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The Natural Pig Toilet

Effects of a natural environment on elimination behaviour in domesticated pigs (*Sus domesticus*)

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1. Abstract

Elimination, the expelling of bodily wastes, and related behaviours in pigs are influenced by various factors, yet research has not explored how natural settings compared to semi-natural or commercial farm settings affect this behaviour. Therefore, this study investigated the pre-elimination behaviours of sows (n=8) and piglets (n=36) in an open-air farm environment, previously used as an old cropland. Recorded behaviours included sniffing, nosing, rooting, foraging, walking and vocalisation over a total of 529 registered elimination events. The results showed that both sows and piglets frequently engaged in explorative behaviours such as sniffing and nosing before elimination events, suggesting an olfactory assessment of the area, possibly to detect previous elimination spots. Rooting, in contrast, was only rarely observed prior to elimination events. Foraging was more common before defecation than urination, likely due to differences in elimination posture, allowing for greater mobility while defecating. Piglets expressed a higher frequency of vocalisations compared to sows, which may be due to social interactions between the different litters. Heatmaps of elimination sites indicated possible links to crops being previously grown in the area, particularly radishes, cabbages, and squash, suggesting a possible olfactory influence. These findings give insight into pig behaviour prior to elimination and spatial preferences for elimination. This may contribute to improving animal welfare by aiding planning for hygiene and waste management based on the animals' preferences. This in turn, can help create more effective farm environments for pigs that align with their behavioural needs, which would promote their well-being.

Keywords: Behaviour, Elimination, Natural conditions, Open-air farm**,** Piglets, Sows, Spatial preference

2. Introduction

Outdoor housing systems in farms, where pigs have access to outdoor areas, allow pigs more opportunities to express their natural behaviours more easily compared to commercial settings. Such housing systems have been reported to reduce the development of abnormal or aggressive behaviours (Ludwiczak et al., 2021). Pigs are social animals that form social structures in form of groups, as do their wild counterparts, the wild boars (*Sus scrofa*) and feral pigs (Jensen, 2002). In natural environments, the most basic social group consists of an adult female (sow) and her offspring, while adult males (boars), live solitary except when participating in social groups for breeding (Graves, 1984, Jensen, 2002, Mayer, 2009). Sows that live in groups with other mature, reproducing females are all closely related with one another, and can contain up to three generations of animals from previous litters that stay with the group (Mayer, 2009). In the wild, feral pigs and wild boars spend a considerable proportion of their active time foraging, rooting, and exploring their surroundings. Their diet is highly varied and omnivorous, including roots, seeds, berries and earthworms (Jensen, 2002, Studnitz et al., 2007). The ability to root and forage is an important part for satisfying pigs' natural behaviours and is often observed even in domesticated pigs when given the opportunity (Moser et al., 2019). In relation to foraging, pigs establish a home range that they consistently use for foraging, resting, and eliminating. These areas are typically large in wild boars, with home ranges varying from a few hectares to several square kilometres depending on the availability of resources in the area (Jensen, 2002, Mayer, 2009). This preference for distinct areas pigs stay within can also possibly influence elimination behaviour of the animals, as they naturally prefer to defecate away from resting and feeding sites (Andersen et al., 2020).

The process of elimination has been defined as "expelling bodily wastes, such as urine or faeces from the body" (Nannoni et al, 2020). In many animal species, elimination behaviour can serve various purposes besides expelling waste from the body. Common usage of it includes scent marking and territorial signalling (Leuchtenberger, 2018). The definition of scent marking has been referred to as the release of odours with glandular secretions, or that of elimination, either through defecation or urination (Kleiman 1966, Cafazzo et al, 2012). For example, dogs and wolves have been reported to use scent marking with urine to deter other packs or individuals (Cafazzo et al, 2012, Zub et al, 2003), while in horses, urination and defecation has been reported to aid stallions in attracting mares and repel other males (King & Gurnell, 2007). For a species that is more closely related to that of the commercial pig, males of the wild boar (*Sus scrofa*), have been reported to scent mark to display dominance against conspecifics and

stimulate female individuals for mating (Mayer & Brisbin, 1986). The various uses of scent marking through the process of eliminating can be of interest when looking deeper into the elimination behaviour of pigs, especially when kept in a more natural environment.

When it comes to elimination, pigs proceed to alter their posture before the elimination occurs (Whatson, 1985), but what micro-behaviours a pig performs before choosing an elimination spot, as well what factors may affect the preferred spot regarding soil or substrate is not well known. Pigs have a natural motivation to eliminate in a different area than their normal resting spot and their feeding area, (Geers & Velarde, 2007), and pigs held in outdoor housing systems have designated and preferred elimination spots (Andersen et al., 2020). In farms where pigs have access to both an indoor pen and outdoor run, pigs prefer to eliminate outside rather than inside (Höne et al., 2023). This relates to the notion that preferred areas of pigs for elimination in conventional farming systems are corners that are damp, colder and bright, which is the opposite to their resting areas, often being drier, warmer and shaded (Höne et al., 2024). In contrast, only little is known about pigs' preferences and choices regarding elimination spots in more natural environments where the animals are allowed to roam freely in an open pen. As mentioned, pigs are motivated to eliminate in certain areas, but factors such as substrate preference are not well known about. Therefore, identifying a preferred substrate may provide a welfare improvement for pigs in commercial farms as the substrate could be implemented in their holding pens and make the location of elimination more manageable and hygienic. The possibility to determine pig elimination behaviour, as well as to motivate pigs to eliminate in dedicated areas in the pen would be a way to improve the welfare for the animals but can also help improve hygiene and working conditions for farmers (Andersen et al., 2020).

In the present study, I investigated the elimination-related behaviours expressed and the preferred spots used by sows and piglets in a natural environment on an open-air farm. More specifically, I assessed what behaviours the animals express when given the ability to roam freely in an area with natural conditions, and if the location of elimination differs from the prementioned preferred elimination spots chosen by pigs at conventional farms. Further, I assessed if the substrate plays a role in the animal's choice of specific elimination spots. The rationale for observing piglets was to assess if the animals shared similar elimination behaviours with their mother from a young age on, including location preferences, or if their behaviour differed from that of adult pigs.

3. Materials & Methods

3.1 Animals and housing

The study was conducted at the open-air farm Ängavallen, in Skåne, Sweden. The observational period lasted from the 17th of June to August 23rd, 2024. The location chosen for the housing of the pigs was an old cropland, estimated to be at around 2600 square meters. This area had not been worked on by pigs or other animals for the last 5 years. On the cropland, multiple different produce had been grown. The cropland was divided into eight pens, with an estimated size of 30 x 10 meters each (figure 1 and 2). For the study, only the first 6 pens, named A to F, were used. The remaining pens were kept empty during the study. Within each pen, a wooden hut was placed, with the estimated dimensions of 3 x 2 x 1.5 meters, whose floor was covered with straw. On the southern end of each pen, a water trough was placed, which was refilled continuously throughout the day.

Each pen had a food trough which was filled with ecological vegetable feed of oats, produced at the farm, twice a day (half a bucket per sow). Each sow had full access to its pen, allowing it to forage and root for food continuously in the old cropland. Piglets and sows were also provided with raw milk from cows at the farm as supplement. Each pen was divided with the aid of an electrical wire. The wire was mounted at a height which allowed the piglets to wander freely across all the pens in the area. A second wire was placed around the outskirts of the area to keep the piglets inside. Sows were given a pen each, except for Pen B and Pen D, which were shared between two individuals.

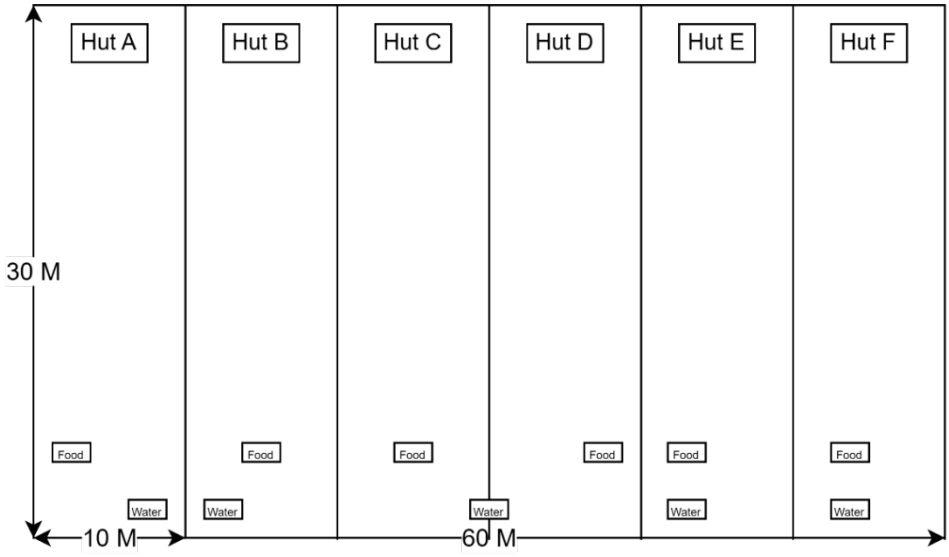

Fig. 1. The layout of the pens in the old cropland including location of the huts, food and water troughs.

Fig. 2. View of one of the pens from the side.

I observed eight sows of the breed Linderöd pig, with a total of 36 piglets. The piglets were born between the period of 24th of June to 5th of August, while the sows were born between the years 2018 and 2019. Of the 8 sows in the study, only six had litters of their own. All piglets were born on location in the wooden huts within each pen.

3.2 Observational methods

For the behavioural observations, all individuals (eight sows plus 36 piglets) within the six pens were included to assess if there were differences between sows' and piglets' behaviours, elimination location and substrate preferences. It has been reported that in piglets, most eliminations occur during daytime from around 13:00 to 14:00, (Andersen et al., 2020), and for adult pigs, eliminations have been reported to occur from 12:00 to 18:00 (Guo et al., 2015). Therefore, I observed the animals between 09:00 and 15:00.

I observed the behaviours of the sows and piglets continuously for 10 weeks, between the dates mentioned above. The animals were observed Monday to Friday if the weather conditions allowed on a group sampling level basis. I did this by walking across a pen, performing

behavioural samplings before an elimination event and continuing to the next pen. To determine that an elimination event was imminent, I primarily relied on specific postural cues displayed by the animals. For sows, the most reliable indicator was the characteristic elimination posture, where they positioned their hind legs and lowered their stance (Baxter, 1984, Nannoni et al., 2020). For piglets, it was more challenging to predict the event precisely, but I noted that they tended to slightly lower themselves with their legs before eliminating, resembling that of the posture of the sows. The timeframe for behaviours prior to the elimination varied, from 10 to 30 seconds. During this timeframe, I recorded each behaviour expressed by an animal, where each expression counted as one occurrence of said behaviour. The behaviours that were recorded in the study are listed in **Table 1.**

Table 1. Ethogram of potential behaviours displayed before an elimination event.

Behaviour type	Behaviour	Description
State	Stand	The pig remains stationary with all four feet on the ground.
	Lie	The pig is stationary with most of its body being in contact with the ground.
	Walk	The pig moves either forward or backward, including turning, with its head raised.
Event/Duration	Exploration: Sniffing	The pig interacts with its environment by sniffing surrounding objects and substrate at <5 cm away.
	Exploration: Nosing	The pig presses its snout against an object or substrate, physically touching it for a short duration.
	Exploration: Licking	The pig extends its tongue out and touches an object or substrate with it.
	Exploration: Rubbing	The pig rubs a part of its body against an object or substrate. Each rub counts as one event.
	Exploration: Rooting	The pig uses its snout to push into the substrate repeatedly to actively move it during a longer duration.
	Exploration: Foraging	The pig opens its mouth to bite onto an object or substrate, which proceeds into actively chewing on gathered material.
	Vocalisation: Low	The pig vocalises with low grunts, either short or long-
	Vocalisation: High	The pig vocalises with squeals, screams or loud grunts.
	Elimination: Urinating	The pig's back is crouched, front legs far front, tail curled and lifted over the back. The pig then eliminates through urinating.
	Elimination: Defecating	The pig's back is crouched, hind legs are bent, tail is curled and lifted over the back and is wagged once done. The pig then eliminates through defecating.

I registered the location of each elimination event with a Garmin GPS device (GPSmap 60CSx, Garmin, USA) and recorded if the animal was either defecating or urinating, and if it was a sow or a piglet.

3.3 Data and analysis

Statistical analyses and illustrations were performed and created with the coding language R (version 4.2.1), through the usage of the free software RStudio (RStudio Team, 2022, version 2022.07.1 + 554). To determine whether there were statistically significant differences in behaviours expressed before elimination between sows and piglets, I used Chi-square (χ^2) tests for independence with a significance level of 0.05. With this, I tested for these following questions.

1. I tested if the frequency of specific behaviours observed and registered prior to a specific elimination type is different between sows and piglets. For example, if I compare sniffing prior to that of urination:
   H_0: There is no difference in frequency of sniffing events prior to urination between sows and piglets.
   H_1: There is a difference in frequency of sniffing events prior to urination between sows and piglets.

2. I also tested if there is a difference in frequency of a certain behaviour in one of the animal groups between the two elimination types. For example:
   H_0: There is no difference in frequency of sniffing events prior to urinating or defecating for sows.
   H_1: There is a difference in frequency of sniffing events prior to urinating or defecating for sows.

Mapping illustrations were made in the free, open-sourced software QGIS (version 3.38.3). Each recorded elimination event was represented in the heatmap with a radius of approximately 10 meters. This means that in the mapping illustrations, each event contributes to the surrounding 10-meter area around it to create the density gradient. I chose the radius as it better visualise the spatial density of eliminations in the pens. Each recorded elimination event is presented with a coloured symbol, depending on the elimination was either urination or defecation.

4. Results

4.1 Behavioural differences between elimination types in sows

I observed a total of 529 elimination events across all animals. This included 214 elimination events for sows, with a distribution of 100 urination events and 114 defecating events. For piglets, 315 elimination events were recorded, with a distribution of 142 urinations and 173 defecation events.

To get a further insight of behavioural differences between elimination types before an elimination event the distribution of behaviours expressed by the animals can be of interest. Therefore, I compared the distribution of the total behaviours expressed by the sows before the two different elimination types, as illustrated in figure 3.

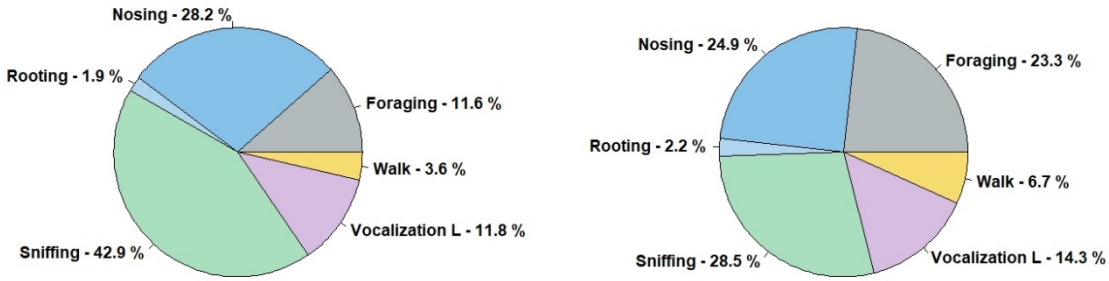

Fig. 3. Distribution of behaviours expressed by the sows before urination (left) and defecation (right).

The most frequently observed behaviour performed by the sows before *urination* was sniffing followed by nosing. Other behaviours, such as vocalisations at low frequencies and foraging were common as well. Walking and rooting were not as commonly expressed before urination compared to the other behaviours.

In contrast, before *defecation*, the most common behaviours were distributed more evenly in their occurrences. The most common behaviours performed by the sows were sniffing, nosing and foraging. Less frequent behaviours expressed before defecation events included rooting, walking and vocalisation at low frequencies.

When compared to occurrences prior to elimination, walking occurred significantly more often prior to defecation than prior to urination ($\chi^2 = 4.145$, $p = 0.04$). Similarly, foraging behaviour

occurred significantly more often before defecation than prior to urination (χ^2 = 22.285, p = <0.05).

For nosing behaviour, no difference in occurrence was found between the two elimination types (χ^2 = 1.2517, p = 0.26). Nosing behaviour was the second most common expression of sow behaviour before any elimination type. When comparing for vocalisations at low frequencies, no significant difference in occurrence was found between urination and defecation for the sows (χ^2 = 1.1975, p = 0.27). For rooting behaviour prior to elimination, no significant difference was found between urination and defecation for sows (χ^2 = 0.01; p = 0.89). For sniffing behaviour prior to elimination, a significant difference was found between urination and defecation for the sows (χ^2 = 22.989; p = <0.05). Yet, sniffing was the most expressed behaviour by the sows before any type of elimination in total.

4.3 Behavioural differences between elimination types in piglets

Like the sows, the distribution of behaviours expressed by the piglets before elimination can be examined to determine if there are significant differences between behaviours based on elimination type, as illustrated in figure 4.

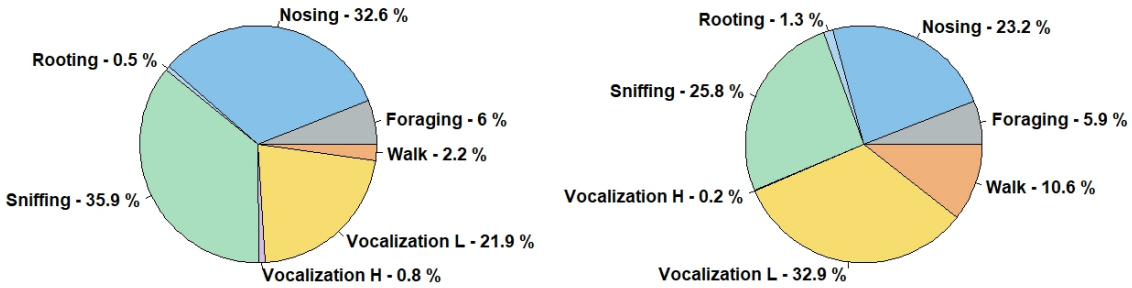

Fig. 4. Distribution of behaviours expressed by the piglets before urination (left) and defecation (right).

For the piglets, sniffing and nosing were the most common behaviours expressed before *urination*, with vocalisations at a low frequency also being a commonly displayed behaviour. Rooting , walking and foraging were rarely observed before *urination*.

Before *defecation*, the most frequently observed behaviours expressed by the piglets were vocalisation at low frequencies, nosing and sniffing. Other behaviours, such as rooting and foraging were less common.

When compared between the two elimination types, walking occurred significantly more often before defecation than prior to urination (χ^2 = 21.746; p = <0.05). Similarly, the piglets vocalised at low frequencies significantly more before defecation than prior to urination (χ^2 = 12.347; p = <0.05).

When comparing sniffing behaviour between the elimination types prior to elimination events, a significant difference was found between defecation and urination in occurrence (χ^2 = 10.013; p = 0.001) for the piglets. Sniffing behaviour was still one of the most prominent behaviours in the piglets regarding of elimination type.

Similar to sniffing, when comparing between the elimination types, nosing behaviour did occur significantly differently prior to defecation or urination (χ^2 = 9.2098; p = 0.002). Also, no significant difference was found in the frequency of foraging behaviour expressed by the piglets before defecation or urination ($\chi^2 = 1.9356e^{-30}$; p = 1).

When comparing elimination types before rarely expressed behaviours, which includes that of rooting and vocalisation at lower frequencies, no significant difference between elimination type (p = 0.3257) was found for rooting behaviour, and the same was true for vocalisations at high frequencies (p = 0.309).

4.4 Behavioural differences between piglets and sows before urination

To determine if there were significant differences between piglets and sows in their behaviours expressed prior to performing a given elimination type, the distribution differences can be of interest, as illustrated in figure 5.

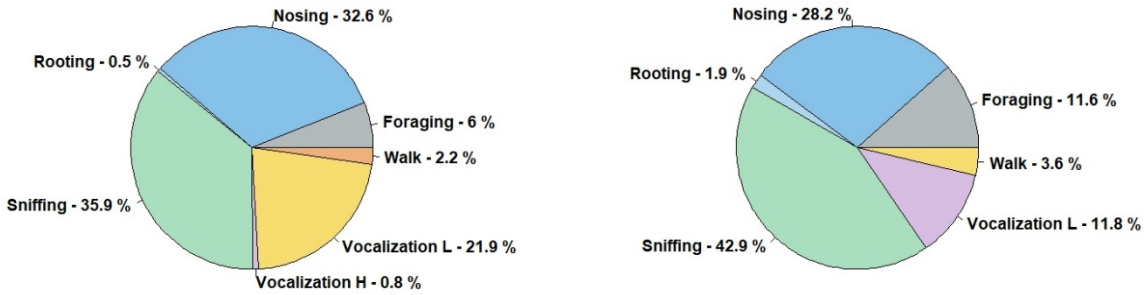

Fig. 5. Distribution of behaviours expressed by piglets (left) and sows (right) before urination.

When comparing the behaviours between piglets and sows before elimination, I found both similarities and differences between the two groups. For both sows and piglets, sniffing and nosing were the most frequently expressed behaviours before *urination.*

However, no significant difference was found in their frequency of occurrence of behaviours between the two animal groups (Sniffing: $\chi^2 = 3.6919$; $p = 0.054$; Nosing: $\chi^2 = 1.5869$; $p = 0.2$). In contrast, vocalisation at low frequencies was performed significantly more often by the piglets compared to the sows before *urination* ($\chi^2 = 13.659$; $p = 0.0002$), and sows foraged significantly more than the piglets ($\chi^2 = 6.631$; $p = 0.01$).

Less commonly expressed behaviours before urination, such as walking and rooting, showed no significant differences between sows and piglets (Walking: $\chi^2 = 0.921$; $p = 0.3371$; Rooting: $p = 0.1144$).

4.5 Behavioral differences between piglets and sows before defecation

I also compared the distribution of behaviours which occurred prior to defecation between piglets and sows, illustrated in figure 6.

Fig. 6. Distribution of behaviours expressed by piglets (left) and sows (right) before defecation.

Sniffing and nosing occurred frequently before *defecation* in both animal groups. Sows expressed sniffing significantly more often than piglets prior to defecating (Sniffing: χ^2 = 4.6982, p = 0.03), but when comparing nosing behaviour between the animal types, no significant difference was found (Nosing: χ^2 = 2.7289, p = 0.09).

Piglets expressed the low vocalisation behaviour significantly more often than sows prior to defecating (χ^2 = 53.792, p = <0.05). Sows foraged significantly more often than piglets, prior to defecating (: χ^2 = 86.626, p = <0.05).

No significant difference was found between piglets and sows in regard to walking, prior to defecating (χ^2 = 3.4837, p = 0.06).

Rooting behaviour before defecation was rarely expressed by both animal groups prior to defecation. No significant difference was found between the animal groups in regard to rooting, prior to defecating (χ^2 = 1.4675, p = 0.2).

4.6 Mapping results

To determine if the sows and piglets displayed a spatial preference for performing elimination, I analysed all recorded events as a heatmap.

Figure 7 shows a heatmap of the spatial distribution and the density of elimination events performed by the sows across the 6 different pens. The highest density of elimination events occurred in the central area of the cropland, spanning across all pens. This indicates a strong preference for this specific area of the cropland. This area is approximately 13 meters away from the huts, which was the sows' primary resting place.

Otherwise, spatial elimination preferences appeared to vary between individual pens, with some sows showing no distinct preference.

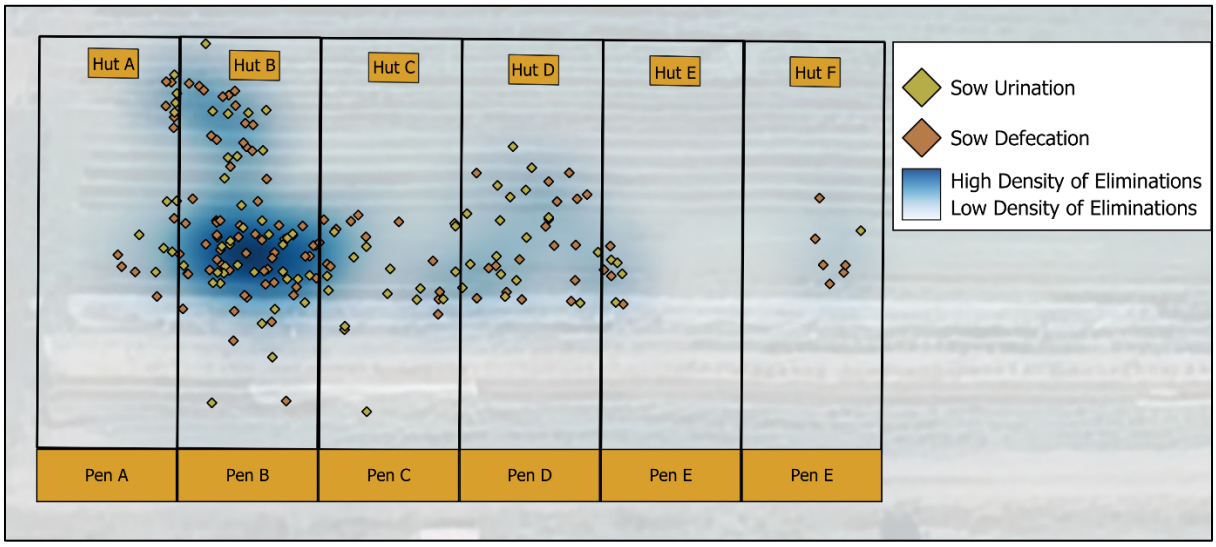

Fig. 7. Heatmap of the spatial distribution and density of elimination events by sows across the six pens. Darker blue areas indicate zones of higher frequencies of elimination events.

Figure 8 shows the density of elimination events performed by the piglets across the six pens. In contrast to the sows, the piglets had access to the entire cropland for their choice of elimination.

Similar to the sows, the piglets showed a high frequency of eliminating within the same central area which spans across all the pens. Another area of interest was the southern end of Pen C, where a high number of eliminations also took place.

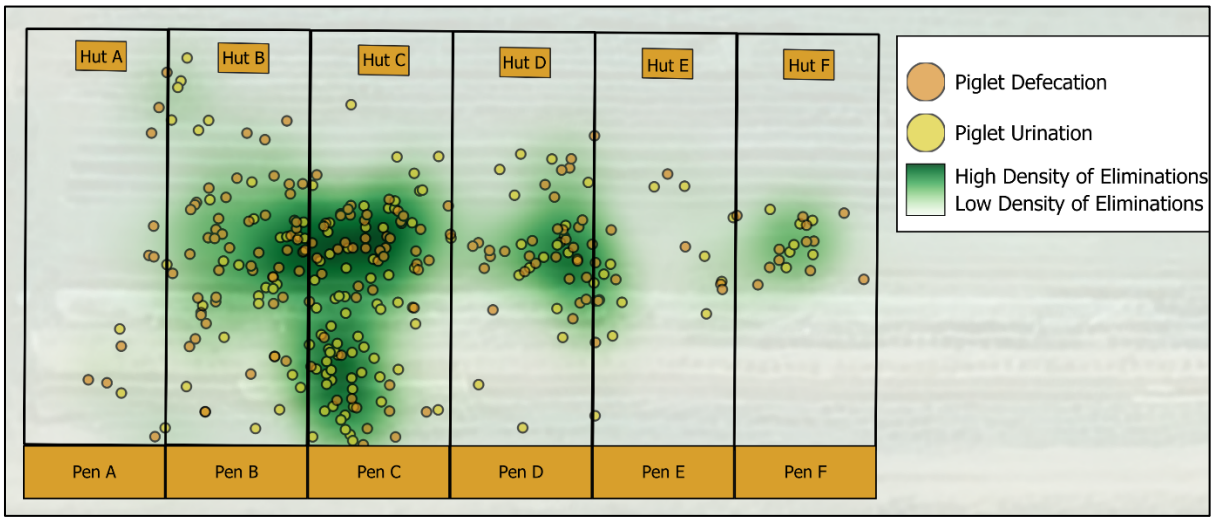

Fig. 8. Heatmap of the spatial distribution and density of elimination events by piglets across the six pens. Darker green areas indicate zones of higher concentrations of elimination events.

Figure 9 shows the combined heatmaps of the sows and piglets from figure 7 and 8, illustrating certain overlapping areas of elimination. The most prominent overlapping area was within the central region between Pen B and Pen C, but as well on the right-most side of pen D. In contrast, no overlap was found in the northern part of Pen A and B, close to the huts, and nothing in the southern part of Pen C.

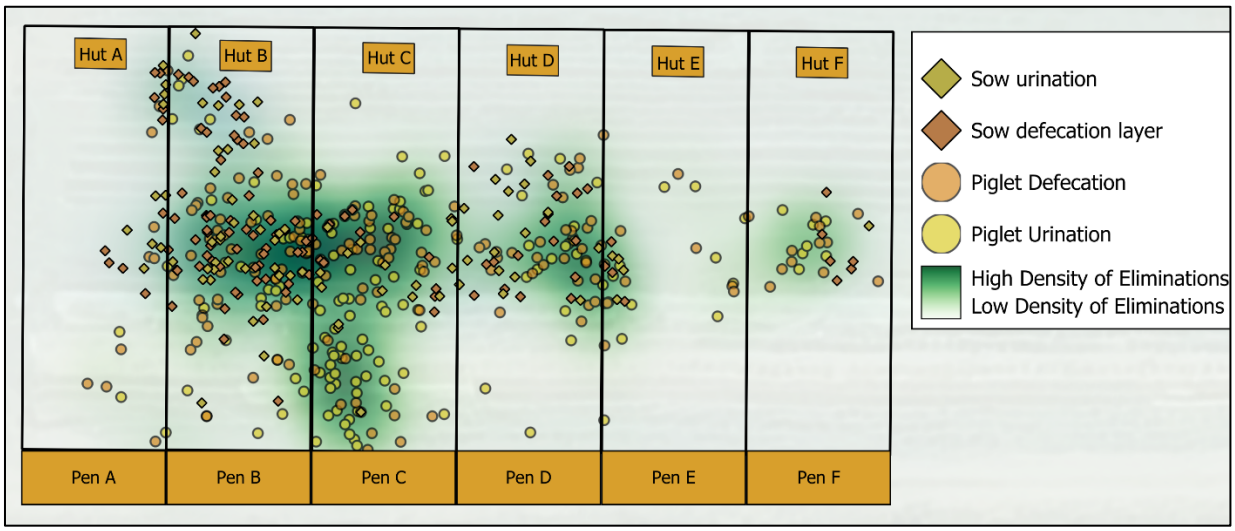

Fig. 9. Combined heatmap of elimination events by Sows and Piglets.

5. Discussion

The aim of this study was to investigate elimination-related behaviours and preferred elimination locations of sows and piglets in a natural outdoor environment. The results show both similarities and differences in the occurrence of behaviours prior to elimination for both sows and piglets.

5.1 Behavioural patterns in Sows

The most commonly occurring behaviours in sows prior to elimination of both types were sniffing and nosing. When exploring their surroundings, pigs rely heavily on their sense of smell, as to locate both edible and nonedible items (Studnitz et al., 2007). Pigs also rely on olfactory cues to recognise their surroundings and conspecifics, which includes the ability to discriminate between individuals based on their urine odour (Horback, 2023; Mendl et al., 2002). Therefore, pigs sniffing, and in turn, nosing the ground prior to elimination could be a mechanism to determine if the location has been previously used as a spot for elimination, either by themselves or a conspecific. Sniffing prior to elimination has been reported to be a commonly expressed behaviour in pigs (Andersen et al., 2019, Guo et al., 2015, Wechsler and Bachmann, 1998). A behaviour that has been found to occur in relation to sniffing is that of rooting, which aids pigs in the exploration of their surroundings and finding sources of food (Rørvang et al., 2023, Studnitz et al., 2007, Wood-Gush and Vestergaard, 1989). During my observations, rooting was a rarely displayed behaviour, occurring only a few times prior to both types of elimination. This suggests that rooting is not a behaviour which is tied to elimination. Pigs have been found to avoid certain strong odours, such as ammonia (Jones et al., 2001), which could explain why rooting is not expressed in relation to elimination areas, as to avoid resurfacing ammonia from the soil. Another possible explanation for the lack of rooting could be that pigs are known to avoid exploring and foraging in proximity to dung, preferring to move away from it (Nannoni et al., 2020.) Yet, foraging behaviour was commonly expressed by the sows in this natural environment of the open-air farm prior to elimination. It has been reported that pigs being held in semi-natural environments spend 52% of their active time during the day foraging (Stolba & Wood-Gush, 1989). This aligns with my observations in the present study regarding foraging behaviour. I found that sows foraged significantly more often prior to defecation than urination. This could be related to elimination posture, as pigs position themselves before urinating or defecating (Guo et al., 2015, Whatson, 1985), by holding a certain stance longer during urination, while being freer to move while defecating, which allows

the animals to forage further while defecating. This finding aligns with the significant difference that I found, where sows proceeded to walk more frequently prior to defecation than urination. Another factor that may have affected the foraging behaviour during elimination is that the area was an older cropland, with many of the pens being overgrown. This, in turn allowed the sows to feed directly from the plants growing, which does not require rooting.

I also observed that the sows vocalised significantly more often prior to defecating than urinating. Pigs have been reported to vocalise when investigating their surroundings, while actively moving (Marchant et al., 2001), which corresponds to what I observed. As sows use low grunts as a form to communicate with conspecifics (Marchant et al., 2001), their restriction to a pen each (except for the sows in pen B and D), may have lowered the number of vocalisations performed, as there were no nearby sows to vocalise to. Interactions with piglets may have influenced the number of sow vocalisations. As the piglets had free access to all pens, they could therefore interact with the sows before the elimination events. In general, the behaviours observed in the sows prior to elimination events in a natural environment strongly suggest olfactory exploration in determining suitable elimination sites for them.

5.2 Behavioural patterns in piglets

Similar to the sows, explorative behaviours were expressed commonly by the piglets. Piglets have been reported to spend a large amount of time exploring their surroundings, which aligns with them expressing explorative behaviours prior to eliminating, such as sniffing and nosing (Buchenauer et al., 1982, Guo et al., 2015, Stolba and Wood-Gush, 1989). In relation to explorative behaviours, I found that the piglets walked significantly more often prior to defecation than urination. Piglets have also been reported to maintain an elimination posture both when defecating and when urinating (Andersen et al., 2020, Guo et al., 2015, Whatson, 1985). Similar to the sows, it appeared that the piglets needed to maintain a stance for a longer time for urinating, while being able to move freely while defecating, thus increasing the occurrence of walking prior to defecation. Piglets have been reported to root and sniff at their elimination spots (Buchenauer et al.,1982). The piglets in my study did not align with those findings, as they displayed the behaviour only rarely before elimination of either type with no significant difference between the two. However, piglets have been reported to not always express certain behaviours prior to elimination, during the period between birth to five weeks

of age (Andersen et al., 2020, Whatson, 1985). As the piglets of my study varied in age, this might explain the inconclusive finding with regard to rooting and sniffing.

Foraging behaviour was also expressed only rarely by the piglets in my study, with no significant difference in occurrence between the two elimination types. This may be due to the age of the piglets, as in semi-natural settings, piglets receive milk up to 17 weeks of age, with the minimum of nine weeks (Pedersen et al., 2025, Stolba and Wood-Gush, 1989). As most piglets in my study had not yet reached that age, they had no need to search for food, as they received their nutrients from the milk provided by their mothers.

Lastly, the most prominent difference in behaviour between sows and piglets was that of vocalisation at low frequencies. This difference may be attributed to a social factor. As stated previously, pigs are known to vocalise when investigating their surroundings and moving, while also being a way of communication between conspecifics (Marchant et al., 2001). As piglets have strong social bonds with their littermates (Petersen et al., 1989), I observed that they often moved around the pens together. As the piglets usually remain near one another, the chance of social interactions is higher, thus increasing the number of total vocalisations performed. As the piglets, unlike the sows, were not restricted to one pen, piglets from different litters could also interact with each other, which may explain the increased vocalisations compared to the sows. The behavioural expressions of the piglets, prior to elimination events, closely resembled those of sows, with a strong preference for exploratory behaviours such as sniffing and nosing, in a natural environment.

These differences and similarities in behaviours between sows and piglets may be the result of a learning process. Piglets, being young animals, are still developing and rely on their mother on how to interact and find their way within their environment. The high sharedness in certain behaviours, such as sniffing and nosing, suggests that they may be innate behaviours, or behaviours acquired through social learning. Social learning is well documented in pigs, particularly in relation to foraging and exploration (Oostindjer et al., 2011, Jensen, 1988). It is possible that piglets observe and mirror the sow's behaviours in relation to elimination, eventually adopting and sharing the same traits and elimination spots as her.

5.3 Spatial distribution of elimination events in the pen

The spatial distribution of elimination events revealed a clear preference for certain areas within the pens. The highest density of elimination events occurred in a central zone spanning all pens, approximately 13 meters from the huts. This area accounted for 59% of all recorded elimination events for the sows and 52% for the piglets. In general, pigs have been reported to preferably eliminate in corners of their pens (Höne et al., 2023, Guo et al., 2015, Nannoni et al., 2020), which differs from my observations. The preference for this central zone is in line with studies reporting that pigs establish designated elimination areas (Höne et al., 2023). When looking at the heatmap of eliminations in the old cropland, the sows, particularly in Pen B, as well as in Pens D and F, eliminated both on the sides and the central part of the pen. This pattern of eliminating more centrally in their pen does not align with findings from previous studies. A possible explanation for these conflicting findings is that pigs are thought to prefer corners as to not be disturbed by other individuals while eliminating (Guo et al., 2015). However, as the sows of the present study were either by themselves, or with just another full-grown sow, it was unlikely for a sow to be disturbed by another individual while eliminating. Although, as the pens are open and divided only by an electrical wire, there remains a possibility that the sows eliminate close to the sides and corner to establish their home range and communicate to the neighbouring sows about the limits of their territories (Hacker et al., 1994). This, in turn, would be possible factor to why the sows eliminated across the same horizontal line across the pens, as to mirror and match the territorial lines and home ranges of the other sows. Also, whereas sows showed a strong preference for the central elimination zone, some pens exhibited individual variations, with sows in certain pens eliminating more frequently near their huts. This may be due to the fact that sows tend to only leave their nesting area for a short period of time to either eliminate and drink during the postpartum phase (Stangel and Jensen, 1991). This results in a new elimination area being created by the sows. And as previously noted, pigs may use olfactory cues to indicate previous elimination areas and would continue to use them even after a longer period. Nonetheless, the preference to eliminate far away from their normal resting spot aligns with previous studies about elimination (Andersen et al., 2020, Guo et al., 2015., Nannoni et al., 2020).

The behavioural pattern of sows preferring to eliminate in specific areas or zones within each of their pens may also be represented in other species, which can tie in multiple different factors of why the animals eliminate where they do. Antelopes and reindeer have been reported to eliminate in certain areas, while avoiding grazing near them. Furthering on that note, it was

found that the number of parasitic larvae was higher in areas used for eliminating than areas used for grazing (Ezenwa,2004, Van der Val et al., 2000, Hart & Hart, 2018). This approach of avoiding parasites by eliminating in certain areas may possibly be similar for that of sows and their elimination area preferences. This can also be the case within the wild species of boar (*Sus scrofa*), where it has been reported that these animals avoid eliminating close to their feeding areas (Feretti et al., 2015).

Piglets, too, eliminated frequently in the same central areas of the pens as the sows. Piglets are known to learn to recognise and follow their mothers at a young age (Petersen et al., 1989), which results in them following the sows frequently. Thus, when staying close to their mother, the piglets are likely to end up eliminating within the same area as their mother. Yet, in contrast, piglets also eliminated frequently and showed a preference for the southern end of Pen C as an elimination area. This area was heavily overgrown, and the piglets frequently hid within this area. No previous studies reported on hiding spots for growing piglets and elimination spots. Accordingly, this phenomenon should be investigated further.

As the location of the eliminations of the sows across the six pens all align in the center of the old cropland, this raises the question of why this area was chosen by all the sows as the preferred area. As I found sniffing and nosing to be prominent behaviours before eliminating, it could be that the pigs chose their location of elimination based on an olfactory preference. Therefore, I compared the preferred elimination spots of the animals to what was grown in the old cropland, which was grown five years ago, and has been let to overgrow over these last years, as illustrated in figure 10.

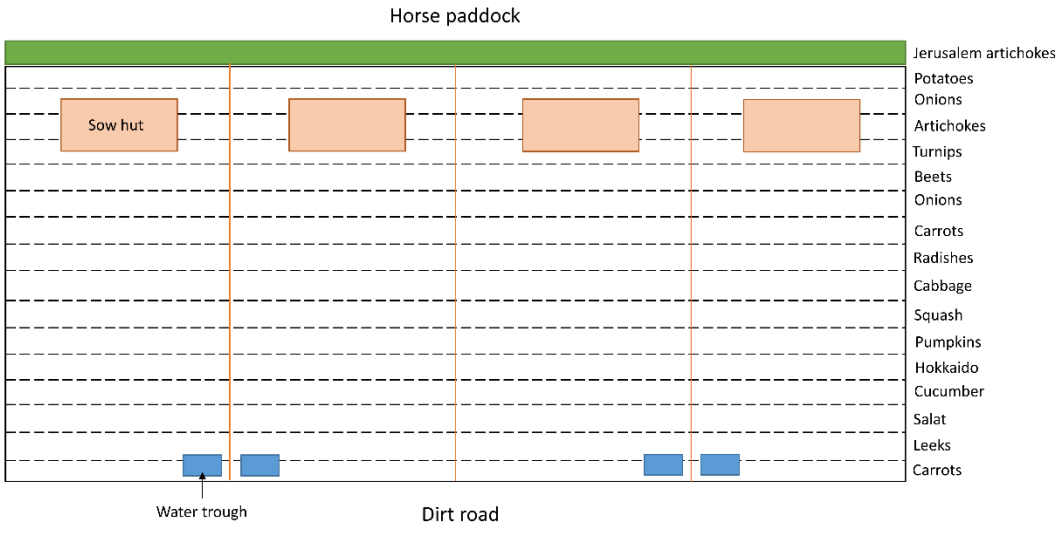

Fig. 10. Sketch of the first four pens over the old cropland. The list on the right shows where crops were previously grown in rows across the area.

When comparing the central zone of the heatmaps with the rows of crops previously grown in the area, the strongest alignment was found with radishes, cabbages, and squash. Currently, no studies assessed whether pigs' preferred elimination areas may be linked to the scents of plant life. The soil composition and hardness may explain why the central area was chosen for elimination, but to the best of my knowledge, no studies about soil hardness and composition have been published about pig elimination.

If elimination sites for pigs are influenced by different scents, future research should assess whether pigs do in fact show a preference for eliminating in areas associated with specific odors. If certain odors can be found that pigs prefer to eliminate on, there could be a possibility to implement those scents in commercial farms, and thus, making it easier for workers to both clean and care for the pens. From my findings, looking further into the crops in the central area may be a good starting point.

Another possible speculation as to why the sows eliminated in the central part of their pens could be that of limited spacing within each pen. With the sows being restricted to only one specific area, the potential area and spots for eliminating is therefore limited. As mentioned previously, pigs are known to avoid eliminating near their resting and feeding areas, and when comparing where these two areas are in each pen, a clearer picture can be formed. As the resting spot for the sows, their huts, were located in the northern end of each pen, and their feeding trough was located in the southern end, the area furthest away from both of these spots is therefore the middle of the pen. So by default, eliminating in the central zone of the pen, or in close proximity to the middle of the pen, is potentially the most optimal area to avoid eliminating in their resting and feeding spots.

5.4 Conclusion

This study provides insight into the different elimination behaviours of pigs in a natural environment. I found that explorative behaviours such as sniffing and nosing commonly occur prior to urination and defecation. The observed preference for a central elimination area, alongside elimination in corners and sides of pens, can be influenced by different factors. This includes that of social or olfactory factors, the ability to limit the spread of parasites within the pen, marking their home range zone to establish their territories, and that the layout of the pen

makes the central area the most optimal position for elimination in regards to distance from their resting and feeding areas. The present findings may have implications for farm management and cleanliness. If further studies into the connection of olfactory preferences regarding elimination in pigs are performed, strategies to encourage specific elimination sites could possibly be found. This, as sniffing was a major behaviour associated with elimination in the result of my study. In turn, this may improve animal welfare and hygiene in other farms.

5. Social and ethical considerations

As my study was purely observational regarding the naturally expressed behaviours of pigs, no formal ethical was required. The animals involved were privately owned and remained in their pens throughout the study. Prior to the beginning of data collection, the local responsible at SLU in Alnarp was consulted to evaluate the design of the study.

Welfare in farm animals is a major concern, particularly in commercial farming systems where space and environmental conditions can prevent animals from expressing their full repertoire of natural behaviours or can negatively affect the expression of certain behaviours. Understanding natural elimination behaviour and spatial preferences connected to this behaviour in pigs can contribute to improving farm management, improve hygiene, and improve the well-being of the animals. By looking further into the factors that influence elimination site selection of pigs, this study provides insights that can help design housing systems that align with pigs' behavioural tendencies regarding elimination. This would promote better welfare, for both pigs in commercial farming, as well farms hosting pigs in semi-natural settings.

In regard to the 17 sustainability goals set by the UN, my study aligns with three of those goals. The first two to note is goal 12, "Responsible Consumption and Production" and goal 15 "Life on Land". By investigating pigs' natural elimination behaviours and spatial preferences in a free-range system, my findings can contribute to more sustainable husbandry practices. Improved understanding of elimination patterns may help farmers manage waste more efficiently and maintain cleaner environments for their animals. And lastly, goal 3 "Good Health and Well-being", can be related to the study through promoting animal welfare with behavioural insights that could relate to reducing parasitic infections and promote the expression of natural behaviours of farm animals.

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