Livestock Science 184 (2016) 78–84

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Suckling strategies in the pig: The Göttingen minipig as a model

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ARTICLE INFO

Article history:
Received 23 August 2015
Received in revised form
6 November 2015
Accepted 29 December 2015

Keywords:
Pig
Sus scrofa
Göttingen minipig
Suckling behaviour

ABSTRACT

Göttingen minipig (GMP) has gained importance as model animal in human medicine. However, little is known about the suckling behaviour of GMP. Suckling is considered as a fundamental behavioural trait in mammals, most important for development and survival of the individual. Understanding its development and changes due to artificial selection is important when planning selection on reproductive traits in sows. GMP is a highly valuable model for studying the suckling behaviour in the pig, because its key features are intermediate between commercial breeds (CB) and wild boar (WB), namely, similar teat number as CB, similar litter size as WB and balanced muscularity of extremities. We compared the suckling behaviour of GMP and CB based on measures of suckling stability (the probability of consecutive sucklings on the same suckling position), suckling ranges (number of teat pairs in the range of the outermost teat pairs that piglets occupied) and piglets' distribution along the udder by use of the MDE-model (effect of geometric constraints, normally expressed as a hump-shaped distribution of organisms). We also incorporated published date on suckling preferences of WB piglets. Our study revealed alterations of suckling behaviour in piglets, wherein GMP showed intermediate suckling strategies (i.e. suckling ranges). However, there appeared to be a certain degree of behavioural conservatism. Domestic piglets maintained the tendency to prefer abdominal (middle) teats, which are anatomically posterior in WB and preferred by wild piglets. It can be suggested, that this general tendency seen in domestic piglets (GMP and CB), is not generated by geometric constraints (mid-domain effect), but appears to originate from the wild ancestor. Results of the present study suggest that the selection of CB for increasing litter size and higher number of teats might have led to imbalances between suckling behaviour, teat number and udder space availability.

1. Introduction

The Göttingen minipig (GMP) is a synthetic breed developed at the University of Göttingen (Germany) artificially selected for small body size, and has gained importance as model animal for studies in human medicine. Minipigs were mainly used in translational research, surgical models, procedural training, and for preclinical toxicological testing of pharmaceuticals (Swindle et al., 2012). Behavioural studies in minipigs mainly focused on behavioural tests suitable for e.g. preclinical toxicity testing (Bode et al., 2010), and on their cognitive abilities (e.g. Moustgaard et al., 2002, 2004). However, much less is known on other aspects of its behaviour. Moreover, to our knowledge the suckling behaviour of minipigs has not even been described, although suckling is considered as a fundamental behavioural trait in mammals, most important for development and survival of the individual. On the other hand the suckling behaviour of commercial pig breeds (CB) has been much more extensively studied (e.g. McBride, 1963; Hemsworth et al., 1976; Puppe and Tuchscherer, 1999; Skok and Škorjanc, 2013, 2014a, 2014b, 2014c), while only one study was published on suckling preferences in wild boar (WB) piglets (Fernandez-Llario and Mateos-Quesada, 2005). In general, these studies showed, that piglets of these two genotypes have diametrically opposite suckling orientation, i.e. to the cranial in CB and the caudal udder in WB. It may be concluded from these observations, that genetic selection in domestic pigs not only caused morphological and reproductive changes, but also differences in suckling behaviour. In particular, in the course of domestication, two features which might crucially affect piglets suckling behaviour have been modified: number of teats and litter size. An average litter size in CB pigs is with about 12 piglets up to three times greater than that of WB (see Fernandez-Llario and Mateos-Quesada, 1998; Fernández-Llario et al., 1999; Gethöffer et al., 2007). Moreover, the litter size in modern high prolific CB sows can be even higher, with litters of 16–20 piglets (see Andersen

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http://dx.doi.org/10.1016/j.livsci.2015.12.012
1871-1413/

et al., 2011; Vasdal et al., 2011). However, the number of teats also increased from four teat pairs in the WB (Fernandez-Llario and Mateos-Quesada, 2005) to at least seven teat pairs in CB (up to 17–18 teats in high prolific sows, see Vasdal et al., 2011).

Against this background, the GMP is a highly valuable model for studying the development of suckling behaviour, because its key features are intermediate between that of CB and WB. GMP sows have similar numbers of teats as CB sows, but their litter size is as small as that of WB. Furthermore, although GMP sows have a smaller body size than either CB or WB sows, their body composition and conformation is intermediate, i.e. the GMP has balanced extremity muscularity (Glodek and Oldigs, 1981). The comparative study of suckling behaviour in Göttingen minipigs could, therefore, elucidate how genetic changes in litter size, number of teats, and specific body structure affect suckling behaviour in piglets.

The aims of this study were to collect data on suckling in GMP litters and (1) to characterize suckling behaviour of GMP piglets with regard to the suckling stability (the probability of consecutive sucklings on the same suckling position), suckling ranges (number of teat pairs in the range of the outermost teat pairs that piglets occupied), and piglets' distribution along the udder estimated using the mid-domain effect (MDE) model, i.e. the effect of the geometric constraints (see Colwell and Lees, 2000; Colwell et al., 2004), and (2) to compare their suckling strategies with data from CB and WB. We hypothesized that, (1) differences in key features (e.g., teat number, litter size, body conformation) results in corresponding differences in suckling behaviour, and (2) some ancestral (wild) patterns of suckling behaviour have been maintained in domestic piglets despite selection for increased litter size and teat number.

2. Materials and methods

This study was carried out according to the European Commission Directive 2010/63/EU (2010) and to the ABS/ASSAB Guidelines for the treatment of animals in behavioural research and teaching.

2.1. Animals

Details on data for the sows and litters included in this study are summarized in Table 1. Behavioural data for CB were partly derived also from previous studies (Skok and Škorjanc, 2013, 2014a). We also incorporated aspects of suckling behaviour data, such as suckling ranges, of WB piglets from published observations (Fernandez-Llario and Mateos-Quesada, 2005). Since farrowing environments can have certain impact on the sow behaviour, milk and colostrum production/intake (Yun et al., 2014; Yun and Valros, 2015), it is important to note, that animals were not kept in a completely controlled environment, especially in WB (natural environment), while the farrowing environments in CB and GMP were comparable. During the present study, there were no health problems recorded in sows and piglets, respectively.

2.1.1. Göttingen minipigs (GMP)

The Göttingen minipig was developed at the University of Göttingen, Germany (Glodek and Oldigs, 1981), by crossbreeding different breeds including the German Landrace pig, the Minnesota Minipig, and the Vietnamese potbelly pig. In the late 1960s, the Göttingen Minipig became available for biomedical research.

The study was carried out from June to September 2014 at the Göttingen Minipig breeding station (Georg August University Göttingen, Department of Animal Sciences, Germany). The study involved 12 sows from the commercial breeding stock and a total of 56 piglets (one litter per sow). On average there were 0.42 stillborn piglets per litter. Cross-fostering was not applied to any of the litters. None of the piglet died during the observation period. Sows with piglets were housed in farrowing pens (area of 1.44 m^2, i.e. 1.2×1.2 m^2) which had concrete flooring that was partly slatted (one third). Pens were of solid wooden sidewalls and equipped with a sow feeder and nipple drinker. During lactation, sows were fed with 700 g of balanced feed mixture per day, offered in two meals. The feed mixture composition was: 13.80% crude proteins, 0.67% calcium, 3.00% crude fat, 0.50% phosphorus, 12.80% crude dietary fibre, 0.20% sodium, 5.90% crude ash, 0.65% lysine, 9.80 MJ ME/kg and 0.22% methionine. Sows had *ad libitum* (always available) access to water. Piglets were provided with a specific nipple drinker and had access to a separate piglet pen (0.18 m^2) with an automatic, thermostatically controlled heating plate with a cover fitted with a 150-W infra-red heating lamp. The temperature inside the piglet area was maintained at 30–33 °C, and the room temperature was regulated to 18–22 °C by a ventilation system. Any additional noise was avoided. A combination of daylight entering through the windows and artificial lighting was used to guarantee 14 h of light of at least 40 lux and 10 h of darkness per day. All farrowing crates were cleaned daily. During the lactation period, piglets had free access to water. Piglets were weaned at the average age of 39 days (range from 36 to 44 days).

2.1.2. Commercial breeds (CB)

CB sows were of two different genotypes, Swedish Landrace and cross-breeds Swedish Landrace × Large White. We included the comparative data on suckling behaviour in CB from previous studies (Skok and Škorjanc, 2013, 2014a), but new data was also collected on the CB piglets for this study (Table 1). Observations from 21 sows with their litters were re-analysed for suckling ranges and the percentage of completely stable piglets at suckling.

Observations were carried out at the Pig Research Centre (University of Maribor, Faculty of Agriculture and Life Sciences, Slovenia) and involved 213 piglets. On average there were 0.40 stillborn piglets per litter. Piglets were weaned approx. 28 days

Table 1
Basic data for the sows and litters included in this study.

Breeds	Genetic background and housing (H)	Observed sows/litters n	Mean parity (range)	Mean litter size (range)	Source of data
CB	Commercial breeds and hybrids (Swedish landrace and Swedish Landrace × Large White) H: Farrowing pens	11	4.5 (1–9)	10.0 ± 2.0 (6–13)	Skok and Škorjanc, 2013 (*MDE*)
		16	4.1 (1–9)	10.0 ± 1.9 (6–13)	Skok and Škorjanc, 2014a (P_{Suck})
		21	3.7 (1–9)	10.1 ± 1.9 (6–13)	this study (*suckling range*)
GMP	Synthetic breed since late 1960s, artificial selection for small body size H: Farrowing pens	12	3.3 (1–5)	5.2 ± 2.3 (2–8)	this study
WB	Natural selection H: wild population	51	/	/	Fernandez-Llario and Mateos-Quesada, 2005 (*suckling range*)

CB = commercial breeds; GMP = Göttingen minipig; WB = wild boar; MDE = Mid-domain effect; P_{Suck} = suckling stability.