



Behaviour of Moura breed pigs in silvopastoral systems

Comportamento de suínos da raça Moura em sistema silvipastoril

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Abstract: Animal production aims to reconcile sustainability and efficiency. In this context, silvopastoral systems emerge as a promising and little explored alternative. This exploratory study evaluated the behaviour of Moura pigs, raised in a silvopastoral system, in the middle of the Araucaria forest and native fields. Behaviour was assessed using an ethogram, to quantify the animals' habits in the forest. This made it possible to analyze the animals' activities, providing information about their social, feeding and general behaviour. As a result, the behavioural evaluation showed that the pigs were able to consume pasture and pine nuts in open areas under the araucaria trees. Furthermore, no anomalous behaviours or stereotypies were detected in animals raised in the silvopastoral system, indicating a better quality of life and well-being of animals raised in a free-range environment. Finally, the silvopastoral system proved to be an alternative for pig farming providing a more natural environment, with greater dietary diversity, a lower rate of negative behaviours and, consequently, improved well-being for the animals.

Keywords: agroforestry; araucaria; ethology; pig farming.

Resumo: A produção animal vislumbra conciliar sustentabilidade e eficiência. Nesse contexto, os sistemas silvipastoris emergem como uma alternativa promissora e pouco explorada. Este estudo exploratório avaliou comportamento de suínos da raça Moura, criados em sistema silvipastoril, em meio à floresta de araucárias e campos nativos. O comportamento foi avaliado por meio de um etograma, quantificando os hábitos dos animais na floresta. O etograma possibilitou a análise das atividades dos animais, fornecendo informações sobre o seu comportamento social, alimentar e geral. Como resultado, a avaliação comportamental evidenciou que os suínos se mostraram aptos a consumir pastagem e pinhão em áreas abertas sob as araucárias. Além disso, não foram detectados comportamentos anômalos ou estereotípias nos animais criados no sistema silvipastoril, indicando melhor qualidade de vida e bem-estar dos animais criados soltos. Por fim, o sistema silvipastoril se mostrou uma alternativa para a criação de suínos, proporcionando um ambiente mais natural, com maior diversidade alimentar, menor índice de comportamentos negativos e, conseqüentemente, melhor bem-estar para os animais.

Palavras-chave: agrofloresta; araucária; etologia; suinocultura.

1. Introduction

The extensive pig farming system is carried out on a large areas of land, where the animals remain completely free, without any application of technology. They can exist simultaneously

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with perennial vegetable crops, and all animals of all categories and ages occupy the same area, competing for the same food⁽¹⁾.

From a preservationist perspective, the pig production that supplies local and regional Brazilian markets partially originates from these simpler production systems. The national swine breeds that stand out in these systems are Piau, Nilo, Canastra, Monteiro, Pereira, Sorocaba, Macau, Pirapitinga, Caruncho and Moura among others, as well as their crosses, which are traditionally raised free range. These breeds, in an extensive production system by small rural producers, feed mainly on grass and other natural foods, which gives the meat a characteristic and differentiated flavour. Producers meet the expectations of a growing market, which values the production of healthy and sustainable food⁽²⁾.

Among the national breeds, the Moura, a descendant of ancient Iberian lineages, stand out in the South Region of Brazil. Raised traditionally over generations, this breed presents excellent marbling in its meat, as well as an intense red color. It has a highly esteemed texture and flavour, which make it a high-value product in gastronomy and in the production of fine sausages⁽³⁾.

As shown in previous research, this superior quality of Moura pork in relation to industrial pig meat is strongly influenced by the animal's diet⁽⁴⁾. When free in the wild⁽⁵⁾, pigs spontaneously consume a wide variety of foods, including forage, roots, insects and grains. This varied diet can contribute significantly to the marbling, flavour and quality of meat. For example, in the Iberian Peninsula, Alentejana pigs are raised in a system similar to silvopastoral, and there is evidence that this system influences the organoleptic characteristics of the ham. This system, which integrates trees, pastures and animals, offers a sustainable and environmentally friendly approach to pig production⁽⁶⁾.

However, animal welfare is one of the central elements in pig farming and must be considered from the animal's birth to slaughter⁽⁷⁾. Some studies⁽⁸⁾ reinforce that animal welfare is closely related to the balance between the animal and its environment, so that any difficulty in the adaptation process is indicative of failures in this regard. The preservation of the forest allows free-ranging pigs to have a broad exploratory behavioural repertoire that is not reproduced by pigs raised in systems that use confinement⁽⁹⁾.

Considering what has been done so far, as well as the scarcity of detailed information on the subject and allowing for the importance of preserving a Brazilian breed, it is crucial to deepen knowledge about the behaviour of Moura pigs raised in silvopastoral systems. Understanding how these animals move, interact with the environment and with each other, in addition to their dietary patterns, is essential to guarantee their well-being and optimize animal production.

Therefore, this exploratory study aimed to record and describe behaviours that have never been documented in the Moura breed in a silvopastoral environment. The goal of this research is to contribute to a more comprehensive knowledge of its ethology and varying aspects related to well-being in the silvopastoral system. Furthermore, the study aims to

document the feeding of pigs with pine nuts, which in the future could contribute to the introduction of more appropriate management practices for the preservation of the Moura breed in sustainable production systems.

2. Material and methods

This research was submitted and approved by the Ethics Committee on the Use of Animals (CEUA), of the Federal University of Fronteira Sul, under registration CEUA no. 8390050721, respecting the regulations established by the National Council for the Control of Animal Experimentation (CONCEA).

2.1 Silvopastoral system

The studied farm is located in the municipality of Bom Retiro, SC, Serra Catarinense, in the South Region of Brazil. The region's climate, according to the Köppen-Geiger classification, is humid mesothermal (Cfb), with cool summers and cold winters. The municipality's average temperature is 15.6°C, varying from -10 to 18°C, with frost, snowfall and icicles (frozen fog) in winter, with an average precipitation of 1.386 mm/year. The soil is characterized as cambisol, clayey, with subtropical montane forest⁽¹⁰⁾.

Moura pigs are raised in a single paddock, fenced at some points on the perimeter and on the West front. The final portion of the property is narrow, in the shape of a wedge, and there are two uneven geological formations, which in addition to delimiting the property, have a large number of araucaria trees, which produce pine nuts from the end of March onwards.

In this environment, trees typical of the Santa Catarina mountain region were also seen scattered throughout the forest, such as cambará (*Moquiniastrum polymorphum*), pau-andrade (*Persea pyrifolia*), tapir bark (*Drimys winteri*), cinnamon (*Cinnamomum verum*), imbuia (*Ocotea porosa*), cedar (*Cedrela fissilis*) and bracatinga (*Mimosa scabrella*), highlighting the araucaria capons (*Araucaria angustifolia*).

2.2 Animals and management

Two hundred fifty Moura pigs were available for this study. They were of varying ages (6.5 ± 2.5 months) and growth stages, released into a single paddock field of 79.23 hectares of native countryside. On the farm where the research was carried out, there were also some crossed animals, which were produced by Moura sows with Duroc males. Raised in a silvopastoral system, the animals were fed a mixture of crushed non-GMO corn, wheat bran and chopped pumpkins in a covered collective trough in the morning and afternoon.

During the day, the pigs had free access to the native countryside and forest resources, which was shared with 55 cattle. During the night, most of the animals slept in a collective shelter and some groups remained in the field/forest. The water came from natural streams and tributaries. All animals were dewormed and vaccinated against infectious diseases, including leptospirosis, infectious pleuropneumonia, enzootic pneumonia and Glässer's disease.

2.3 Behavioural observations

Measures were adopted to observe behaviour *in loco* and *ad libitum*, including care with the routes taken, in order to avoid overlapping locations and animals that had already been observed that day. Horse riding was used for movement, in order to minimize interference, due to the fact that the pigs were accustomed to this species in the field and due to the long distances that the observer had to travel.

Given the large area to be covered as well as the vast presence of forest cover, a specific methodology was developed for this work. The direct observation method was used to describe the behaviour of groups of pigs, which were distributed across a 79.23 hectare pasture/forest area. The observer remained camped in a suspended tent for a period of two uninterrupted days (48 hours) in May 2022, following the Moura pigs on horseback, which allowed the pigs to get approximately two meters away. This initiative, in addition to identifying groups of animals (here defined as families), allowed the description of possible twilight and nocturnal behaviours of pigs. Once one family was identified and analyzed, another was identified and so on.

As the pigs were located, they were approached cautiously, and the behaviour of each animal was noted, based on a list of actions previously prepared according to Table 1. The group or individual animal was monitored until the activity changed or the observer left the field of vision⁽¹⁾.

Table 1 Ethogram for behavioural analysis in pigs raised in an extensive silvopastoral system.

Animal activity	Description of the animal's activity
Inactive lying down	Lying with eyes closed, sleeping
Standing	In station, without specific movement
Lying alert	Lying down with eyes open and attentive
Sitting or kneeling	Sitting or kneeling
Poking around	Exploration of the soil to capture food
Wallow in the mud	Bathing in mud, rolling in damp soil
Drinking water	Drinking water
Grazing	Consumption of pasture, grasses or plants
Walking	Picket occupation, displacement
Aggressiveness	Mutual aggression, disputes, biting, territoriality
Repetitive behaviours	Addictions and abnormal stereotypes

After recording the behaviours, the observer left the area, moving in a different direction from the recorded pigs. Therefore, when another unanalyzed group was identified in another place, a new approach was taken, always taking care to avoid a repetition of animals. The procedure was replicated on both days, with counting restarted on the second day.

In this work, it was not possible to quantify the time allocated to each activity; rather, the activities performed by the animals at the time they were found were recorded. In addition, the existence of differences between behaviours or between days was not computed, giving the work a descriptive focus.

2.4 Statistical analysis

Quantitative statistical analysis was carried out by calculating the relative frequencies in percentages of events and behavioural states, using *ad libitum* and behavioural sampling, in which the observer recorded everything that was found to be specifically relevant ⁽¹²⁾. Considering that the herd of the animal species studied was composed of countless pigs, and that it was obviously not possible to study all of them, it was decided to study the sampling of *ad libitum* behaviour, taking into account that a behavioural unit, as can be observed in the pilot, occurred several times throughout the observation day for a considerable number of animals, if not all.

In some cases, such as in sampling the frequency of return to the farm headquarters during the pine nut harvest period, the data were ordered as the average of the frequencies on random days of the month, plus or minus the standard errors of the means. The tests applied were analysis of variance followed by Dunnett's test using Graph Pad Prism 8.0 software.

3. Results and discussion

3.1 Pig behaviour in native pastures with access to the forest

Pigs are gregarious, sociable and linearly hierarchical animals, which determines the formation of well-established groups. In the population under study, there were no intact males in the groups formed, and the establishment of classic leaders such as those that occur in the presence of boars was not observed. The hierarchy was determined by varied pigs, such as adult females or castrated adult males leading family groups.

In 48 hours of observation 138 pigs were found, without distinguishing age, sex or weight. Of these, 66 pigs were counted on the first day and 72 pigs on the second day. This sample represents 55.2% of the total population who were subjected to the ethogram.

A varied repertoire of attitudes was observed. The main behaviour displayed by the animals during observation was grazing without walking. Twenty-one animals were found grazing on a site on the first day and 23 animals on the second day. Figure 1 presents the frequencies of the main behaviours observed over two uninterrupted days of observation.

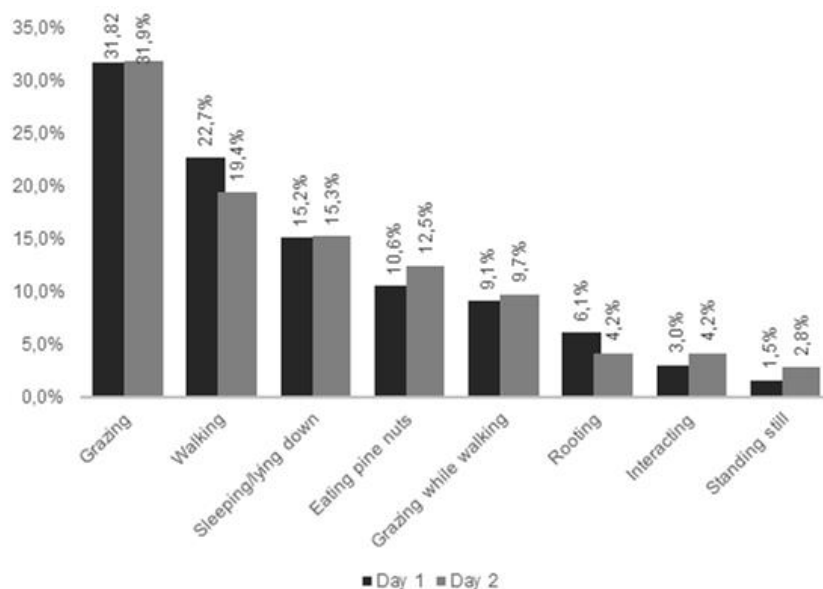


Figure 1 Behavioural activities performed by pigs raised freely in native pasture areas, on two uninterrupted days. The ordinate axis shows the percentages of animals found in a given activity; the abscissa axis represents the expressed behaviour.

In addition to the behavioural activities expected by the authors, other behaviours also became evident. A collective movement behaviour was observed in groups of three to four animals, which left the feeding area early in the morning to graze via different routes. It was noted in this study that, right after the morning feeding, the pigs spontaneously left for the field and during this movement, all the pigs moved in lines, forming groups with different ages and sexes, without showing any signs of conflicts, even with the absence of family ties.

In this study, a group of 14 Moura pigs separated from the others on the two days they were monitored. At the end of each afternoon, the group divided into two: the smaller juvenile pigs separated from the larger ones. The segregated pigs took shelter at night in a place that contained a type of dry grass bed (Figure 2). On the two days observed, the pigs started moving towards the resting place at around 5:40 p.m., remaining there during the night and leaving at dawn.



Figure 2 Night photograph of a group of Moura pigs grouped together on a bed of grass straw at night (Source: Authors' Collection).

While the other pigs returned to the farm for routine feeding, a group remained in the field even at night. This intriguing choice may suggest that the availability of natural foods in the environment may have reduced the dependence of these animals on food provided by humans ⁽¹³⁾. A parallel assessment was carried out by counting the animals that returned to the farm at night from March to July, which corresponds to the pine nut harvest. Fewer pigs remained in the field at night in the month of May in particular, compared to the other months of the year with a total of 50% that returned to the farm during the night (Figure 3).

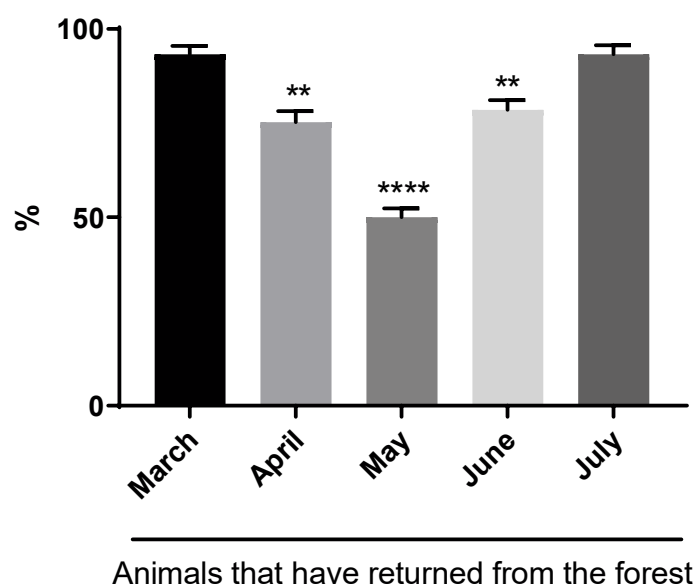


Figure 3 Frequency of return at night of Moura pigs to the farm headquarters during the pine nut harvest months. The columns represent the average of eight to ten relative frequencies collected on random days of the current month and the vertical bars represent the standard errors of the means. ** $P < 0.01$; **** $P < 0.0001$: Differ significantly. Dunnetts test.

This decision by the animals, observed in late afternoon, may have been motivated by factors other than the abundance of food in the forest, such as the difficulty of returning due to the distance of 2,178 meters to the farm headquarters.

3.2 Diet of the Moura breed in Mata das Araucárias

This exploratory study was conducted at the end of the pine nut season, that is, late May/early June. Consequently, a large quantity of the pine cones produced in that year, 2022, had already fallen to the ground and been consumed. Despite this, during the study, a large number of animals were observed eating pine nuts (Figure 4) in open areas under the araucaria trees (11.8%) and most were grazing (32.59%). This observed behaviour is described in historical literature, and the data found reinforces that keeping pigs on pasture is adequate to meet their essential nutritional demands^(14,15,16).



Figure 4 Juvenile Moura pig in a silvopastoral system feeding on pine nuts under araucaria trees (Source: Authors' Collection).

A rate of 15.55% of pigs sleeping or lying down during the day close to places with a greater quantity of pine cones was observed. Another feeding behaviour of Moura pigs was to graze while walking. They walked five to ten steps, ate a portion of grass and followed the trail to another pine tree. There is evidence of this description only in books that deal with the subject of pig drovers in the South Region of Brazil⁽¹⁷⁾.

Throughout the environment and on the route between the farm headquarters and the area with the highest concentration of fruiting araucaria trees, a pattern of grazing and collecting resources in the soil was evident, without losing the formation of the established small group. Every few moments the animals rooted around. This behaviour occurred less frequently than expected, perhaps due to the preference for consuming pine nuts⁽¹⁸⁾.

3.3 Welfare of the Moura breed in a silvopastoral system

These pigs did not show anomalous behaviours or behavioural stereotypes similar to those observed in industrial swine farming (e.g. fights, tail cannibalism, etc.) due to the positive relationship they established with the environment.

In the context of the pigs' physical freedom, this study found that the animals spontaneously leave the feeding area and head to the pasture in small groups (Figure 5). In contrast to intensive farming systems, where animals remain in closed environments with limited space and are prone to stressful situations, the silvopastoral system provides complete freedom of movement and autonomy to search for food⁽¹⁹⁾.



Figure 5 Group of Moura pigs grazing and walking in a silvopastoral system with complete freedom of movement in search of resources in the soil (Source: Authors' Collection).

During the two-day follow-up, 15.55% of the animals were observed sleeping. This spontaneous behaviour may indicate nutritional satisfaction and environmental comfort, in addition to being part of the natural repertoire and circadian cycle of these animals. Evaluating the behaviour of pigs in the silvopastoral system, considering the freedom of movement, the expression of natural behaviours and the occupation of the environment, it was possible to infer that the animals obtained food efficiently and without excessive effort ⁽¹⁵⁾.

Interactions between pigs were positive (1.48%), involving sniffing movements and touching their noses to each other. Aggressiveness, a behaviour present in confining accommodations, was not detected. Even though the herd was heterogeneous, they did not express aversive behaviours or participate in anomalous interactions. This allowed us to consider the achievement of stable well-being among this population⁽²⁰⁾.

The silvopastoral system, with its enriched environment, reduces some factors that harm the animals' well-being. Studies demonstrate that pigs in enriched environments have lower levels of stress compared to confined animals⁽²¹⁾. However, some welfare indicators are difficult to measure in the silvopastoral system. For example, we cannot guarantee with certainty whether the stress generated by the active search for food is lower than the stress in intensive systems, when food is offered *ad libitum*⁽²²⁾.

Furthermore, other indicators of well-being may be negatively affected. Any imbalance can affect the availability of food resources, requiring increased exploitation of the environment by pigs. When confined in intensive systems, animals are subjected to adverse conditions, thus changing their behaviour in general and mainly in relation to food intake. When this is altered, it can result in a drop in their zootechnical indices, mainly due to changes in eating habits⁽²³⁾.

An example of an adverse condition is thermal stress generated by cold below comfort levels, where animal growth becomes slow and, with decreasing temperatures, the efficiency

of food conversion is reduced ⁽²⁶⁾. Pigs have a poorly developed thermoregulatory systems, but are resistant to cold as adults, which makes it difficult for them to adapt to the tropics⁽²⁴⁾.

As it is a breed of European origin, rustic and prolific, the Moura breed over time has adapted very well to the semi-temperate climate of the Serra Catarinense Region⁽⁴⁾. No thermal suffering was observed in juvenile or adult animals, even in adverse weather conditions, such as frost and negative temperatures. During the data collection period, the temperature was mild and ranged from 12 to 15°C in sunny weather. Of course, the dynamism of the environment, with sudden changes in the natural structural elements of the silvopastoral system can be harmful. Providing shade, shelter and protection is important in an environment that is always changing⁽²⁵⁾.

As the total area is extensive and shared with other animal species, the quality of pasture, pine nuts and the availability of water resources are dynamic and may not always favour pigs. Therefore, changes in these elements can affect the behaviour and well-being of animals, requiring additional research^(22,23,26).

4. Conclusion

The Moura breed has demonstrated adaptation to the extensive silvopastoral production system under the conditions of this study. In addition, despite the distance travelled daily by the animals, they fed on pine cones and native pasture, maintaining a good body score, and did not demonstrate repetitive or anomalous interactions.

Declaration of conflict of interest

The authors declare no conflict of interest.

Credit Authorship Contribution Statement

Conceptualization: V. Schlemper. *Data curation:* S.R.M. Schlemper and V. Schlemper. *Formal analysis:* E.L. Soares and V. Schlemper. *Investigation:* E.L. Soares and V. Schlemper. *Supervision:* V. Schlemper. *Methodology:* E.L. Soares and V. Schlemper. *Project administration:* V. Schlemper. *Writing - original draft:* E.L. Soares and V. Schlemper. *Writing - proofreading and editing:* S.R.M. Schlemper and V. Schlemper. *Final manuscript:* S.R.M. Schlemper and V. Schlemper.

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