successful genetic selection is a standardised and feasible assessment of behaviour traits (Turner et al., 2009). Various tests for the assessment had been studied (e.g. Grandin, 1993; Le Neindre et al., 1995; van Erp-van der Kooij et al., 2000; Turner et al., 2006a, 2006b; Cassady, 2007).

Skin lesion scores seem to be a convenient indicator of aggressiveness and are thus used in various studies to evaluate for instance, the extent of post mixing aggressiveness in groups of pigs and to compare the effects of different pig housing systems on behaviour (e.g. Barnett et al., 1993; Weng et al., 1998; Spoolder et al., 1999; Turner et al., 2000, 2006a). The results by Stukenborg et al. (2011) indicated that more aggressive pigs (more fights per pig, longer overall fight time and more initiated fights) have more skin lesion post mixing. Under the condition of relatively stable groups the number of skin lesions is a useful indicator for selecting docile animals, especially after the establishment of the social order (Turner et al. 2009). In a resident intruder test individual aggressiveness was more persistent for highly aggressive piglets than for the less aggressive conspecifics (D'Eath, 2002). Taken together, these results suggest that skin lesions are associated with agonistic interactions, and that aggressiveness of pigs can be reliably measured.

In further studies associations were found among aggressiveness and reactivity towards other challenging situations (e.g. Thodberg et al., 1999; Ruis et al., 2000; D'Eath et al., 2009). For example, more aggressive pigs received higher handling scores indicating more active behaviour at weighing (D'Eath et al., 2009). Thus, an interaction between behaviour towards conspecifics and handling or human beings seems to be possible.

In order to integrate behaviour traits into breeding programmes, correlations between the aggressive behaviour of pigs measured by direct observations and simple, indirectly measured behaviour tests related to aggressiveness must be identified. In previous studies the relationship between aggressions and skin lesions recorded immediately after mixing has been investigated (Turner et al., 2006a, 2006b, 2009; Stukenborg et al., 2011). However, little is known about long-therm consistency of this relationship, i.e. whether skin lesions recorded at any point in time reflect the individual's aggressiveness displayed at mixing. We hypothesised that more aggressive sows would show generally a higher number of skin lesions compared to less aggressive sows, and that the pattern of skin lesions would differ between more aggressive and less aggressive sows. Furthermore, the aim of this study was to investigate phenotypic correlations between aggressive behaviour post mixing, handling and reproductive performance to obtain indications of potential side-effects when breeding for less aggressive individuals.

Materials and methods

Animals and housing

One hundred twelve German Landrace sows were used in the study. They were housed under commercial conditions at the research farm Relliehausen of the University of Göttingen. The animals descended from 43 dams and 15 sires. The commercial piglet production followed a 3-week cycle with a 28-day lactation period. The sows, which had farrowed once to seven times, were randomly mixed into seven groups of 10–20 animals. Due to repeat breeding, integration of primiparous sows, and culling of sows the group size varied. Each group included sows which farrowed within the same period of time. Four weeks after artificial insemination the sows were tested for pregnancy and the pregnant animals were moved from the service centre with individual housing into the dry sow area. There, the sows were housed in a large dynamic group with up to 52 animals. However, before a new group of pregnant sows was included into large dynamic group, the animals were kept separately for 3–4 days in an adjacent integration pen. Usually three sow groups were housed in the dry sow area, but for the first 4 days after each mixing, four groups were housed together until one group of sows in advanced pregnancy was moved into the farrowing area after 71 days. The need to integrate the observations into the daily workflow led to repeated measurements. Therefore, 18 sows were observed three times, 40 sows two times and 54 sows once (behaviour observations n = 188).
The total space allowance in the integration pen was 69 m². After the initial period the integration pen was included into the dry sow area and the total space allowance there was 170 m². Due to different group sizes the space allowance per sow varies

from 3.3 to 4.1 m². The area was equipped with two electronic sow feeding stations (En-Sta GmbH, Beckum, Germany). For enrichment two scratch brushes, two balls and four chains were installed. Panels divided the pen into lying and excretion area. The feed rations were calculated by the feeding computer in relation to the stage of pregnancy. Therefore, the rations varied from 1.9 to 3.1 kg feed per sow and day. The feed ingredients were 44 % barley, 34 % wheat, 10 % high protein soybean meal, 9 % supplementary and mineral feed and 1 % soybean oil. Energy content was 12.51 MJ ME per kg feed. Reproduction parameters were obtained from the farm log book. The live born piglets were individually weighed within the first 4 days after birth, the second weighing was done at weaning.

Behavioural observations

All behavioural observations, including video analyses as well as scoring of the lesions and behaviour was done by one person. Tests were designed to cause a minimum of labour costs and disturbance of the daily work flow to meet requirements of commercial farming and breeding.

Observations on aggressive behaviour

Behavioural observations in the group housing were done by video recording the sows post mixing in the integration pen. Therefore, four video cameras were installed in order to observe the whole area. Before video recording started, sows were marked with large numbers on their backs and sides to identify the individuals when analysing the video. The observation was continuously done for 3 h starting at the moment when the first sow entered the integration pen.

The video tapes were digitalized and the videos were analysed by using the VLC media player (Version 0.9.6; VideoLAN organisation, Paris; 1996-2008). During the first 3 h after mixing the occurrences of all agonistic interactions were recorded as described in Table 1. An aggressor was defined as an individual who bit or snaped at another sow (receiver). If the receiver bit back, this was additionally recorded as reciprocal fight. If the receiver escaped, record was only made of the aggressor and the receiver. To further differentiate more aggressive and less aggressive sows, two classes were built in adaption from earlier studies (e.g. D'Eath et al., 2010) and based on the behavioural observations at mixing. Group 1 included individuals recorded more than five times as aggressor and less than six times as receiver; group 2 included individuals recorded more than five times as receiver and less than six times as aggressor.

Table 1

Description of traits and ethogram of aggressive behaviour patterns (adapted from Martin and Bateson, 1993, Turner et al., 2006a).

Parameter	Description
Agonistic interaction	Biting of another conspecific which evoked a reaction of the receiver (counterstrike or escape)
Aggressor	Initiator of the agonistic interaction
Receiver	The attacked sow
Non-reciprocated aggression	Receiver escaped
Reciprocal fight	Receiver defended itself (e.g. by biting back)

Skin lesion score

Before moving the sows from the dry sow area to the farrowing barn, they were washed for hygiene and health reasons. This cleaning had the positive side-effect that skin lesions could be categorized easily. For evaluating the skin lesion the body of the sow was divided into three parts on both sides: front, middle, and rear. Every body region was evaluated by using the following 4-score scale: no scratches (1); less than 5 scratches (2); 5–10 scratches (3); more than 10 scratches (4) (Turner et al 2006a; Brown et al. 2009).

Separation test

The sows' reaction to the separation from their litter was observed within the first 4 days after birth and approximately 14 days later. The sows' body position was recorded twice per each test and five categories were differentiated: (1) lying on her side, (2) lying on her belly, (3) sitting, (4) standing or (5) eating/drinking. The first observation was made before separate the piglets from their mother and the second one after returning the first three piglets back to their dam. While the piglets were picked up out of the farrowing pen, the sow's maximum reaction was evaluated (Table 2). Apart from the reactions categorised by the body position (score 1–4), score 5 represented aggressive behaviour against the stockman within the limited possibilities of the farrowing crate (Hellbrügge et al., 2008).

Table 2

Description of sows' reaction at the separation test (Hellbrügge et al., 2008).

Score	Definition
1	No reaction (e.g.: sow remains lying on her side)
2	Little reaction (e.g.: sow raises head)
3	Medium reaction (e.g.: sow sits up)
4	Strong reaction (e.g.: sow stands up, is nervous)
5	Aggressive towards stockperson (e.g.: sow bites or snapes)

Statistical analysis

The analysis was done using the Statistical Analysis System (SAS 9.3; software SAS Institute Inc., Cary, NC; 2002-2010). The skin lesion scores of both sides were pooled for each section and a mean value was calculated, respectively. Therefore, three dependent variables were available for analysis (mean lesion score front, mean lesion score middle, mean lesion score rear). Although skin lesions and maternal abilities were recorded using a scoring system, the underlying behaviour can be assumed to be distributed continuously. Unbalanced, repeated data can be dealt with appropriate statistical techniques such as the mixed model (Cnaan et al. 1997). Therefore, a mixed model including linear and categorical variables was used (PROC MIXED). For the following model the sows were not divided in classes, but the frequencies of being aggressor and receiver as well as the frequency of involvement in reciprocal fights were included as linear variables. Categorical variable was the parity with the following distribution (parity 1, n = 33; parities 2–3, n = 65; parities 4–5, n = 62; more than 5 parities, n = 28) and the group sows were kept in (group 1–7). The group-effect combined on the one hand the group size and on the other hand the individual aggressiveness of the sows in that group. Thus, the final model was:

$$y_{ijklmno} = \text{aggressor}_i + \text{receiver}_j + \text{fight}_k + \text{parity}_l + \text{group}_m + sow_n + e_{ijklmno}$$

where y indicates the skin lesion score for the front, middle or rear body area, respectively. Aggressor, receiver and fight were included as covariates and parity and group as fixed effects; sow is the random factor of the individual animal accounting for repeated observations, and e is the random error.

The mixed model was used for estimating variance components for the skin lesion scores as well as for the number of records as aggressor and receiver and the number of reciprocal fights. Variance components were used to calculate repeatabilities according to Bourdon (2000). Data of agonistic interactions and reciprocal fighting were log10-transformed twice to improve normality. Pearson correlation coefficients were calculated excluding repeated measurements per animal.

Results

Observations of aggressive behaviour

In Table 3 behavioural traits recorded by video analysis are presented. The wide range of the parameters indicates great differences in the aggressive behaviour of the individuals. For example, the number of agonistic interactions per sow ranged from 0 to 37 with a mean of 7.2 ± 5.1.

Table 3

Mean, standard deviation (SD), minimum and maximum for behavioural parameters, observed during first 3 h after mixing in the integration pen (n = 188).

Parameter	Mean	SD	Minimum	Maximum
AI per observation	53.1	17.3	32	97
AI per sow	7.2	5.1	0	37
Initiated AI per sow	3.5	4.3	0	33
Being attacked per sow	3.6	3.0	0	21
Reciprocal fights per sow	1.7	2.0	0	14
Non-reciprocal attacks per sow	2.7	3.7	0	30

AI: agonistic interactions

Skin lesion score

The scores for skin lesions in the front (head, ears, shoulder and neck) ranged from score 1 to 4 and the mean value (± SE) was 2.7 ± 0.1. The receiving animals were evaluated with higher scores for skin lesions in the cranial section ($F_{1,68}$ = 4.23; p = 0.0435). The score increased by 0.04 ± 0.02 scores per additional attack. However, there was a tendency that animals involved in reciprocal fights 3 h post mixing had decreased lesion scores ($F_{1,68}$ = 3.01; p = 0.0871). The number of times an individual acted as an aggressor did not affect the skin lesion score ($F_{1,68}$ = 0.01; p = 0.9094). Furthermore significant differences could be assessed for parity class ($F_{3,68}$ = 4.02; p = 0.0108) (Fig. 1) and group ($F_{6,68}$ = 2.65; p = 0.0228).

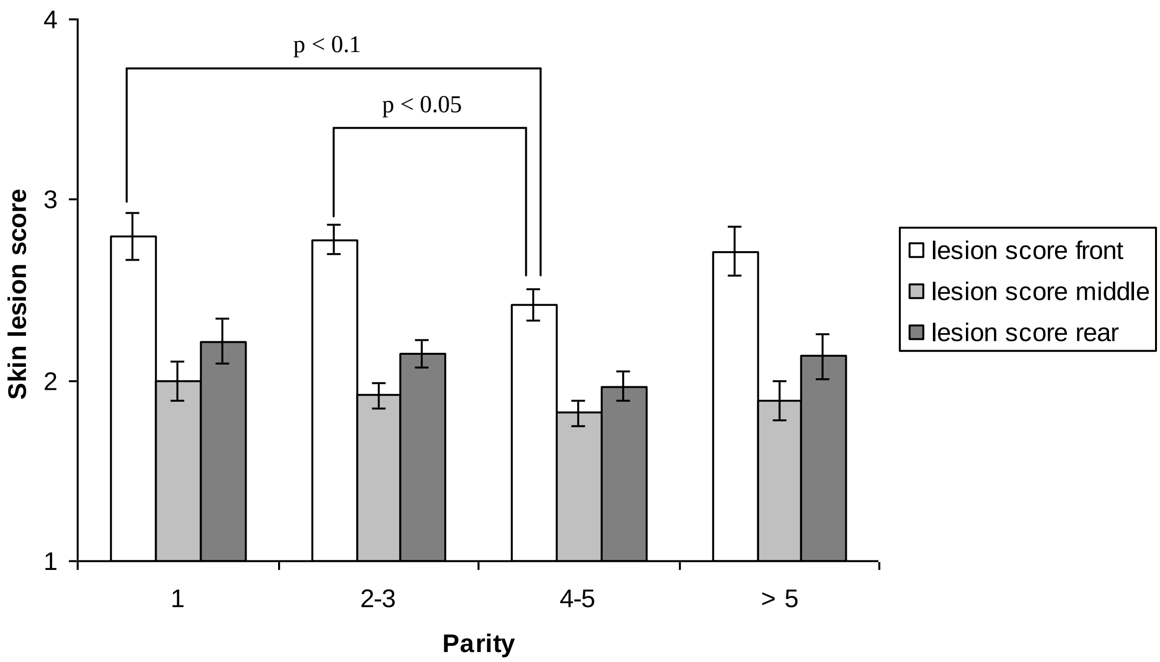

Figure 1. LS-Means ± SE for skin lesion scores according to the parity class (statistical comparisons were conducted within body area (front/middle/rear))

The overall mean (± SE) for the middle region (back, flank and teats) was 1.9 ± 0.1. None of the independent variables showed a significant influence on the extent of the skin lesions.

The third score (rump, haunches and vulva) for skin lesions had a mean (± SE) of 2.1 ± 0.1. Further results were similar to the results of skin lesion score middle. The frequencies of being involved in fights as an aggressor, receiver or in reciprocal fights did not significantly influence skin lesion scores in the caudal region. Also, there were no differences in caudal skin lesions between parity classes ($F_{3,68}$ = 1.52; p = 0.2159). However, the group affected significantly the skin lesion score rear ($F_{6,68}$ = 3.81; p = 0.0025).

Repeatability

For skin lesion score front, middle or rear a repeatability of r = 0.26, r = 0.34 and r = 0.29, respectively, were estimated. Furthermore, repeatability estimates for number of records as aggressor was r = 0.29, as receiver r = 0.09 and for the number of reciprocal fights, r = 0.27.

Table 4

Mean and standard deviation (SD) for more aggressive (≥ 6 initiator of AI and < 6 receipt of AI: n = 49) and less aggressive sows (≥ 6 receipt of AI and < 6 initiator of AI: n = 38) of reproductive parameters measured for the litter subsequent to behavioural observations.

	More aggressive sows		Less aggressive sows	
Parameter	Mean	SD	Mean	SD
Total born	11.3	3.6	10.7	2.9
Live born	11.0	3.5	10.4	2.9
Stillborn	0.3	0.7	0.3	0.7
Total weaned	9.9	3.0	9.5	2.7
Total losses	1.4	1.7	1.2	1.6
Average birth weights	2.1	0.3	2.1	0.3
Average weaning weights	8.4	1.4	8.7	1.1

AI: agonistic interactions; Total born: total number of mummified, stillborn and live born piglets; Live born: total number of viable and nonviable live born piglets; Stillborn: total number of mummified and stillborn piglets; Total weaned piglets: total number of weaned piglets after 28-day lactation period; Total losses: difference between total born and total weaned piglets; Average birth weight: sum of birth weights divided by total number of weighed live born piglets; Average weaning weight: sum of weaning weights divided by total number of weaned piglets.
Reproductive parameters in piglets per litter; weights in kg.

Correlations between behaviour traits

Due to autocorrelation, highly significant correlations were found between the number of reciprocal fights and the number of records as aggressor (r_p = 0.52, p < 0.001) or receiver (r_p = 0.32, p < 0.001). Furthermore, the number of records as receiver correlated positively with skin lesion score front ($r_p = 0.29$, $p < 0.01$), middle ($r_p = 0.31$, $p < 0.001$) and rear ($r_p = 0.19$, $p < 0.05$). A negative correlation between cranial skin lesion score and behaviour at the second separation test was found ($r_p = -0.28$, $p < 0.01$).

Table 5

Pearson correlations between behaviour and reproductive traits (n = 112)

Reproductive traits	Aggressiveness						Handling	
	AGG	REC	RF	LSF	LSM	LSR	BS1	BS2
Total born	0.20	–0.05	–0.01	–0.28	–0.20	–0.16	0.15	–0.05
	*	n.s.	n.s.	**	*	n.s	n.s.	n.s.
Live born	0.19	–0.04	0.01	–0.31	–0.23	–0.18	0.14	–0.03
	*	n.s.	n.s.	***	*	n.s.	n.s.	n.s.
Stillborn	0.11	–0.07	–0.05	0.01	0.03	–0.01	–0.06	–0.08
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Total weaned	0.08	0.03	–0.10	–0.16	–0.12	–0.01	0.08	–0.13
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Total losses	0.21	–0.13	0.13	–0.23	–0.15	–0.25	0.11	0.10
	*	n.s.	n.s.	*	n.s.	*	n.s.	n.s.
Average birth weights	0.01	0.09	–0.14	0.28	0.16	0.38	–0.07	–0.13
	n.s.	n.s.	n.s.	**	n.s.	***	n.s.	n.s.
Average weaning weights	0.05	0.01	–0.01	0.24	0.14	0.12	–0.02	–0.01
	n.s.	n.s.	n.s.	**	n.s.	n.s.	n.s.	n.s.

AGG: aggressor of an agonistic interaction; REC: receiver of an agonistic interaction; RF: reciprocal fight; LSF: skin lesion score front; LSM: skin lesion score middle; LSR: skin lesion score rear; BS1: behaviour at the first separation of the litter; BS2: behaviour at the second separation of the litter. Total born: total number of mummified, stillborn and live born piglets; Live born: total number of viable and nonviable live born piglets; Stillborn: total number of mummified and stillborn piglets; Total weaned piglets: total number of weaned piglets after 28-day lactation period, Total losses: difference between total born and total weaned piglets; Average birth weight: sum of birth weights divided by total number of weighed live born piglets; Average weaning weight: sum of weaning weigts divided by total number of weaned piglets.

n.s.: not significant.

*p < 0.05

**p < 0.01

***p < 0.001

Correlations between behaviour and reproduction traits

Means and standard deviations for reproductive performance of more aggressive and less aggressive sows are shown in Table 4. More aggressive sows give birth to more total born piglets. Table 5 presents the phenotypic correlations between the behaviour and performance traits. Similar to the presented means in Table 4, the correlations show that sows initiating frequently attacks had more total and live born piglets which also led to higher losses. Skin lesion scores show a number of significant correlations to reproduction traits. Generally, the higher the scores for skin lesion (i.e. the more wounds) the lower the litter performance of the sows are. However, the lower number of live born piglets per litter probably led to fewer losses during rearing and higher average weights of the piglets of sows with higher skin lesion scores.

Discussion

Skin lesion score

Skin lesions have been used in several studies to estimate individual aggressiveness of pigs and the results showed that aggressive behaviour and the extent of skin lesions are related (Turner et al., 2006a, 2006b, 2009; Stukenborg et al., 2011). Based on these studies one could deduce that skin lesions could be used as an indicator for aggressiveness for breeding calm and docile pigs. In previous studies moderate to high heritabilities were found (e.g. Løvendahl et al., 2005; Turner et al., 2006b, 2009). However, the results for the relationship between skin lesions and individual aggressiveness of pigs were not universally detected. Turner et al. (2006a) found that the duration spent in reciprocal fights and being bullied were significant determinates of skin lesion scores. Genetic correlations were estimated between skin lesions in the anterior region of the body 24 h post mixing and aggressive behaviour (e.g. reciprocal fighting r_g = 0.67, receipt of non reciprocal aggression r_g = 0.70) (Turner et al., 2009). In the study by Stukenborg et al. (2011) growing pigs with increased lesion scores 48 h post mixing had more fights per pig, a longer overall fight time and initiated more fights ($p < 0.05$) directly after weaning than 40 days later. The cranial area was identified as the main region of skin lesions (Stukenborg et al.,

2011) which agrees with the finding by Turner et al. (2009) as well as our present study. Overall, there is significant evidence that aggressive pigs which initiate agonistic interactions or were involved in reciprocal fights have more skin lesions immediately after mixing, but likewise the skin lesion score of receivers of non reciprocal aggressions increased (Turner et al., 2006a, 2009). Turner et al. (2006a) suggested that the skin lesion score methodology has benefits for recording behaviour traits of a large sample size; however several aspects still remains unexplained. Our results did not show a significant effect of being the initiator of agonistic interactions (aggressor) on the skin lesion score. Instead, there was rather significant evidence that the receipt of aggressions (receiver) is associated with more skin lesions. Contrary to the results of previous studies, a tendency was found that the involvement in reciprocal fights post mixing led to lower skin lesion scores after 71 d in the dry sow area.

Two main aspects could explain differences of these results compared to earlier studies. Due to aim of fitting data collection into the workflow typical for commercial conditions the evaluation of the skin lesion scores was done 71 d post mixing and the sows were regrouped with their conspecifics of the large dynamic group in the dry sow area. Thus, the recorded skin lesions showed the animal's involvement in agonistic interactions post mixing of the large group rather than just the initial period after group housing in small groups where direct observations of aggressive behaviour took place. Pigs` renewal of skin takes 30 days (Meyer, 1996). Therefore, our skin lesion score does not represent the lesions and wounds originating from the initial post mixing aggression. Thus, although both skin lesions and aggressive behaviour showed moderate long-term (> 4 months) repeatabilities within the variables, phenotypic correlations between aggressive behaviour and skin lesion score assessed 10 weeks later were low or non-existent. Therefore, skin lesions scores cannot be recommended as a general indicator of individual aggressiveness.

Furthermore, the remixing of the groups obviously led to agonistic interactions between the introduced sows and the sows of the large group. The total number of agonistic interactions will likely increase because of the large number of individuals that need to re-establish the social order in a group size of up to 70 sows. However, a large number of individuals does not inevitably lead to increased aggressions, as pigs which were previously housed in groups of 80 animals showed reduced levels of aggressiveness towards unfamiliar conspecifics (Turner et al., 2001).

There are more factors influencing the extent of skin lesions than just the individual aggressiveness of pigs. The level of aggressiveness is also affected by the pigs' level of familiarity, pen effects, environment and space or group sizes (e.g. Ewbank and Bryant, 1972; Fraser, 1974; Turner et al., 2001, 2006a; D'Eath, 2002; Hoy and Bauer, 2005). In our study the extent of skin lesions was significantly affected by the parity and the group. The parity is linked with age and body weight of the sows, and heavier as well as adult sows are dominant to lighter animals (Arey, 1999; O'Connell et al., 2003) or sub-adults and juveniles (D'Eath and Turner, 2009), respectively. Low ranking sows have more skin lesions than high ranking sows (Borberg and Hoy, 2009) and our results give evidence that the dominant sows mainly were those that farrowed four or five times (Fig. 1). The group sows were kept based on their stage of pregnancy, affected the skin lesion scores. The common housing of aggressive individuals obviously leads to increased aggressions within the whole group (D'Eath, 2002). A pen effect was also found by previous studies (Turner et al., 2006a, 2009; D'Eath et al., 2009). To overcome the problem, that pigs will always strive to establish a social order via fighting, even if the most dominant individual is removed, the group selection theory of Griffing (1967) seems to be a possible approach for the breeding of calm and less-aggressive pigs. With the procedure of group selection, each sire family is housed as a group and selected or rejected as a group (Muir, 1996). Griffing (1967) suggested that with competition not only the direct effects of the genes of an animal must be considered, but also the associate contributions from other genotypes in the group to optimise production of a given genotype in a competitive environment. Group selection has previously been used successfully in poultry to reduce aggression and increase production (e.g. Craig and Muir, 1996; Hester et al., 1996; Muir, 1996). Group selection could also have benefits for swine breeding due to the competitive environment in pig production (Muir, 2001) and might be a possible strategy for breeding calm and docile pigs using skin lesions as an indicator for aggressiveness to improve animal well-being (Muir, 1996). However, further investigations are necessary to test the feasibility of this approach.

Correlations between behaviour and handling traits

Earlier studies found evidence for relationships between aggressive behaviour at mixing and animals' response to other challenging situations (e.g. Thodberg et al., 1999; Ruis et al., 2000; D'Eath et al., 2009). This relationship could be supported in tendencies by our results. A correlation of r_p = –0.28 (p < 0.01) was calculated between skin lesion score front and the sow's behaviour at the second litter removal. However, there were no significant phenotypic correlation between records of agonistic interactions and sow's reaction at the second separation of their litter. These results agree with the findings of Hellbrügge et al. (2008) who likewise found no phenotypic correlations between aggressive behaviour and separation tests. However, genetic correlations indicated that aggressive sows in the group were more responsive towards the separation from their litter (Hellbrügge et al., 2008). A relationship between skin lesions and behaviour in the sepration test was only demonstrated for the second separation test in the present study, but sows seem to be less reactive during the first separation from their litter because of the aftermath of the parturition (Hellbrügge et al., 2008). Nevertheless a selection against aggressiveness using skin lesion scores probably slightly affects the behaviour of sows towards stockmen.

Correlations between behaviour and reproductive traits

Agonistic interactions negatively affect the reproductive performance of sows. Cronin et al. (1996) found evidence that sows housed in groups during gestation had a higher number of stillborn piglets compared to individually housed sows. Sows housed socially in small (5 animals) or large groups (38 animals) gave birth to less alive born and more mummified piglets (Broom et al., 1995). These results suggested a negative effect on the gestation by agonistic interaction in the group housing.
In our study sows which initiated frequently agonistic interactions had more total born and alive born piglets based on both the correlations (Table 5) as well as the group-differences when distinguishing between more and less aggressive sows (Table 4) and similar relationship was found earlier for litter size and dominance rank (Hoy et al., 2009). Genetic correlations between aggressiveness of sows in the group and for example total born (r_g = 0.15) and live born piglets (r_g = 0.16) (Hellbrügge et al., 2008) confirmed this unfavourable association. The skin lesion score reflects agonistic interactions of the group housing period of 71 days. Overall, the sows which were frequently attacked at mixing and later evaluated with higher skin lesion scores,

produced fewer piglets. This result shows the implications of aggressiveness on animal welfare and performance.

Conclusions

Our results showed that animals being attacked more frequently had an increased number of skin lesions, and skin lesions showed reasonable long-term consistency (> 4 months). However, higher skin lesion scores were neither significantly influenced by frequency of being an initiator of an agonistic interaction nor of being involved in reciprocal fights. Therefore, the skin lesion score does not represent the overall individual aggressiveness of sows under commercial conditions and is inadvisable for use as a selection tool in breeding programmes of swine. Nevertheless, correlations between sows' skin lesions and fertility (e.g. live born piglets) were evident, confirming the importance of skin lesions as a general indicator of pig performance and welfare.

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KAPITEL 5

Genetic parameters for pigs' behaviour in different tests for handleability and aggression as well as links to performance

Prepared for submission
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Genetic parameters for pigs' behaviour in different tests for handleability and aggression as well as links to performance

Uta König von Borstel [a,*], Björn Tönepöhl [a,**], Anne K. Appel [a], Barbara Voß [b], Horst Brandt [c], Matthias Gauly [a]

[a] Department of Animal Science, Livestock Production Systems, Georg August University Göttingen, 37075 Göttingen, Germany

[b] BHZP GmbH, 21368 Dahlenburg-Ellringen, Germany

[c] Institute for Animal Breeding und Genetics, Justus Liebig University Giessen, 35390 Giessen, Germany

* corresponding author: Tel. +49 551 39 10139; fax: +49 551 39 5587.

E-mail address: koenigvb@gwdg.de

** corresponding author: Tel. +49 551 39 5612; fax: +49 551 39 5587.

E-mail address: btoenep@gwdg.de

Abstract

Associations (phenotypic and genetic correlations) between different behaviour tests and indicators for behaviour patterns as well as heritabilities of those traits are important for the integration of handleability and less-aggressive behaviour into breeding programmes of swine. Therefore, the behaviour and indicators of behaviour of 976 pigs (814 Pietrain x German Landrace crossbred, 162 German Landrace purebred) were recorded at different ages using several tests under commercial farm conditions. For each pig observations of two backtests, weighing behaviour at three points in life and two skin lesions scores as an indicator for aggressions were collected. Furthermore, correlations to performance traits were analysed. Heritabilities for behavioural traits ranged from 0.02 to 0.36 suggesting that most of the traits were useful for genetic selection (e.g. backtest 2 (BT2): $h^2 = 0.36 \pm 0.08$; finishing pig scale score: $h^2 = 0.20 \pm 0.07$). A short-term consistency of behaviour (14 d) was found between backtest 1 (BT1) and BT2 ($r_p = 0.30$; $r_g = 0.84 \pm 0.11$) and there was an association ($r_p = 0.13$; $r_g = 0.57 \pm 0.21$) between BT2 and the rearing pig scale score (RSS). Selection on calmer behaviour on the scale (RSS) seemed to be possible using BT2 as indicator trait. However, the backtest needs high labour and time input, especially for large number of animals, and together with the overall weak relationships towards the other traits, this indicator appears to be not useful for selection purposes. Furthermore, only weak associations between weighing behaviour at different ages as well as no relationships among weighing behaviour and skin lesions were found. The pigs' reactions in different test situations were very inconsistent regarding the overall low phenotypic and genetic correlations of our study. However, there was a tendency that pigs which had more skin lesions at the end of the rearing period gained better (e.g. daily gain finishing period vs. skin lesion score before mixing: $r_g = 0.43 \pm 0.25$).

Keywords: backtest, behaviour, genetic parameters, pig, correlations, weight gain

Introduction

Public concern about well-being of farm animals increased (Arey and Edwards, 1998; Brown et al., 2009) leading to considerable changes in pig production systems. Requirements for pig housing (e.g. group housing of pregnant sows) and welfare (e.g. manipulating objects) were passed (2008/120/EG). However, there are also structural changes in livestock farming. Herd sizes increases and new housing systems with higher levels of automation are used (Hoy, 2005; Marquer, 2010). Overall, pig housing systems will be characterized by group housing which leads inevitably to agonistic interactions within the group (Meese and Ewbank, 1973), and due to less human-animal-interactions, the pigs not get used to human beings (Boivin et al., 1992; Boissy et al., 2005). The need for calm and docile pigs increases to reduce stress for the animals at handling or mixing procedures.
Due to heritabilities of behaviour and its indicator traits (e.g. Turner et al., 2006b; Velie et al., 2009; Holl et al., 2010) the integration of behavioural traits into pig breeding programmes appears to be a possibility to enhance animal welfare by breeding docile pigs (Erhard et al., 1997; D'Eath et al., 2009). However, associations between different behaviour traits must be identified to get further information about the consistency of animal's behaviour. The results of earlier studies show phenotypic as well as genetic relationships among different behaviour tests. Aggressive behaviour at mixing is genetically associated with the response to handling in pigs (D'Eath et al. 2009). There were also phenotypic associations

between the number of escape attempts in the backtest and the results of a social confrontation test (Hessing et al., 1993) as well as the results of pigs' behaviour towards novel objects/situations (e.g Van Erp-van der Kooij et al., 2002; Brown et al., 2009). Over a short period pigs responded consistently to a specific challenge, but not when challenging in a different context (Spoolder et al.,1996). In conclusion, a short-term consistency of behaviour using different behaviour tests could be indicated and there were evidence for genetic associations between different behavioural traits. Furthermore, the results of earlier studies (e.g. Turner et al., 2006b; Velie et al., 2009; Holl et al., 2010) suggest an association between behaviour and performance traits which have to be estimated before using behaviour traits for selection purposes.

The aim of the presented study was to estimate phenotypic and genetic correlations between behaviour during backtest, weighing behaviour, skin lesion scores and weight gains. The results shed light on the association between the behaviour traits as well as short-term and long-term consistency of pigs' behaviour. Furthermore, heritabilities of behaviour traits were estimated for the swine population under study.

Materials and methods

Animals and housing

The investigation was carried out using 976 pigs. Among them were 814 Pietrain x German Landrace crossbred (418 castrates and 396 females), 162 German Landrace purebred (92 castrates and 69 females). The pigs descended from 135 sows and 31 boars. Pigs were selected for present study, when involved in all behaviour tests, i.e. animals with incomplete information were excluded. Thus, behaviour characteristics from suckling piglet to slaughtering pig were recorded for each animal. Pedigree data included two generations back, resulting in a total of 1.688 animals in the pedigree.

The animals were housed under commercial farm conditions at the research farm of University of Göttingen. The piglet production followed a 3-week cycle with a 28-day lactation period. First the piglets were penned with littermates in the farrowing pen with fully perforated plastic floors. The total space allowance in the farrowing pen was 5 m² including the farrowing crate of the sow and the creep area (0.65 m²). According to German standard procedures iron injections, tail docking and castrating of male piglets was conducted during the piglets' first 3 d after birth. Furthermore, each piglet was tattooed on the right ear for individual identification. At weaning, the pigs were additionally marked by an ear tag, before the animals were taken into rearing quarters and mixed with unfamiliar conspecifics, when necessary. The group sizes there were either 10 (3.57 m²), 30 (11.1 m²) or 41 (15.5 m²), and the floor was fully perforated. For investigation and manipulation activities either a plastic star on a chain or a piece of wood on a chain was available per every 10 animals in the pens. The feeding systems included dry feeders, wet dry feeder and drinking nipples. Rearing ensued up to a body weight of 40 kg. Then the pigs were moved into the finishing barn, where they were either housed in groups of 12 (9.3 m²), 24 (18.6 m²), and 36 (27.9 m²) animals or in a large group of 120 (75.9 m²) pigs with automatic sorting and feeding systems. In both systems dry feeders and drinking nipples as well as fully slatted concrete floors were installed. Plastic stars on a chain were available as enrichment items. The finishing pigs were slaughtered at a live weight of approximately 115 kg. Water and feed was available ad libitum for pigs during the fattening with the exception of the small groups in the finishing barn. In the latter case, the pigs were fed twice a day. Production information was obtained from the farm log book. Daily gains for suckling (PDG), rearing (RDG), and finishing period (FDG) as well as average daily gain of lifetime (ADG) were available.

Behavioural observations

All behavioural observations, including backtests as well as scorings of the lesions and behaviour were done by one person. Tests were designed to cause a minimum of labour costs and disturbance of the daily work flow to meet requirements of commercial farming and breeding. Therefore, behavioural observations were integrated into common procedures (e.g. weighing).

The backtest was performed first between 1 to 4 d of age (BT1) and again between 15 to 19 d of age (BT2), i.e. for each piglet 14 d after the first backtest. For this procedure, piglets were separated from their dam. Then each piglet was individually turned on his back and restrained for 30 seconds in this supine position (Hessing et al., 1993). The total number of attempts to struggle was recorded. Each series of struggling without a break was counted as one escape attempt.

Table 1

Definition of scores for handling (adapted from Grandin, 1993; Yoder et al., 2011) and aggressiveness (adapted from Turner et al., 2006a; Brown et al., 2009).

Behaviour trait	Score	Definition
Handling (load scores)	1	The pig enters the scale without hesitation
	2	The pig hesitates briefly before entering
	3	The pig refuses to entering; tries to escape
Handling (scale scores)	1	Calm; no/very little movements
	2	Exited; slow movements
	3	Very exited; fast movements
Aggressiveness (skin lesions)	1	No lesions
	2	Several lesions (i.e. less than 5 scratches)
	3	Many distinct lesions (i.e. 5 to 10 scratches)
	4	Wounds, lesions all over the body

Table 2

Time-line of the experimental procedures.

Area	Farrowing					Rearing		Finishing	
Week	0	1	2	3	4	5-10	11-15	16-22	23-27
Procedure	B				W		F		S
Behaviour		BT1		BT2	PSS		RLS RSS LS1	LS2	FLS FSS

B: birth; W: weaning, start of rearing period; F: start of fattening period; S: slaughtering; BT1: backtest between 1 to 4 d of age; BT2: backtest between 15 to 19 d of age; PSS: piglet scale score; RLS: rearing pig load score; RSS: rearing pig scale score; LS1: skin lesion score before mixing; LS2: skin lesion score 24 h post mixing; FLS: finishing pig load score; FSS: finishing pig scale score.

All observations for handling behaviour were recorded as described in Table 1. At weaning the behaviour of the animals on a scale for piglets (Satorius, Göttingen, Germany) was observed for 30 seconds and evaluated with a score from 1 to 3 (PSS). A second weighing was done when moving the pigs from rearing quarters into the finishing barn using a commercial pig scale (Texas Trading, Windach, Germany). During this handling procedure, the behaviour of each pig was scored twice: (a) while the handler placed the pig onto the weighing scale (RLS) and (b) during its first 30 s on the scale (RSS). Both scores rated the pig's agitation from low (1) through to high (3) (Table 1). The extent of skin lesion and wounds was evaluated using a score from 1 to 4 (LS1) (Table 1). The recording of the skin lesion scores was rerun 24 h post mixing (LS2). Before loading the slaughtering pigs on a vehicle for sale, the animals were weighed for the last time. Test procedures were similar to the second weighing including a behaviour score for loading onto the scale (FLS) and while weighing (FSS). The time-line of the experimental procedures is shown in Table 2.

Statistical analyses

The data from behaviour tests and the production information were analysed with a mixed model using the statistical software SAS package (SAS 9.3; software SAS Institute Inc., Cary, NC; 2002-2010). Age and weight at testing were likewise tested for their effects on behaviour variables, but not considered in the further genetic analysis because of low and in the most cases insignificant influences. Due to the commercial conditions, animals were housed in different husbandry systems at rearing and finishing. Therefore, the type of housing was included into the models to analyze the traits recorded during the rearing or finishing period (Table 2). The extent of pigs' skin lesions post mixing is mainly influenced by the number of unacquainted pigs resulting in fights for a new social order (Meese and Ewbank, 1973; Arey and Edwards, 1998). Therefore, four classes were generated regarding the number of unacquainted pigs (no unfamiliar pig; 1–10 unfamiliar pigs; 11–30 unfamiliar pigs; more than 30 unfamiliar pigs). The Model for ADG included the housing at rearing as well as at finishing. All behaviour and production traits were treated as linear variables. Genetic parameters were estimated bivariately using the VCE 6.0.2 software by Kovac et al. (2008).

Thus models for behaviour as well as performance traits including the following effects:

BT1, BT2, PSS, PDG (suckling period):

$y_{ijklm} = sex_i + breed_j + \mathit{litter}_k + \mathit{pig}_l + e_{ijklm}$

RLS, RSS, LS1, RDG (rearing period):

$y_{ijklmn} = sex_i + breed_j + rearing_k + \mathit{litter}_l + \mathit{pig}_m + e_{ijklmn}$

LS2 (finishing period):

$y_{ijklmno} = sex_i + breed_j + rearing_k + merging_l + \mathit{litter}_m + \mathit{pig}_n + e_{ijklmno}$

FLS, FSS, FDG (finishing period):

$y_{ijklmn} = sex_i + breed_j + finishing_k + \mathit{litter}_l + \mathit{pig}_m + e_{ijklmn}$

ADG (lifetime):

$y_{ijklmno} = sex_i + breed_j + rearing_k + finishing_l + \mathit{litter}_m + \mathit{pig}_n + e_{ijklmno}$

where:
y indicates the observation for pig's reaction in the behaviour tests, skin lesions and performance traits
sex is the fixed effect of the gender with two classes (barrow/female)
breed is the fixed effect of the genetic line with two classes (German Landrace/Pietrain x German Landrace)
rearing is the fixed effect of the housing type in the rearing quarters (three classes)
finishing is the fixed effect of the housing type in the finishing barn (two classes)
merging is the fixed effect of the number of unfamiliar pigs post mixing (four classes)
litter is the random permanent effect of the litter
pig is the random effect of the animal
e is the residual effect

Results

Phenotypic means, minima, maxima and standard deviations of the behaviour and performance traits are presented in Table 3. The type of housing system affects the behaviour of pigs. For example, Figure 1 shows the effect of rearing housing system on RSS. Rearing pigs housed in groups of ten animals were more passive while weighting and scored with significant lower scores compared to animals of larger groups.

Table 3

Phenotypic mean, minimum, maximum and standard deviation (SD) of behaviour and performance traits

Trait	Mean	Minimum	Maximum	SD
Backtest 1	2.43	0	8	1.20
Backtest 2	2.46	0	9	1.19
Piglet scale score	2.00	1	3	0.76
Rearing pig load score	1.84	1	3	0.80
Rearing pig scale score	1.99	1	3	0.77
Finishing pig load score	1.45	1	3	0.68
Finishing pig scale score	1.49	1	3	0.67
Skin lesion score 1	2.25	1	4	0.76
Skin lesion score 2	2.86	1	4	0.87
Daily gain suckling period	224	29	404	53
Daily gain rearing period	413	191	651	67
Daily gain finishing period	760	339	1096	104
Daily gain lifetime	600	435	744	53

Backtest: number of attempts to struggle; Weighing behaviour: score 1–3; Skin lesions: score 1–4; Daily gains: grams.

Heritabilities

Variance components and heritabilities are presented in Table 4. For a few traits (e.g. RLS, PDG) the additive genetic variance was very low and heritabilities for these traits were not significantly different from zero. Furthermore, as a result of the low additive genetic variance, genetic correlations of these traits towards other traits were in most cases near 1 or –1. Therefore, these results were not included in Table 4.

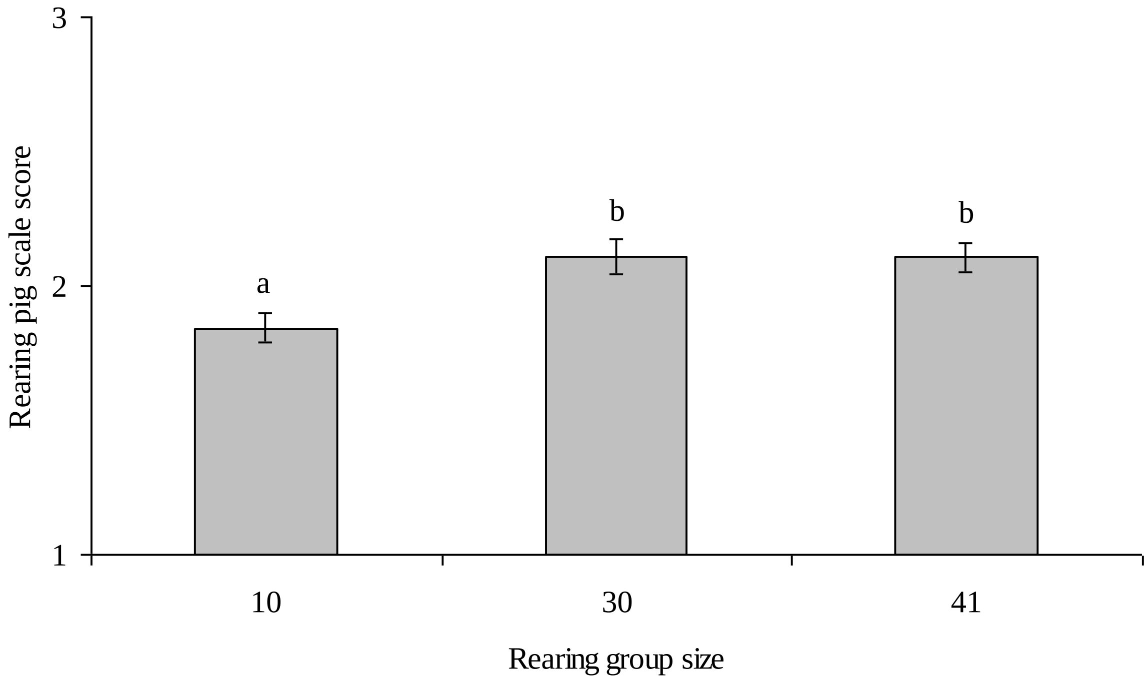

Figure 1. Effect of group size including different housing types at rearing on rearing pig scale score (Different letters indicate significant differences at $p < 0.001$).

The highest heritability was estimated for FDG ($h^2 = 0.57 \pm 0.13$) and the lowest for FLS ($h^2 = 0.02 \pm 0.03$). Heritabilities for behavioural traits ranged from 0.02 to 0.36. Between heritabilities for daily weight gain great differences are shown due to high litter effects for PDG and RDG ($\sigma^2_{LE} = 0.39 \pm 0.04$; $\sigma^2_{LE} = 0.38 \pm 0.06$).

Correlations between behaviour traits

Table 5 shows the genetic correlations between backtests, scale scores and lesion scores. Due to the high standard errors results are frequently not different from zero (Table 4). However, genetic correlations between BT1 and BT2 were $r_g = 0.84 \pm 0.11$ and between BT2 and RSS $r_g = 0.57 \pm 0.21$. LS1 was genetically correlated with LS2 ($r_g = 0.56 \pm 0.25$). Among RLS and RSS genetic correlations of $r_g = -0.45 \pm 0.31$ were estimated. Genetic correlations of PSS with other traits have to seen with caution due to extremely low additive genetic variance of PSS (Table 4).

Table 4.
Estimates of additive genetic variance (σ^2_A), common environmental litter variance (σ^2_{LE}), residual variance (σ^2_e) and heritability (h^2) for behaviour and performance traits.

Traits	σ^2_A	σ^2_{LE}	σ^2_e	h^2
Behaviour traits				
Backtest 1	0.32	0.12	1.04	0.22 ± 0.10
Backtest 2	0.52	0.08	0.87	0.36 ± 0.08
Piglet scale score	0.04	0.13	0.46	0.07 ± 0.07
Rearing pig load score	0.05	0.04	0.55	0.04 ± 0.06
Rearing pig scale score	0.07	0.02	0.48	0.12 ± 0.05
Skin lesion score 1	0.08	0.05	0.43	0.14 ± 0.06
Skin lesion score 2	0.07	0.09	0.45	0.12 ± 0.07
Finishing pig load score	0.02	0.00	0.44	0.02 ± 0.03
Finishing pig scale score	0.09	0.00	0.33	0.20 ± 0.07
Performance traits				
Suckling period daily gain	123.18	1150.99	1711.92	0.04 ± 0.06
Rearing period daily gain	291.59	1620.19	2355.43	0.07 ± 0.09
Finishing period daily gain	5977.52	1093.16	3450.46	0.57 ± 0.13
Average daily gain lifetime	1234.60	308.34	1021.64	0.48 ± 0.11

Phenotypic correlations between behaviour traits were also presented in Table 5. LS1 and LS2 were auto correlated (r_p = 0.64) because lesions that existed during evaluation of LS1 can be expected to be present to almost the same degree during evaluation of LS2. High phenotypic correlation was found between BT1 and BT2 (r_p = 0.30). Overall, the phenotypic correlations between the behaviour traits were low. However, there was an association between number of escape attempts during BT2 and RSS (r_p = 0.13). RLS was negatively correlated with RSS (r_p = –0.14). Furthermore, the scale scores (PSS, RSS, FSS) were slightly correlated (Table 5).

Correlations between behaviour and performance traits

There is only a considerable genetic correlation between FDG and LS1 r_g = 0.43 ± 0.25. The rest of the genetic correlations show high standard errors which are frequently higher than the correlations. Due to low additive genetic variance of PDG and RDG the genetic correlations towards behaviour traits have to seen with caution. Similar, PSS has a very low additive genetic variance, too (Table 3).

There were only considerable phenotypic correlations between LS1 and PDG (r_p = 0.10) as well as RDG (r_p = 0.15). The rest of phenotypic correlations were lower than r_p = 0.10.

Table 5. Estimates of genetic correlations (above diagonal), heritabilities (on diagonal), and phenotypic correlations (below diagonal).

	Handling					Aggressiveness	
	BT1	BT2	PSS	RSS	FSS	LS1	LS2
BT1	**0.22 ± 0.10**	0.84 ± 0.11	–0.24 ± 0.53	0.29 ± 0.30	–0.44 ± 0.30	–0.03 ± 0.33	–0.03 ± 0.11
BT2	0.30	**0.36 ± 0.08**	–0.48 ± 0.65	0.57 ± 0.21	0.05 ± 0.20	–0.01 ± 0.22	–0.46 ± 0.30
PSS	0.03	0.04	**0.07 ± 0.07**	0.63 ± 0.67	0.26 ± 0.41	1.00 ± 0.01	0.41 ± 0.49
RSS	0.04	0.13	0.08	**0.12 ± 0.05**	0.12 ± 0.27	0.41 ± 0.31	–0.44 ± 0.34
FSS	–0.01	0.03	0.06	0.11	**0.20 ± 0.07**	0.25 ± 0.30	–0.02 ± 0.33
LS1	–0.03	–0.03	0.01	0.04	–0.03	**0.14 ± 0.06**	0.56 ± 0.25
LS2	–0.03	–0.05	0.02	–0.03	–0.02	0.64	**0.12 ± 0.07**

BT1: backtest between 1 to 4 d of age; BT2: backtest between 15 to 19 d of age; PSS: piglet scale score; RSS: rearing pig scale score; FSS: finishing pig scale score; RLS: rearing pig load score; FLS: finishing pig load score; LS1: skin lesion score before mixing; LS2: skin lesion score 24 h post mixing.

Table 6. Genetic correlations between behaviour and performance traits.

	Handling					Aggressiveness	
	BT1	BT2	PSS	RSS	FSS	LS1	LS2
PDG	–0.61 ± 0.92	–0.21 ± 0.60	1.00 ± 0.01	0.71 ± 0.77	0.41 ± 0.76	–0.37 ± 0.91	–0.61 ± 1.63
RDG	0.15 ± 0.65	–0.70 ± 0.28	1.00 ± 0.01	1.00 ± 0.01	0.33 ± 0.53	1.00 ± 0.01	0.33 ± 0.55
FDG	–0.07 ± 0.06	–0.05 ± 0.20	0.50 ± 0.42	0.20 ± 0.25	0.14 ± 0.21	0.43 ± 0.25	0.31 ± 0.29
ADG	0.06 ± 0.24	–0.27 ± 0.21	0.67 ± 0.49	0.17 ± 0.26	0.24 ± 0.22	0.33 ± 0.27	0.33 ± 0.29

BT1: backtest between 1 to 4 d of age; BT2: backtest between 15 to 19 d of age; PSS: piglet scale score; RSS: rearing pig scale score; FSS: finishing pig scale score; RLS: rearing pig load score; FLS: finishing pig load score; LS1: skin lesion score before mixing; LS2: skin lesion score 24 h post mixing.

Discussion

Individual differences in behavioural characteristics were shown by previous studies using a number of standardised tests (e.g. Grandin, 1993; Le Neindre et al., 1995; van Erp-van der Kooij et al., 2000; Turner et al., 2006b; Cassady, 2007). However, generally there was only a short-term consistency in individual behaviour (Spoolder et al., 1996; Brown et al., 2009). The association between backtests at different ages in our study (r_p = 0.30) was similar to the findings of previous studies. Van Erp-van de Kooij et al. (2002) found between different backtests at 3 d and 17 d of age a correlation of r_p = 0.31 ($p < 0.001$). However, backtests at 10 d and 17 d of age were associated more strongly with each other (r_p = 0.48, $p < 0.001$) (Van Erp-van de Kooij 2002), perhaps indicating that piglets' behaviour recorded very shortly after birth is influenced to a larger extent by environmental conditions (e.g. level of vigour, time since last suckling bout), compared to later ages. Cassady (2007) performed backtests first between 6 and 10 d of age and again between 13 and 17 d of age. The repeatability of the total number of attempts to struggle was r_p = 0.49 (Cassady, 2007). Repeatability between backtests at 7–14 d of age and 1 week later for total number of attempts to struggle was r_p = 0.21 in a study of Velie et al. (2009). However, other studies did not find associations between backtest parameters (Forkman et al., 1995; Ruis et al., 2000). Overall, the results indicate a short-term consistency regarding the total number of attempts to struggle which agrees with our findings (BT1 vs. BT2: r_p = 0.30; r_g = 0.84 ± 0.11). These relations are often relatively low considering that there is only a short period between the tests. However, there is evidence that backtests performed within 6–17 d of age showed higher correlations compared to backtest correlations in the first days of life (Van Erp-van de Kooij et al., 2002; Cassady, 2007). Due to the body weight of the piglets a practicable use of backtest is only possible up to an age of 4 weeks. Therefore, no results are available for older animals.

In spite of low repeatabilities, piglets are commonly divided into passive or active coping style using the backtest observations (Hessing et al., 1993; Ruis et al., 2000; Van Erp-van de Kooij et al., 2002). Hessing et al. (1993) classified piglets into three categories (resistant: > two escape attempts, intermediate: two escape attempts; non-resistant < two escape attempts) based on the outcome of five successive backtests. Active types (resistant) show more aggression and a higher general activity and passive types (non-resistant) respond more with immobility and avoidance in a challenging situation (Hessing et al., 1993; Ruis et al., 2000). In a social test resistant piglets were the aggressive and the non-resistant piglets the non-aggressive ones (Hessing et al., 1993). Van Erp-van de Kooij (2002) showed contrasting results for association between backtest and human approach as well as novel object test. Higher scores indicated that pigs touched the object or person faster. In the experimental group animals that scored high in the backtest also had high scores for the human approach test. However, there was a trend that pigs struggling more during the backtest scored lower in the novel object test (Van Erp-van de Kooij et al., 2002). No phenotypic correlations between backtest measurements, resident intruder test, human approach test and novel object test were found by Velie et al. (2009). In the presented study highest correlation was found between BT2 and RSS (r_p = 0.13). Piglets, which struggled more frequently, were slightly more active on the scale. However, this association was only found for BT2 and RSS and phenotypic relationships were negligible among backtest, handling and aggressiveness (Table 5).

Earlier results for consistency in behavioural traits varied (Spoolder et al., 1996; Van Erp-van de Kooij et al., 2002; Brown et al., 2009). However, animals' response towards handling seems to be comparably consistent. In a restraint test the behaviour of bulls and steers was recorded four times in a 30 d interval using a scoring system from 1 (calm, no movement) to 5 (rearing, twisting of the body and struggling violently) and the author suggested that agitated behaviour is very persistent over these handling sessions (Grandin, 1993). Similarly, horses' reactions in novel object test while under a rider show high repeatabilities of r = 0.69–0.75 across time (König v. Borstel et al., 2012). Lawrence et al. (1991) conducted several handling tests (e.g. ease of transit) with Landrace and Large White gilts over a 3 h period. The results showed significant positive correlations between handling tests (e.g ease of transit vs. response to sudden human approach: r_p = 0.44, $p < 0.001$). These results give evidence that animals' behaviour towards handling is persistent over time. However, our results could not support these findings. Among the scale scores at different ages (PSS, RSS, FSS) only very low correlations were found (Table 5). The correlation between RLS and RSS was r_p = –0.14 and r_g = –0.45 ± 0.31. Pigs, which refused to enter the scale, were less excited on the scale. This agrees with the findings by D'Eath et al.

(2009). Moving into and leaving the crate was negatively correlated with pigs' behaviour in the crate (D'Eath et al., 2009). Contrary to these results Yoder et al. (2011) found between load and scale score a correlation of $r_p = 0.13$ ($p < 0.01$) for the behaviour of Chester White, Duroc, Landrace and Yorkshire pigs at an age of approximately 185 d. Differences might be affected by the breed and age of the pigs. However, there was no relationship between load (FLS) and scale score (FSS) of slaughtering pigs in our study.

The estimated heritabilities for behaviour traits in this study are comparable to the results of previous studies. The attempts to struggle recorded during the backtest were moderately to highly heritable (Bunter and Landsdowne, 2004; Velie et al., 2009). In our study BT1 shows a lower heritability ($h^2 = 0.22 \pm 0.10$) compared to BT2 ($h^2 = 0.36 \pm 0.08$). D'Eath et al. (2009) estimated heritabilities for load (24 h post mixing: $h^2 = 0.15 \pm 0.02$; end of test period: $h^2 = 0.16 \pm 0.02$) and scale score (24 h post mixing: $h^2 = 0.17 \pm 0.03$; end of the test period: $h^2 = 0.10 \pm 0.02$). Holl et al. (2010) found for scale activity score $h^2 = 0.23$. The results of our analysis yield $h^2 = 0.08 \pm 0.06$ (RLS) and $h^2 = 0.02 \pm 0.03$ (FLS) for load scores as well as for scale scores $h^2 = 0.07 \pm 0.07$ (PSS), $h^2 = 0.12 \pm 0.05$ (RSS) and $h^2 = 0.20 \pm 0.07$ (FSS). Due to very low additive genetic variances PSS, RLS, and FLS seems to be not useful for breeding issues. The extent of skin lesions is heritable. The heritabilities ranged from $h^2 = 0.22 \pm 0.07$ (Turner et al., 2006b) to $h^2 = 0.43 \pm 0.04$ (Turner et al., 2009). However, in this study heritabilities for skin lesion score were lower (LS1: $h^2 = 0.14 \pm 0.06$; LS2: $h^2 = 0.12 \pm 0.07$). Overall, the results show that the majority of behaviour traits might useful for breeding purposes based on their heritabilities, but further issues (e.g. feasibility, validity) have to be taken into account before using these traits for breeding.

Based on the present data, limited conclusions can be drawn from genetic and phenotypic correlations among behaviour and performance traits. Owing the small sample size, generally standard errors for genetic correlations were rather high, frequently resulting in correlations that are not significantly different from zero (Table 6). However, there were phenotypic and genetic correlations between skin lesions and daily gains indicating that higher levels of aggressiveness lead to better performance (LS1 vs. RDG: $r_p = 0.15$; LS1 vs. FDG: $r_g = 0.43 \pm 0.25$). Although a pronounced relationship between skin lesions and individual aggressiveness is not unambiguously detected (e.g. Turner et al., 2006a; Tönepöhl et al., 2013), pigs with more skin lesions were at least involved in reciprocal fights probably caused by limited access to feed. This gives evidence that these pigs have better weight gains due to higher assertiveness at the feeder.

Overall, the results of our study show only strong associations between the backtests (r_p = 0.30, r_g = 0.84 ± 0.11), but between backtests, weighing behaviour and skin lesions no or only weak phenotypic and genetic correlations were found. One exception was the association between BT2 and RSS (r_p = 0.13; r_g = 0.57 ± 0.21). Pigs which struggled frequently during BT2 were more active on the scale at the age of approximately 90 d. Backtest observations at an age of 15 - 19 d are more useful regarding associations towards other behaviour tests and based on the higher heritability for BT2 compared to BT1 (Table 5). These results give evidence that BT2 is a possible indicator for RSS. However, there is only a marginal phenotypic correlation among these traits which indicates inconsistence in the phenotypic expression of the behaviour patterns. Therefore, several recordings of the backtest have to be done to get more reliable information. For example, Hessing et al. (1993) classified piglets based on the results of five backtests and showed relations towards aggressive behaviour. The integration of the backtest procedures into commercial farm conditions is possible, but in our study test time for backtest was 30 s per piglet that led to duration of 360 s for a litter of 12 piglets. In conclusion, regarding our results it seems to be possible using the backtest as indicator for weighing behaviour, but the labour and time input to perform the backtest is very high relative to the limited benefits that can be expected from the incomplete correlations to potentially important traits such as RSS. Overall, the backtest is not feasible as an indicator trait for selection of docile and calm pigs due to the lack of strong associations towards other behaviour tests. There were also no correlations between scale scores at different ages. In earlier studies the authors suggested that different tests measured different dimensions of personality (van Erp-van de Kooij et al., 2002). The individual reaction of animals might be affected by situation (test), but also habituation or altered motivation are important factors (Forkman et al., 2007).

Implications

Breeding of calm and less-aggressive pigs could contribute to improved animal welfare as well as lower stress levels for stockmen at handling pigs. However, the selection of suitable behaviour traits related to handleability and/or aggression is the first important step for integration of these characteristics into breeding programmes. The results of the present study show that there were no useful associations between the backtest as an indicator for behaviour in different behaviour tests as well as skin lesions (indicator for aggressions). Therefore, the recording of behaviour traits is more appropriate at a later point. Due to low residual variance as well as high additive genetic variance, the FSS may be useful for selection on handleability for instance.

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KAPITEL 6

Allgemeine Diskussion

6.1 Einleitung

In der vorliegenden Arbeit wurde überprüft, inwiefern eine Integration von Verhaltensmerkmalen in Zuchtprogramme beim Schwein möglich ist. Dazu wurde zunächst der Einfluss des Haltungssystems auf das Verhalten der Tiere untersucht. Der Schwerpunkt der Arbeit lag allerdings auf der Fragestellung, welche Verhaltensmerkmale als Selektionskriterium geeignet sind und wie diese standardisiert und praxistauglich erfasst werden können. Dafür wurden unterschiedliche Verhaltenstests (z.B. Wiegetest) sowie die Erfassung von Indikatoren (z.B. Hautläsionen) in den Arbeitsablauf eines Betriebes eingegliedert. Sowohl Parameter für die Umgänglichkeit als auch für die Aggressivität der Tiere wurden erfasst und deren Beziehungen zueinander sowie zu Tageszunahmen und Fruchtbarkeitsleistungen berechnet. Außerdem wurde überprüft, ob die erfassten Merkmale Heritabilitäten in einem züchterisch nutzbaren Bereich aufweisen.

6.2 Umwelt

Der Einfluss des Haltungssystems in Kombination mit dem sozialen Umfeld auf das Verhalten von Schweinen konnte in der vorliegenden Studie gezeigt werden (Kapitel 3). Mastschweine, die in 30er Gruppen mit Trockenfutter- und Breifutterautomaten aufgezogen worden sind, waren während der Verhaltenstests aktiver (z.B. in der Waage) und hatten insgesamt auch weniger Hautläsionen verglichen mit Tieren aus 10er Gruppen in deren Buchten nur Trockenfutterautomaten aufgestellt waren. Zu ähnlichen Ergebnissen kamen bereits andere Autoren (z.B. Beattie et al., 1996; Bracke and Spoolder, 2008). Beim Vergleich von eingestreuten und einstreulosen Systemen fielen die Verhaltensunterschiede noch deutlicher aus (Kelly et al., 2000). Für Zwecke der Selektion muss insofern unbedingt die Haltungsumwelt berücksichtigt werden. Weiterhin spielt die Zusammensetzung der Gruppe für das Verhalten des Individuums eine wichtige Rolle. Untereinander unbekannte Tiere bilden durch Kämpfe innerhalb der ersten Tage nach dem Zusammenstallen eine neue Rangordnung (Meese and Ewbank, 1973; Arey and Edwards, 1998). Unklar ist, wie die kognitiven Fähigkeiten von Schweinen verschiedener Rassen in Bezug auf das Wiedererkennen von Artgenossen ausgebildet sind. Bei Wildschweinen bestehen die Gruppen für gewöhnlich aus maximal 30 Tieren (Hoy, 2009) und vermutlich liegt die Anzahl der Artgenossen, die sich ein Schwein merken kann, ebenfalls in diesem Bereich. Obwohl in einigen Studien Hinweise gefunden worden sind, dass größere Gruppen nicht unbedingt zu mehr agonistischen Interaktionen innerhalb der Gruppe führen (Turner et al., 2001), sollte die Gruppengröße unbedingt als Einflussfaktor berücksichtigt werden. Ein weiterer Faktor auf Verhalten der Tiere ist der Tierbetreuer. In früheren Studien wurde das Verhalten von Schweinen verglichen, die vorher positive (z.B. ruhiges Verhalten des Menschen, streicheln) oder negative (z.B. Vertreiben der Tiere mit Elektroschocks) Erfahrungen gegenüber Menschen gemacht hatten. Die Ergebnisse zeigen, dass Schweine mit negativen Erfahrungen deutlich ängstlicher gegenüber Menschen sind (Hemsworth et al., 1986; Pearce et al., 1989; Day et al., 2002). Dies ist vor allem bei der Erfassung von Merkmalen für die Umgänglichkeit der Tiere sehr wichtig.

Daraus folgt, dass die Umweltfaktoren bei der Erfassung von Verhaltensmerkmalen genau zu berücksichtigen sind, d.h. die Merkmalserfassung ist in einer standardisierten Umwelt vorzunehmen (Station), die allerdings die Situation in der Praxis widerspiegeln muss (Genotyp-Umwelt-Interaktionen). Um Verhaltensbeobachtungen für ein Zuchtprogramm zu etablieren, müssen demnach die Beobachtungen an Schweinen durchgeführt werden, die 1) in einer standardisierten Umwelt (Gruppengröße, Haltungssystem, Betreuungspersonal) gehalten worden sind, 2) bei denen die Beziehungen zu anderen Schweinen bekannt sind (Verwandtschaft und Bekanntheitsgrad untereinander) und 3) gleichaltrig sind (Gewicht, Erfahrung u.a. sind vergleichbar). Die Kenntnis der Verwandtschaft und Bekanntschaft der Schweine untereinander ist hier vor allem für die Erfassung von aggressiven Verhaltensweisen wichtig.

6.3 Erfassung von Verhaltensmerkmalen

Verhaltensmerkmale können bei verschiedenen Tierarten mit einer großen Anzahl von unterschiedlichen Tests und Indikatoren erfasst werden (z.B. Grandin, 1993; Le Neindre et al., 1995; van Erp-van der Kooij et al., 2000; Turner et al., 2006a; Cassady, 2007). Für eine Berücksichtigung der Verhaltenscharakteristika „Umgänglichkeit" und „Aggressivität" in Zuchtprogrammen beim Schwein müssen allerdings zunächst Verhaltenstests oder Indikatoren für Verhalten ausgewählt werden, die für eine standardisierte Erfassung in landwirtschaftlichen Betrieben geeignet sind und aussagekräftige Daten im Bezug auf diese neuen Zuchtmerkmale liefern. Die Nutzung sowohl der Beurteilung der Hautläsionen von Schweinen als Indikator für aggressives Verhalten als auch des Backtests bzw. dessen Zusammenhänge zu Aggressivität und Umgänglichkeit war für die Erfassung von Verhaltensmerkmalen zu überprüfen.

Der Zusammenhang zwischen agonistischem Verhalten beim Gruppieren von Schweinen und der Anzahl und Schwere der Hautläsionen konnte in früheren Studien gezeigt werden (Turner et al., 2006a, 2006b, 2009; Stukenborg et al., 2011). Allerdings konnte nicht in allen Studien eindeutig dargelegt werden, dass Tiere, die häufiger agonistische Interaktionen initiierten, auch mehr Hautläsionen haben (z.B. Turner et al., 2006a, 2009). Auch die Ergebnisse dieser Arbeit (Kapitel 4) zeigen, dass die aggressiveren Tiere nicht mehr Hautverletzungen aufweisen. Der Zusammenhang war sogar umgekehrt, denn die häufiger angegriffenen Tiere hatten mehr Hautläsionen. Im Unterschied zu den vorangegangenen Studien lag zwischen den Beobachtungen des agonistischen Verhaltens und der Erfassung des Hautläsionsscores ein Zeitraum von 10 Wochen. Die Verletzungen spiegelten daher nicht mehr die Auseinandersetzungen beim Gruppieren wider, da die Wundheilung der Haut beim Schwein ca. 30 d dauert (Meyer, 1996). Anhand der moderaten Wiederholbarkeiten (z.B. r = 0,29 für die Häufigkeit der Initiierung von agonistischen Interaktionen) war eine Konstanz für aggressives Verhalten zu beobachten. Die Ergebnisse der Studie zeigten, dass vor allem die Gruppenzusammensetzung das Ausmaß der Hautläsionen bestimmte (Kapitel 4). Die Nutzung der Hautläsionen zur Erfassung der individuellen Aggressivität erscheint insofern problematisch, da die Intensität der Auseinandersetzungen vor allem vom Bekanntheitsgrad der Tiere untereinander abhängig ist (siehe Kapitel 2; Abschnitt „2.2 Aggressive Verhaltensweisen“). Des Weiteren führt das gemeinsame Aufstallen von aggressiveren Tieren insgesamt zu mehr Auseinandersetzungen (D'Eath, 2002) und dementsprechend zu mehr Hautverletzungen. Turner et al. (2009) sehen daher die Nutzung von Hautläsionen als Selektionsmerkmal gegen Aggressivität vor allem bei stabileren Gruppenzusammensetzungen als sinnvoll an. In der Studie sind aus fünf Würfen jeweils drei Tiere mit gleichem Geschlecht und gleicher Rasse zusammengestallt worden. Die positiven genetischen Korrelationen zwischen der Erfassung von Hautläsionen 24 h und 3 Wochen nach dem Zusammenstallen reichten von $r_g = 0,26 \pm 0,08$ bis $r_g = 0,54 \pm 0,07$, d.h. die Anzahl an Hautläsionen 24 h nach dem Zusammenstallen weist einen moderaten Zusammenhang zur Anzahl an Hautläsionen 3 Wochen nach dem Zusammenstallen auf. Aber auch hier zeigte sich, dass vor allem die angegriffenen Tiere mehr Hautläsionen aufwiesen (z.B. Hautläsionen im cranialen Bereich vs. Empfänger von einseitigen Aggressionen: $r_g = 0,70 \pm 0,11$) (Turner et al., 2009). Die Anzahl an Hautläsionen als Indikator für individuelle Aggressivität zu benutzen, erscheint unter Berücksichtigung der vorliegenden Ergebnisse sowie den Resultaten von anderen Studien (z.B. Turner et al., 2006a, 2009) als Selektionsmerkmal ungeeignet, da ein eindeutiger Zusammenhang zwischen hoher Anzahl an Hautläsionen und vermehrten Angriffen auf Artgenossen nicht vorhanden ist.

Auch der Backtest wurde bisher als Indikator bzw. Prädiktor für bestimmte Verhaltensweisen in zahlreichen Studien untersucht (Hessing et al., 1993; van Erp-van der Kooij et al., 2002; Cassady, 2007; Velie et al., 2009). Mit Hilfe dieses Tests sollten bereits zu einem frühen Lebenszeitpunkt Informationen zum späteren Verhalten der Tiere erfasst werden. Bei der Beurteilung der Ergebnisse von Verhaltenstests wird häufig von Stressbewältigungsstrategien („coping style“) der Tiere gesprochen (Erhard and Schouten, 2001). Dabei wird in aktive (Flucht, Kampf) und reaktive (keine Bewegung, Ausharren) Bewältigungsstrategie unterschieden, die sich auch bei Verhaltenstests zeigen sollen (Henry and Stevens, 1977; Hessing et al., 1994). Beim Backtest wurden die Tiere anhand der Anzahl an Befreiungsversuche in drei Kategorien (reaktiv, intermediär, aktiv) eingeteilt, um anschließend Beziehungen z.B. zur Aggressivität oder zu physiologischen Stressparametern zu analysieren (z.B. Hessing et al., 1993; Ruis et al., 2000; Velie et al., 2009). Trotz der Einteilung in Klassen waren die Ergebnisse früherer Studien nicht eindeutig im Bezug auf Aggressivität oder Angst vor unbekannten Gegenständen/Personen (van Erp-van der Kooij et al., 2002; Velie et al., 2009). In der vorliegenden Arbeit (Kapitel 5) wurde keine Einteilung der Ferkel anhand der Ergebnisse beim Backtest vorgenommen. Trotzdem wurden Zusammenhänge zwischen zwei im Abstand von 14 d durchgeführten Backtests ($r_p = 0.30$; $r_g = 0.84 \pm 0.11$) sowie dem zweiten Backtest und dem Verhalten von Läufern beim Wiegen ($r_p = 0.13$; $r_g = 0.57 \pm 0.21$) ermittelt. Eine kurzfristige Konstanz im Verhalten beim Backtest konnte also festgestellt werden. Außerdem scheint der Backtest zumindest ansatzweise zur Bestimmung des Verhaltens beim Wiegen geeignet zu sein und besitzt zudem im Vergleich zu den anderen Verhaltensmerkmalen hohe Erblichkeiten (Backtest 1: $h^2 = 0.22 \pm 0.10$; Backtest 2: $h^2 = 0.36 \pm 0.08$). Obwohl die Dauer des Tests in dieser Arbeit bereits von 60 s (Heesing et al., 1993) auf 30 s reduziert wurde, erscheint er durch den insgesamt zu hohen Arbeits- und Zeitaufwand im Vergleich zu dem zu erwartenden Nutzen für eine regelmäßige Erfassung von Verhalten ungeeignet. Außerdem konnten keine Korrelationen zwischen den unterschiedlichen Verhaltensmerkmalen (Backtest, Wiegeverhalten) sowie zwischen diesen Merkmalen und Scores für Hautläsionen gefunden werden. Die Tiere zeigen in den unterschiedlichen Tests verschiedene Reaktionen und weisen keine Konsistenz/Konstanz im Verhalten auf (Van Erp-van de Kooij, 2002). Dies erschwert die Auswahl des richtigen Verfahrens zur Erfassung von Verhaltensmerkmalen.

Da sowohl der Backtest als auch die Hautläsionen als Indikatoren für Aggressivität und Umgänglichkeit nicht geeignet sind, müssen direkte Verhaltensbeobachtungen erfasst werden, um diese als Merkmale in Zuchtprogramme zu integrieren. Zur Erfassung von Temperament oder Umgänglichkeit scheint der Wiegetest geeignet. Für das Verhalten auf der Waage konnten Heritabilitäten von $h^2 = 0{,}12 \pm 0{,}05$ und $h^2 = 0{,}20 \pm 0{,}07$ geschätzt werden, was den Ergebnissen früherer Arbeiten entspricht (z.B. Holl et al., 2010). Die Erfassung erfolgte anhand eines Notensystems von 1 (ruhig; wenig Bewegung) bis 3 (sehr aufgeregt; viel Bewegung). Dieses einfache Notensystem führte zur Benutzung der gesamten Skala bei der Beurteilung und lässt sich leicht anwenden. Gleichzeitig könnte in dem einfachen Bewertungssystemen mit nur drei oder vier Kategorien ein Grund für die geringen Korrelationen zwischen den verschiedenen Tests liegen. Für eine bessere (statistische) Auswertung sollte das Notensystem um eine oder zwei weitere Kategorien erweitert werden. Bei der Beschreibung der einzelnen Klassen wird die Aktivität der Tiere als Anzeichen für die Aufregung der Tiere herangezogen, in einigen Publikationen wird daher von einem „scale activity score“ gesprochen (Holl et al., 2010; Schneider et al., 2011). Diese Verbindung beruht darauf, dass der Organismus bei Stress hervorgerufenen durch bestimmte Situationen mit der Ausschüttung von Hormonen (z.B. Adrenalin), erhöhtem Blutdruck sowie erhöhter Herzfrequenz reagiert. Dies spiegelt sich wiederum in höherer Aktivität wider (von Borell, 2009). Dennoch stellt sich die Frage, ob die Selektion anhand des oben genannten Beurteilungssystems zwar zu ruhigerem Verhalten in der Waage führt, aber gleichzeitig auch zu inaktiveren Tieren. Vor allem für das Stallpersonal könnten inaktive Tiere zu mehr Stress beim Treiben oder Verladen führen, da diese Tiere vermutlich häufiger stehen bleiben und ständig angetrieben werden müssen. Die in der Arbeit berechneten phänotypischen und geschätzten genetischen Korrelationen zwischen dem Verhalten beim Treiben auf die Waage und dem Verhalten in der Waage (r_g = –0,45 ± 0,31; r_p = –0,14) weisen bereits auf diesen Trend hin. Ähnliche Beobachtungen sind auch aus der Literatur bekannt (z.B. D'Eath et al., 2009). Daher sollte sowohl das Verhalten beim Treiben der Tiere als auch deren Verhalten in der Waage berücksichtigt werden, wenn das Temperament bzw. die Umgänglichkeit anhand dieses Testverfahrens in Zuchtprogrammen beim Schwein integriert werden soll.

Für die Erfassung von agonistischem Verhalten sind weiterhin direkte Beobachtungen bzw. Videoaufnahmen bei der Neugruppierung von Schweinen notwendig, da die Anzahl und Schwere von Hautläsionen nicht wie vermutet mit einer höheren, sondern eher mit einer reduzierten Aggressivität verbunden war, was die mögliche Nutzung des Parameters als Indikator ausschließt. Hautverletzungen entstehen durch agonistischen Interaktionen (Anzahl, Intensität u.a.), d.h. eine Selektion auf mehr Hautläsionen würde vermutlich zu Tieren führen, die insgesamt häufiger an Kämpfen beteiligt sind. Außerdem bleibt bei dieser Methode zur Erfassung individueller Aggressivität eine hohe Anzahl an Fehlermöglichkeiten (z.B. Umwelteffekte, Hautläsionen durch Stalleinrichtungen). Aufgrund eines signifikanten Gruppeneffekts auf die Ausprägung der Hautverletzungen wurde in Kapitel 4 bereits die Gruppenselektion als mögliche Zuchtmethode angesprochen, d.h. Tiere aus einer Familie werden in einer Gruppe zusammen gehalten und anhand des Aggressivitätslevels (z.B. Hautläsionen aller Tiere) der ganzen Gruppe selektiert. Bei Geflügel konnte mit dieser Selektionsstrategie die Mortalität durch Federpicken und Kannibalismus deutlich gesenkt werden (Craig and Muir, 1996). Eine Übertragung auf die Schweinezucht scheint möglich (Muir, 2001). Beachtet werden sollte aber, dass sich Schweine gegenüber bekannten anders verhalten als gegenüber fremden Artgenossen (z.B. Jensen, 1994; Turner et al., 2001). Dennoch bleibt festzuhalten, dass sich die Beobachtungen des agonistischen Verhaltens beim Gruppieren zurzeit als sicherstes und sinnvollstes Merkmal anbieten. Die Erfassung dieser Beobachtungen ist aber hauptsächlich in den Basiszuchtbetrieben durchzuführen, da der Aufwand dafür nicht unerheblich ist. Außerdem können in diesen Betrieben die im Abschnitt „Umwelt“ genannten Vorrausetzungen im Bezug auf Haltungssystem, Bekanntheit und Tiere am besten erfüllt werden.

6.4 Korrelationen zwischen Verhaltens- und Leistungsmerkmalen

Zwischen funktionellen Merkmalen und wichtigen Produktionsmerkmalen bestehen häufig negative Korrelationen. Beispielsweise hat die einseitige Zucht auf hohe Milchleistung bei Rindern zu einer reduzierten Gesundheit und Fruchtbarkeit geführt (z.B. Pryce et al., 1998; Berry et al., 2003). Aber auch in der Schweinezucht werden ähnliche negative Zusammenhänge vermutet (Muir and Schinckel, 2002; Breuer et al., 2005). In einer Studie von Hellbrügge et al. (2008) wurden Zusammenhänge zwischen Aggressivität und Wurfgröße angedeutet (aggressives Verhalten in der Gruppe vs. gesamt geborene Ferkel: r_g = 0,15 ± 0,14). Auch in der vorliegenden Arbeit konnte dieser ungünstige Zusammenhang gezeigt werden. Einerseits hatten die beim Zusammenstallen aggressiveren Sauen (Initiierten mehr agonistische Interaktionen) größere Würfe und andererseits hatten die Sauen, die beim Ausstallen aus der Gruppenhaltung mit höheren Scores für Hautläsionen bewertet wurden, weniger gesamt geborene Ferkel (Kapitel 4). Diese Zusammenhänge zeigten sich bei den phänotypischen Korrelationen. Vermutlich haben auch die Rangpositionen innerhalb der Gruppe Einfluss auf diese Ergebnisse (Borberg and Hoy, 2009; Hoy et al., 2009). Auch die Korrelationen zwischen Tageszunahmen und Score für Hautläsionen (z.B. Tageszunahmen während Endmast vs. Hautläsionsscore vor Zusammenstallen: r_g = 0,43 ± 0,25; Tageszunahmen während Aufzucht vs. Hautläsionsscore vor Zusammenstallen: r_p = 0,15) weisen zumindest tendenziell auf ungünstige Zusammenhänge zwischen Verhaltens- und Produktionsmerkmalen hin. Aufgrund der in den letzten Jahren relativ einseitigen Zucht auf hohe Leistungen für Tageszunahme und Wurfgröße wurde vermutlich auch indirekt auf aggressivere Schweine gezüchtet. Die Tiere, die sich durch aggressiveres Verhalten besser durchsetzen konnten, z.B. beim Zugang zu Futter, hatten daher die höheren Tageszunahmen sowie bessere Fruchtbarkeitsleistungen, wobei das Durchsetzungsvermögen innerhalb der Gruppe aufgrund der bis dato üblichen Haltungssysteme (Einzelhaltung der Sauen, Kleingruppen bei Mastschweinen) noch keine so große Bedeutung besaß. In einer Studie von Turner et al. (2006b) hatten die Tiere mit einer höheren Anzahl an Hautverletzungen geringere Tageszunahmen (r_g = –0,34 ± 0,23; r_p = –0,08 ± 0,04). In einer anderen Studie waren die genetischen Korrelationen sowohl zwischen dem Wiegeverhalten von Schweinen und deren Lebendgewicht (r_g = –0.38) als auch zu Messungen der Rückenspeckdicke (z.B.

r_g = –0.11) negativ (Holl et al., 2010). Die Zusammenhänge zwischen Verhaltens- und Produktionsmerkmalen scheinen insgesamt nicht eindeutig zu sein. Diese müssten innerhalb der Rassen bzw. Linien einzeln analysiert werden. Falls sich dabei ungünstige Beziehungen zwischen Aggressivität oder Umgänglichkeit und den wichtigen Produktionsmerkmalen bestätigen, wird die Integration von Verhaltensmerkmalen in Zuchtprogramme im Prinzip noch dringlicher um diesem Trend entgegen zu wirken.

6.5 Genomische Selektion

Funktionale Merkmale wie die Umgänglichkeit und Aggressivität weisen zwar eine genetische Varianzen sowie moderate Heritabilitäten auf, aber eine zuverlässige Erfassung im Feld ist schwierig und die Daten sind häufig nicht normalverteilt (Bennewitz, 2010). Daher könnte für diese Merkmale eine genomische Selektion ein vielversprechender Ansatz sein. Grundvoraussetzung für die genomische Selektion war die Sequenzierung der Genome von landwirtschaftlichen Tieren und die Erstellung von Single-Nucleotide-Polymorphismen-(SNP) Markerkarten sowie die Entwicklung von DNA-Chips, mit denen zurzeit bis zu einer Millionen SNP dargestellt werden können. An Referenzpopulationen erfolgt eine SNP-Chip-Genotypisierung sowie die Erfassung der Phänotypen für ein bestimmtes Merkmal. Daraus werden dann die Effekte der verschiedenen Marker für ein bestimmtes Merkmal geschätzt. Anhand einer SNP-Chip-Genotypisierung können daraus für ein Tier die Markereffekte aufsummiert werden, die den geschätzten genomischen Zuchtwert bilden (Meuwissen et al., 2001; Goddard and Hayes, 2007, Bennewitz, 2010). Die genomische Selektion hat sich aber bisher vor allem im Milchviehbereich etabliert (Hayes et al., 2009). In der Schweinezucht hat sich diese aufgrund von unterschiedlichen Aspekten (Kostenersparnis viel geringer als beim Rind, Referenzpopulationen sind zu klein, u.a.) noch nicht durchgesetzt. Aber auch hier sind bereits Projekte angelaufen (z.B. FrOGS in Bayern), um die genomische Selektion in der Schweinezucht nutzen zu können. Falls das gelingt, könnte dies im Bezug auf die Integration von Verhaltensmerkmalen ein wichtiger Schritt sein. Grundvoraussetzung bleibt aber die Erfassung der Phänotypen, ohne die eine genomische Selektion nicht möglich ist.

6.6 Schlussfolgerungen

Anhand der vorliegenden Arbeit wird deutlich, dass sich die Integration von Verhaltensmerkmalen in Zuchtprogramme beim Schwein weiterhin schwierig gestaltet. Vor allem der Aufwand für Erfassung von Verhaltensmerkmalen, die mit den Zielmerkmalen „Umgänglichkeit“ und „Aggressivität“ korrelieren, bleibt hoch. Aus den Ergebnissen dieser Arbeit können folgende Schlussfolgerungen abgeleitet werden:

- Das Verhalten von Schweinen wird im hohen Maße von Umweltfaktoren beeinflusst, wobei sich auch schon kleinere Veränderungen (z.B. Fütterungssystem und Buchtengröße) im Haltungssystem auswirken.
- Haltungssystem, Gruppenzusammensetzung und Alter der Tiere sollten bei der Erfassung von Verhaltensmerkmalen genau berücksichtigt werden.
- Eine höhere Anzahl an Hautverletzungen ist nicht mit einer höheren Aggressivität verbunden.
- Eine Vereinfachung der Erfassung des Verhaltens durch Backtest oder Hautläsionen als Indikatormerkmale ist aufgrund der fehlenden oder schwachen Zusammenhänge zu den Zielmerkmalen nicht möglich.
- Die fehlende Konsistenz/Konstanz im Verhalten der Tiere (z.B. beim Wiegen) erschwert die Auswahl des richtigen Tests zur Erfassung von Verhaltensmerkmalen für Umgänglichkeit. Die Ausprägung von aggressiven Verhaltensweisen scheint beständiger zu sein.
- Für die Erfassung der Umgänglichkeit der Tiere stellt der Wiegetest (Verhalten beim Treiben auf die Waage sowie in der Waage) in einem Alter von ca. 180 d mit einem erweiterten Beurteilungssystem (mind. Score 1–4) eine Möglichkeit dar. Das Verhalten in der Waage weist zudem eine moderate Erblichkeit von $h^2 = 0.20 \pm 0.07$ auf.
- Für die Erfassung von aggressiven Verhalten bleibt die direkte Beobachtung der agonistischen Interaktionen bei der Neugruppierung von Schweinen.

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Curriculum Vitae

Björn Tönepöhl

geboren am 31.12.1983 in Korbach, deutsch, ledig.

Ausbildung

02/2010 – 11/2012	Georg-August-Universität Göttingen Department für Nutztierwissenschaften Abteilung Produktionssysteme der Nutztiere Promotionsstudium Abschluss: Doktor der Agrarwissenschaften
10/2007 – 09/2009	Justus-Liebig-Universität Giessen Masterstudiengang Nutztierwissenschaften Thema der Masterarbeit: Umgänglichkeit und Temperament bei Fleischrindern Abschluss: Master of Science
10/2004 – 09/2007	Justus-Liebig-Universität Giessen Bachelorstudiengang: Agrarwissenschaften und Umweltmanagement Thema der Bachelorarbeit: Applikation eines granulierten Kalkdüngers mit Selen auf einer Rinderweide Abschluss: Bachelor of Science
09/1995 – 07/2004	Alte Landesschule Korbach Gymnasium Abschluss: Allgemeine Hochschulreife