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Thermographic quantitative analysis by quadrants of australian saddles used in basic horseback riding courses

Análise termográfica quantitativa por quadrantes de selas australianas utilizadas em curso de equitação básica

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Abstract
The saddle is a particularly important piece of equipment when it comes to training horses. Any problem with this, or in its adjustment, can cause discomfort, pain and injury to the horses. The aim of this study was to analyze Australian saddles thermographically, in a quantitative way by quadrants, performing a primary detection of how pressure distribution occurs in Australian saddles commonly used in Mangalarga Marchador (MM) gaited horses during a basic riding course, in order to signal whether there is a need for a more complete assessment of saddle befitting this type of activity. For this purpose, ten similar Australian saddles used by ten MM horses were thermographically evaluated during a basic riding course. Thermographic images were obtained from the ventral face of the saddle before and after one hour of exercise. The images were divided into 9 quadrants and compared quantitatively before and after the ride. Quantitative analysis by quadrants including 3 central quadrants for assessing the gullet region was effective, providing the necessary detail for data analysis. Inappropriate contact of the gullet region with the animal's back was demonstrated in 100% of the saddles, with the central quadrant of the gullet being the most affected, indicating the inadequacy of this type of saddle for MM in this activity. Therefore, there is a need for a more complete assessment of saddle befitting an Australian saddle type to this equestrian activity, aiming at improvements in animal welfare.
Keywords: thermography; zootechnics; horseback riding; saddle fitting.

Resumo
A sela é um equipamento de grande importância quando se trata do treinamento de equinos. Qualquer problema nesta, ou em seu ajuste, pode ocasionar desconforto, dores e lesões aos equinos. Objetivou-se, com o uso da análise termográfica quantitativa por quadrantes, realizar uma detecção primária de como ocorre a distribuição de pressão em selas australianas comumente utilizadas em cavalos da raça Mangalarga Marchador (MM) durante um curso básico de equitação, de forma a sinalizar se existe a necessidade de uma avaliação mais completa da adaptação de selas *(Saddle Fitting)*para

este tipo de atividade. Para isso, foram avaliadas termograficamente dez selas australianas similares, utilizadas por dez animais da raça MM durante a realização de um curso básico de equitação para cavaleiros iniciantes. As imagens termográficas foram obtidas da face ventral da sela antes e após uma hora de exercício. As imagens foram divididas em nove quadrantes, comparadas quantitativamente, antes e depois da utilização, quanto a: temperatura do mesmo quadrante e equilíbrio entre quadrantes. A análise quantitativa por quadrantes incluindo três quadrantes centrais para avaliação da calha foi efetiva, proporcionando o detalhamento necessário para a análise dos dados. Demonstrou-se contato inapropriado da região da calha com dorso do animal em 100% das selas sendo quadrante central da calha o mais afetado, indicando a inadequação deste tipo de sela para MM nesta atividade. Havendo, portanto, necessidade de uma avaliação mais completa da adaptação de selas *(Saddle Fitting)* tipo australiana, a esta atividade equestre visando melhorias no bem estar animal.
Palavras- chave: termografia; zootecnia; equitação; ajuste de sela.

Introduction

Horse breeding is growing in Brazil. In this scenario, the State of Goiás stands out as the fourth largest producer of horses, with an estimated herd of 395 thousand animals[1]. Due to the expressive herd, the qualification of the workforce is necessary both for dealing with animals and for the equipment production. In this context, saddlery is one of the branches that stands out, moving around 176.4 million reais per year[1]. However, even in the face of this number, the sector lacks qualified labor.

Each breed of horse has body characteristics that favor a particular activity. The Brazilian horse breed Mangalarga Marchador (MM) is widespread throughout the national territory. It is characterized by the comfort of its marcha gait, which provides a wide range of activities performed by these animals, such as gait championships, exhibitions, horse riding, sports and leisure. With 600 thousand registered animals[2] and a great tendency for the proliferation of the animal herd destined for leisure, there is also a growing concern among the owners of these animals' regarding the learning of new riding techniques and the acquisition of new equipment that guarantee the rider's safety and the horse's well-being.

There are several types of equipment used in each equestrian modality in order to directly influence performance and animal welfare. The saddle is the equipment responsible for attenuating the contact between the body of the horse and the rider, therefore, it should provide the best comfort for both without causing damage to health. There are several types of saddles in the industry. A preference is observed according to the activity practiced in Brazil. English saddles are used for equestrian disciplines like in FEI (International Equestrian Federation). Western saddles are mainly used for American Quarter Horses in many disciplines of the breed and cattle work, and the Australian saddles are used for gaited horses, some working horses, exhibition and

leisure animals.

Regardless of the type used, the saddle design must be developed so that the panel area distributes all the pressure of the rider's weight without other parts of the saddle putting pressure on inappropriate regions of the animal. The gullet found in the center of the saddle between the panels, must not be in contact with the horse's spine[3,4]. Likewise, if the saddle has a defect, it can generate focal pressure points[5], in other words, saddles that have an imbalance can generate problems arising from pressure peaks at specific points, which can cause pain, lameness[6], injury, or regional atrophy[7].

There are several techniques such as observation, measurements, palpation, pressure pads and thermography to assess the saddle fitting on the animal. In this way, it is possible to evaluate the space ("gap") between the horse's spine and the saddle gullet, the adequacy of the width and length of each type of saddle to the animal, as well as the correct positioning, in which the saddle is not over the scapulae[8] and/or exceeding the last rib[3]. When the thermographic image of the saddle is analyzed after its use, it is possible to see if the rider's weight was correctly distributed locating any pressure peaks that resulted from bad saddle fitting[9,10, 11-12].

The Australian type of saddle is commonly used in Brazil by the majority of leisure horses and gaited breeds, due to the fact that it provides a greater sensation of comfort and safety to the beginner rider when compared to some English saddles, which are not widespread in rural areas in the Center-West region of Brazil. Australian saddles commonly used in the MM breed are made of leather, have a hard tree, an arch in the region of the pommel, may or may not have flaps, which vary in size. The depth of the seat generally varies according to the size of the saddle, the cantle inclination, and the angle of the tree; the smallest being deeper and the largest being flat. The tree is usually slightly shorter than the horizontal length of the panels. The panels and the tree are neither adjustable nor malleable. The gullet width varies a lot, and may even be absent in some trees.

In basic horsemanship courses for gaited horses of the MM breed, it is common to use Australian saddles on 100% of the animals for several hours. In a previous study[12], evaluating saddles of MM horses for marcha gait competition, 83.3% of asymmetry was found in the contact area of the panels which distributes the weight of these saddles on the animal's back, indicating possible spots of overload and future injuries. In marcha gait competitions, the riders who present the animals are very experienced professionals. On the other hand, the fact that beginner riders have a lower level of riding can further aggravate the unequal distribution of weight on the animal's back in this type of saddle.

The objective was, therefore, using quantitative thermographic analysis by quadrants, perform a primary detection of how pressure distribution occurs in Australian saddles commonly used in Mangalarga Marchador horses during a basic horseback riding course, in order to point whether there is a need for a more complete assessment of saddle befitting this type of activity.

Material and methods

This paper was submitted to the Ethics Committee on the Use of Animals (CEUA) of the Federal University of Goiás under protocol n° 022/19.

Using thermography, the ventral face of 10 similar Australian saddles weighing 7 kg each were evaluated; used in 10 animals of the MM breed, in which there were 6 females and 4 males, with an average weight of 370 kg (± 20), an average chest perimeter of 168 cm (± 3), an average height of 1.45 m (± 3), mean age of 5 years (± 2) and body score of 3 (scale from 0 to 5) according to Carrol and Huntington[13].

All saddles were used during the same basic horseback riding course, using one saddle per set of horse and rider for a period of 1 hour on each animal. The saddles were made up of a girth and billies for its attachment to the horse, and pads with a 2.5 cm thick foam lining were used, this being the (maximum) limit accepted by the regulations of the Brazilian Association Mangalarga Marchador Horse Breeders. The saddles were positioned on the animals' backs according to Schleese[4], fitting the pad to the gullet.

All animals performed the same exercises at the same time, in the same sequence, for the same duration, at the same intensity. The exercises consisted of: halt, transitions, circles, half circles or loops and changes in direction. These exercises were performed in the three gaits consisting of: 20 min of walk, 30 min of marcha and 10 min of canter. The riders also performed flexibility exercises for the rider, such as riding with and without stirrups, during the walk and marcha gaits. All riders were beginners with the same level of riding and weighing 20% of the weight of the corresponding horse.

The basic horseback riding course took place in Senador Canedo, with a latitude of 16°41'01.5" and longitude of 49°09'38.9", in the City of Goiânia, in the State of Goiás, Brazil. The course started at 4 pm and lasted 60 min. The average room temperature on the date and time of the experiment was 29°C, with an average relative humidity of 58%.

For the thermographic images' execution, each saddle was placed one meter away from the FLIR E-40 camera, forming a 90° angle with the camera, with the ventral face of the saddle (panels and gullet) placed in front of the lens in a shaded location. Two thermographic images were taken, the first one 10 minutes before the animals were saddled, and the second one just after the end of the course, when the animal was unsaddled. The images were analyzed using the FLIR TOOLS software. The thermographic image of each saddle was divided into 9 quadrants (Figure 1). The quadrants were numbered from 1 to 3, with 3 quadrants in the left panel (left region), 3 quadrants in the gullet (central region), and 3 quadrants in the right panel (right region) in a methodology adapted from Soroko et al.[10].

Analysis of variance was performed in a randomized block design, in a split-plot scheme. Tukey's test was used to compare means ($p = 0.05$). The sets of horses and riders constituted the blocks. To assist the statistical analyses, the R software (R Core Team, 2020)[14] was used.

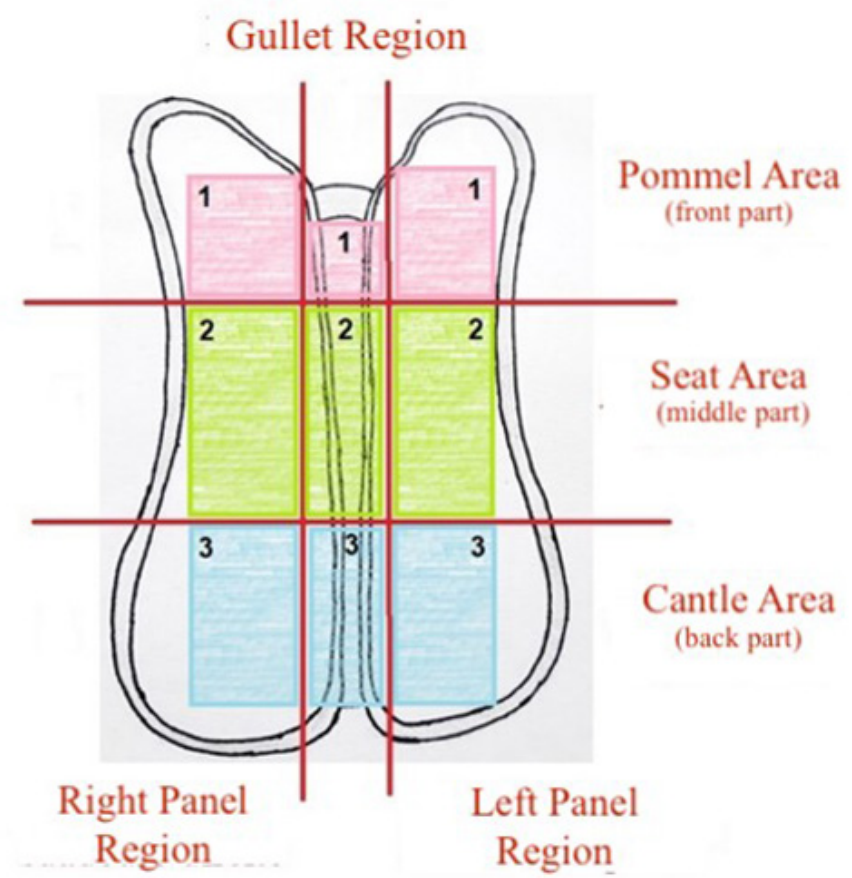

Figure1: Characterization of the ventral surface regions of the saddle and the quadrants analyzed

Caption: The saddle regions are represented in the longitudinal direction in the figure, being from left to right: left panel, gullet and right panel. The upper part of the saddle, or area of the pommel, represents the area close to the withers when using the saddle on the animal. The pink areas correspond to the number 1 quadrants. The green areas correspond to the number 2 quadrants, and the blue areas correspond to the number 3 quadrants.

Results

Using thermographic images of before and after the exercises, a temperature increase ($p < 0.05$) was observed in all quadrants evaluated after the exercise due to the use of the equipment on the animal. This demonstrates that all the lower parts, such as panels (right and left) and gullets (center), from Australian saddles used in a basic horseback riding course on MM horses, have made contact with the animal's back (table 1).

Greater pressure can be noticed in the entire gullet region in relation to the three regions evaluated (gullet, right panel and left panel), with the central quadrant area C2 in the gullet region (exact center of the saddle) the point of greatest overload, followed by the

quadrants C3 (hind) and C1 (front), respectively (Table 1). This demonstrates unbalance of the saddle and incorrect confection of the gullet area, a region where there should be no contact with the horse.

Table 1: Evaluation between quadrants of the left (panel-L), central (gullet-C) and right (panel-R) regions before and after an hour of riding course

Region	Quadrant	Before	After
Left	L1	24.01 aB	29.43 aA
	L2	23.80 aB	29.46 aA
	L3	23.62 aB	29.56 aA
Center	C1	23.84 aB	30.00 cA
	C2	23.82 aB	32.14 aA
	C3	23.77 aB	31.48 bA
Right	R1	24.04 aB	29.20 aA
	R2	23.91 aB	29.53 aA
	R3	23.78 aB	29.55 aA

Means followed by distinct letters, uppercase on the line and lowercase on the column, differ from each other by the Tukey test ($p < 0.05$).

When comparing the pressure exerted on the quadrants between the right and left panels, it is observed that they are balanced before and after the use of the saddle (Table 2), that is, with an equal pressure distribution between the right and left sides; also presenting an equal pressure distribution or balance between their respective quadrants (Table 2).

Table2: Comparison between the quadrants of the right and left panels

	Region	Quadrant 1	Quadrant 2	Quadrant 3
Before	Right	24.04 aA	23.91 aA	23.78 aA
	Left	24.01 aA	23.80 aA	23.62 aA
After	Right	29.20aA	29.53aA	29.55aA
	Left	29.43aA	29.46aA	29.56aA

Means followed by distinct letters, uppercase on the line and lowercase on the column, differ from each other by the Tukey test ($p < 0.05$).

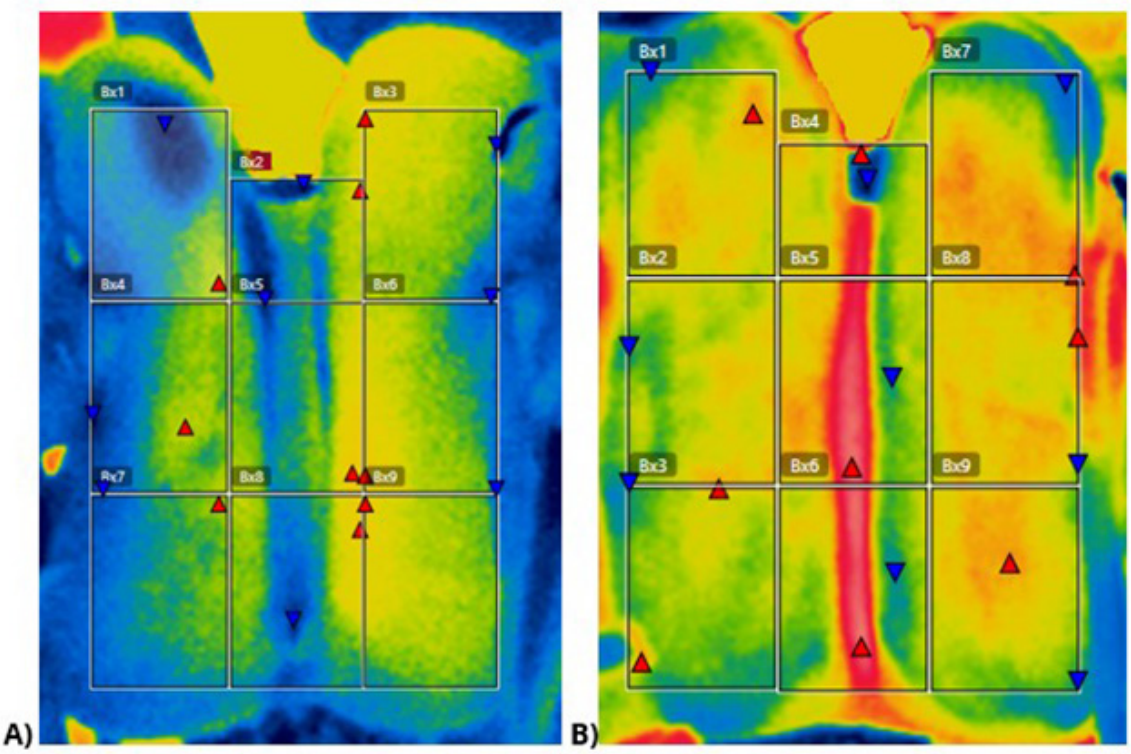

Figure 2: Thermographic image of the ventral face of the Australian saddle before (A) and after (B) its use in a basic horseback riding course

Discussion

The ideal situation for a saddle to be used correctly is if there was a personalized saddle for each horse[3], and having been made by a capacitated person to meet the anatomical characteristics of the animal. In the present moment, this does not occur in leisure or sport practiced by the MM breed in Brazil, mainly due to the lack of knowledge on the part of coaches, owners and breeders about the damage that a poorly made or ill-fitting saddle can cause. Also, due to the large number of animals that a single breeder has, which leads some breeders to claim problems due to the financial impact it would represent, despite the improvement in performance.

The saddle that fulfills its objective must not have asymmetries between the pressure distribution of the panels, as well as the entire region of the gullet must not touch the animal's spinal column, presenting a width of at least five centimeters[3] the ideal being between 6 and 10 centimeters, so that there is no such contact even when supporting the weight of the rider[4]. However, as shown in Table 1, in the present study, the saddle was in contact with the animal along the entire length of the gullet in the three analyzed quadrants. As the center (C2) is the area of greatest pressure, possibly because it corresponds to the seat area which concentrates the rider's weight. This indicates that the saddles that were used not only do not provide adequate comfort to the horse

but also do not correctly distribute the rider's weight. This finding demonstrates the inadequacy of this type of saddle for these animals during this activity, especially when led by beginner riders, harming the well-being of horses. Thus, the use and manufacture of this type of saddle must be carefully reassessed. Early recognition of ill-fitting saddles can avoid compromising the movement of the animal's spine, the development of back pain, muscle atrophy and/or decreased performance[3].

In show-jumping breeds, an imbalance was observed in 62.8% of the saddles, presenting 37.2% of contact between the gullet region and the animal[9]. Research with the MM breed in the marcha contest activity[12] showed that 83.3% of the saddles had asymmetries in the areas of contact and improper contact between the gullet region and the animal's spinal column. Previous works did not carry out quadrant analysis. In the present study, with quadrant analysis, it was possible to observe the exact region of greatest pressure, since 100% of the saddles analyzed had some contact between the trough and the region of the equine's spinal column. In Figure 2, it was possible to observe that the highest temperatures (in red) corresponded to the quadrants C1, C2 and C3 indistinctly in the gullet region, in the evaluation only of the coloring. A correct distinction was only made in the area of greatest pressure, which is found in C2, after quantitative statistical evaluation by quadrants (Table 1). It is observed that the Australian saddles used by beginner riders in horseback riding courses with marcha gaited horses can cause greater damage to animal well-being when compared to activities of marcha competition and use of other types of saddle/sports performed by other breeds.

The higher temperature in the central region indicating greater pressure by the gullet in the central portion (C2), as already described, shouldn't happen, however, in a study carried out using a pressure measuring pad[15], higher pressure was observed in the central region of English saddles without a tree, when compared to English saddles that had trees, the last being beneficial because they present uniform pressure distribution over a larger contact area. Confronting the literature to our results, it is possible to suggest that Australian saddles intended for leisure and horseback riding courses for beginner riders do not have adequate structure for the purpose proposed, causing us to observe similar behavior to what occurs in saddles without trees, differently than expected. In this way, the current structure of Australian saddles can compromise animal welfare.

Each breed has a type of saddle most suitable mainly for the type of equestrian activity developed. In one study, the western saddle was more suitable for use on Arabian horses than the English saddle when compared thermographically[11]; however, there are several saddle options according to the biotype and sport practiced with each breed. There are differences in equipment and forms of use in different countries and cultures. In the present study, all saddles were positioned in the appropriate place, according to Schleese[4], on the animal's back, in order to minimize positioning interferences. However, the model of the saddle panel influences the pressure distribution and the movement of the horse's back[15]. Thereby, it can be seen that the need for adaptation in the production and use of this equipment is vital, in order to adapt to the marcha breeds and activity to which the individual is exposed.

It is observed, in the present evaluation, that the desired balance between the right and left panel regions (Table 2), is in agreement with a study that exposes the right and left panels must have, and distribute the weight of the saddle and rider evenly on the animal's back[4].

Thermography can be used in different ways to assess pressure/heat spots in equipment[9,10, 12, 15-16] and in the horse[11,17-18], and demonstrated similarity between the temperature in the horse's body and that found in the panels when mounted by light riders[17]. It has also been used before and after rein and riding exercises, in order to assess the influence of the rider and his level of riding on pressure spots, suggesting changes according to the rider's ability[17]. Therefore, it becomes essential to standardize the level of riding of the rider, in addition to the horse breed and the activity exercised by the rider when thermographically evaluating saddles.

The reliability of the thermographic analysis is high (94%) when used on the animal's back[18]. Increasingly, its use in the analysis of equestrian equipment begins to spread, in addition to being a noninvasive method. It is accessible for initial and quick assessment of fitting and distribution of saddle pressure on the animal's back. It also presents other advantages such as lower cost in relation to the use of pressure pads and greater practicality as it requires easier training of the team than when compared to tests of pain on palpation.

The methodology used in the present study proved to be useful in quantifying focal pressure regions and assessing saddle imbalance after use. The methodology used was based on quadrants where, in a previous study[10], only 6 quadrants were used, 3 in the left region and 3 in the right region, thus evaluating the pressure distribution in panels areas and the rider's influences. In the present study, after extensive visual and thermographic evaluation of saddles and sports and leisure animals in Brazil, we chose to place 3 more quadrants in the central region of the saddle, because despite the literature on weight distribution in saddles with trees, are the exclusive function of panels[7], the same has not been observed in Brazil. Therefore, the methodology had to be adapted for this study to lead to the evaluation of the central region (gullet). This adapted methodology had great importance for detailing the regions under greater pressure, enabling the correct quantitative assessment of the data, which may favor future strategies for adjustments in the manufacture and correction of saddles.

Limitations of the present study: There are many variations in the saddle structure, even when we evaluate similar saddles in the same model of Australian saddles made in Brazil. The variations can be easily noticed or more discreet, requiring more precise evaluations by other equipment. Data such as gullet width, tree angle, and saddle length, among others, are necessary for the exact determination of problems in the making and fitting of saddles to the horse. Their absence, in the present study, limits us to infer greater conclusions in this work. In this way, quadrangle thermography is useful to detect only regions of higher or lower pressure in the ventral part of the saddle, detecting the primary existence of a problem and confirming the need for further studies with the approach of more data on the saddle and the horse, in different saddle-fitting assessment methodologies not only for this modality of equestrian activity but for all

activities in which the horse is riding.

Conclusion

Australian saddles commonly used in basic horseback riding courses in Mangalarga Marchador gaited horses showed contact with the region of the equine spinal column, placing undue pressure on the entire area of the saddle gullet, especially in the region of the rider's seat, indicating the unsuitability of this type of saddle for these horses during this type of activity. Based on these findings, the need for a more complete assessment of the saddle fitting of Australian saddles to this equestrian activity is demonstrated, aiming at improvements in animal welfare.

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