Applied Animal Behaviour Science 174 (2016) 32–41

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

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

Assessing walking posture with geometric morphometrics: Effects of rearing environment in pigs

Céline Tallet[a,b,*], Emilie Sénèque[c], Claire Mégnin[a,b], Stéphane Morisset[d], David Val-Laillet[e], Marie-Christine Meunier-Salaün[a,b], Carole Fureix[c,1], Martine Hausberger[f]

[a] INRA, UMR1348 PEGASE, F-35590 Saint-Gilles, France
[b] Agrocampus Rennes, UMR1348 PEGASE, F-35000 Rennes, France
[c] Université de Rennes 1, UMR CNRS 6552 Ethologie Animale et Humaine, CNRS, 35042 Rennes Cedex, France
[d] Independent Biostatistician, F-01150 Chazey sur Ain, France
[e] INRA, UR1341 ADNC, F-35590 Saint Gilles, France
[f] CNRS, UMR 6552 Ethologie Animale at Humaine, Université de Rennes 1, 35042 Rennes Cedex, France

ARTICLE INFO

Article history:
Received 15 December 2014
Received in revised form 16 October 2015
Accepted 18 October 2015
Available online 24 October 2015

Keywords:
Methodology
Pig
Posture analysis
Rearing condition
Welfare

ABSTRACT

Rearing social animals like pigs in isolation from conspecifics can have consequences on behaviour and physiology. The aim of this experiment was to determine whether rearing conditions affect body posture. We adapted a method for quantitative evaluation of posture based on geometric morphometrics, developed in horses, for pigs and applied it in different conditions. Forty-eight 75-day-old females were reared either alone in 2.25 m^2 pens (IH, $N = 24$ animals and 4 groups) or in groups of four in 4.64 m^2 pens (GH, $N = 24$) for two weeks. They were habituated to human handling (stroking, speaking) and marking on their backs every day, and tested individually once a day for 10 min in a corridor outside the home pen during the two subsequent weeks. We observed their behaviour and posture during the first exposure to the test (novelty), and the fourth and fifth (after habituation). On the sixth and seventh tests, a familiar stockperson was present in the corridor (human presence). Before each test, the animals were marked with seven landmarks along their length, corresponding to their anatomical points and were easily located. An experimenter took pictures of the animals walking along the corridor, and these pictures were transferred to Tps software for analysis.

GH animals were more often active in the rearing pen than IH (median (IQ) 15% of observations [12–20%] *versus* 2% [0–13%]; $P < 0.05$). All animals except one IH initiated contact with the handler during the last sessions of handling (Fisher's exact test, ns). Principal Component Analyses revealed significant effects of rearing and testing conditions on pigs' behaviour and posture. Novelty led to fewer vocalisations and more exploration for IH than GH animals ($P < 0.05$), but there were no differences between treatments after habituation to the testing situation. The backs of IH animals were more rounded than those of GH ($P < 0.05$; dimension 1 of PCA), independently of the test condition. Human presence had no effect on posture.

In conclusion, the method based on geometric morphometrics that we developed to study pig posture detected variations in walking posture in pigs associated with rearing conditions. Postures might reflect affective states in pigs, as shown in other species, but further studies are needed to verify this.

1. Introduction

Body posture is an important aspect of animal behaviour, and would reflect adaptation of postural tonus to the stressful situations for instance (Kiley-Worthington, 1976). However, evaluating body posture is not simple. The simplest methods rely on visual observations by an experimenter, describing variations in the position (*e.g.* high/low) and/or movement of parts of the body like the ears, tail,

* Corresponding author at: INRA, UMR1348 PEGASE, F-35590 Saint-Gilles, France.
E-mail address: celine.tallet@rennes.inra.fr (C. Tallet).
[1] Present address: Centre for Behavioural Biology, Department of Clinical Veterinary Science, University of Bristol, Langford House, Langford BS40 5DU, UK.

http://dx.doi.org/10.1016/j.applanim.2015.10.008
0168-1591/

legs or back. For instance, in dogs, posture is described according to flexion of the legs, position of the back (lowered or not), whether the dog is crouching or not (Beerda et al., 1998; Schilder and van der Borg, 2004). In stressful situations the posture is lower, with bent legs and lowered tail. Kiley-Worthington (1976) observed that a high level of excitation may lead several species, including pigs, horses and dogs, to hold their head and tail in a high position. Visual observations seem to be simple but have some limitations, in particular that they do not allow an accurate, quantitative evaluation of the posture: for example, the back could be more or less lowered in dogs. In addition, they rely on the observer's subjective evaluation, even if precautions are taken to ensure repeatability of the method.

Quantitative methods have been developed to provide more detailed assessment. For instance, Lepicard et al. (2000) recorded the elevation of the trunk of mice from videos by measuring the distance between the trunk and a horizontal beam on which the animals walked. They showed that a greater distance confirmed an arched posture, and found postural differences between anxious and non-anxious strains of mice. In cattle, a system to describe back posture has been developed to detect lameness, using video images for analysis and calculations (Poursaberi et al., 2010). This included the contour of the cow's back and curvature from three virtual points located at standard positions. These two studies only considered back posture, without taking into account the head's position. Another possibility is to use kinematics to characterise the geometry of movement from videos, after positioning markers at different places on the body (von Wachenfelt et al., 2009; Gregoire et al., 2013). This approach was used recently to evaluate leg flexion of pigs for detection of lameness (Gregoire et al., 2013; Stavrakakis et al., 2014) and neck posture in horses (Lesimple et al., 2012). Distances and angles between the markers can be calculated from videos to assess the shape of the animal, so the method can provide considerable quantities of information. However, the authors emphasise that it has technical challenges: it necessitates use of high quality, precisely specified materials for recording and analysing; displacement of the markers on the skin must be avoided; use of algorithms for calculations is challenging; and a large consumption of time and money is involved (Gregoire et al., 2013).

Another method has been recently developed in horses, adapting geometric morphometrics to analysis of body posture from head to tail (Deleporte et al., 2008; Fureix et al., 2011). Geometric morphometrics analyses variation in shapes and is applied in systematics, palaeontology and phylogeny. It also uses markers on the body, relies on instantaneous images (photographs or captured from videos), and can reveal subtle variations in the shape (and thus posture) of animals. In horses, it was used to discriminate behavioural postures (*e.g.* walking, standing) and to identify the influence of management on posture (*e.g.* pasture *vs.* individual stalls, leisure/riding lessons types of equitation, etc.). The authors suggested that the method is promising to assess individual postures, to compare groups of animals and to contribute to welfare assessment (Fureix et al., 2011). As well as a global approach, it may also allow identification of precise aspects of posture that could be useful and should be more thoroughly examined. For example, the global approach identified neck shape as a major issue, and a correlation between neck shape and back disorders was revealed (Lesimple et al., 2012). The method uses free software (Tps, http://life.bio.sunysb.edu/morph/) that allows automatic calculation of the shape of animals.

In the present study we used geometric morphometrics, based on the method of Fureix et al. (2011), to assess potential variations of body posture in relation to rearing conditions in pigs, *i.e.* individual *vs.* group housing. The rearing environment influences pig behaviour and emotional state: social isolation is known to induce a high level of stress compared to group rearing, indicated by behavioural, endocrine and immune changes (Barnett et al., 1981; Herskin and Jensen, 2000; Tuchscherer et al., 2014). Isolation and group housing might therefore also affect body posture.

We also compared the posture of the pigs in different situations intended to modulate their emotional state. We compared isolation in a novel testing environment (a source of stress for pigs: Murphy et al., 2014), with the same environment after habituation, and with the presence of a handler previously associated with positive interactions (a possible cause of positive states: Tallet et al., 2014).

We tested two hypotheses:

(1) Rearing animals in isolation with little space compared to rearing animals in a group with more space will produce differences in body posture. More precisely, individually housed animals could develop a rounded back associated with a low position of the head (Kiley-Worthington, 1976).
(2) Placing animals in different situations potentially modulating their emotional state will also produce differences in their posture.

2. Materials and methods

The design of the experiment was approved by the local ethics committee (Comité Rennais d'Ethique en Matière d'Expérimentation Animale, case R-2010-CT-01).

2.1. Animals and rearing conditions

We studied 48 75-day-old female pigs (*Sus scrofa domesticus*) randomly allocated to two different treatments, in three independent but identical replicates (January–March 2010). They were born at the experimental unit of Saint-Gilles (INRA, France, GPS: 48.1452, −1.830114) from 30 Large White × Landrace sows inseminated with Pietrain semen. Piglets were weaned at 28 ± 2 days of age, then spent 5 weeks in a post-weaning environment and were moved to the finishing building for the experiment at 75 days of age. In the finishing room, the temperature was automatically set at 22 °C. The animals had *ad libitum* access to food (standard fattening diet, Cooperl Arc Atlantique, Plestan, France) and water and troughs were replenished every morning (around 08:00 h).

The two treatments were variations in the social and spatial housing conditions. *Individually housed (IH) animals* ($N = 24$) were reared alone in 2.25 m^2 pens (0.85 m × 2.65 m). Pens were separated by opaque walls. Animals could not see each other but could hear and smell their conspecifics. *Group-housed (GH) animals* ($N = 24$ individuals in 6 pens) were reared in groups of four in 4.64 m^2 pens (1.75 m × 2.65 m, 1.16 m^2 per animal). All the animals were reared in the same room. The mean weight of IH animals was 31.5 kg ± 0.3 and that of GH animals was 32.6 kg ± 0.4 at the start of the experiment.

2.2. Familiarisation to human handling

Morphometrics necessitates handling the animals to place landmarks, so all pigs were first habituated to handling. Pigs received 14 sessions of handling over a period of two weeks (D1–D12, excluding week-ends, Table 1). During the first week, they received 2 sessions per day (08:30 and 13:30 h, excluding the first morning when they were transferred to the finishing building). During the second week, sessions occurred once per day (08:30 h). Troughs were replenished 1 h before the sessions.

In the familiarisation sessions the handler stood motionless at the entrance of the pen for 30 s, then sat on a bucket for 30 s (IH animals) or 1 min (GH animals); the duration was longer for GH