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In memoriam

LIGIAE BÂRZU

(1930-2003)

archaeologist and professor

Cuprins/ Content

Articole și Studii/Articles and Studies

Recenzii și prezentări de carte/ Reviews and Book Presentations

Working animal's welfare in antiquity. An interdisciplinary comparison of ancient horse breeding and training methods, as well as historical equipment, with modern horse welfare research results

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Abstract: Working animals, the method of their breeding, preparation for work and equipment related to their use, are inextricably linked with production and trade around the world from prehistoric times to the present day. Typically, archaeological research focus on analysing the effects of human-animal cooperation, not the breeding and training process itself. The article presents an interdisciplinary approach to the subject, combining the analysis of ancient texts, obtained through excavations, elements of the horse tack, as well as the effects of the work of reenactors with the approach to animals presented by modern animal psychologists and trainers and their research on the welfare of working horses. The first part focuses on the comparison of ancient texts with current guidelines regarding the handling of farm animals and the principles of natural training methods. The second part of the is devoted to the comparison of the construction of Scythian, Roman and Medieval saddles with modern saddles, as well as the results of a meta-analysis of research on the pressure exerted on the horse's back by various types of saddles. The presented analysis was performed using the ANOVA method. The indicators used in it were the pressure force of the saddle on the back, measured in kPa, by the mat system Novel GmbH, Novel Electronic and Pliance-X System, as well as the presence of sweat stains on the back under the saddle. The obtained values were compared with known pain scales in order to identify the saddle exerting the least harmful pressure on the horse's back.

Keywords: horses, saddle, animals, welfare, antiquity.

Introduction

Working animals, defined as an animal which is kept mainly to do work, such as a draft animal or a service animal, not mainly as a pet nor for its animal products. Their use has played a major role in both human life and the development of civilization. Numerous archaeological studies prove on what a wide scale, our ancestors used working animals, especially horses. They were not only a valuable commodity in antiquity, but were also used as draft animals, war animals and a means of transport.[1] However, before a horse could pull a cart or chariot, it had

[1] Overgaauw, P. A., Vinke, C. M., van Hagen, M. A., & Lipman, L. J. 2020, 17 (11).

to be properly trained. Today, based on the work of many trainers, veterinarians, biologists, zoologists, animal psychologists, the knowledge of those involved in preparing horses for work is expanding, and the conditions in which these animals work are trying to meet their species needs more and more. Much is being said about providing horses with psychological comfort, and legal conditions are also being created to protect them from excessive exploitation by humans. While the equestrian community often discusses how horsemanship has changed over the past 30 years, the roots of horsemanship are rarely discussed.[2] As part of this work, I would like to present historical and archaeological evidence of a highly advanced knowledge of the needs of horses during the Bronze and Iron Ages. I would also like to present contemporary research results on the effects of saddles on the horse's spine and analyse them in the context of ancient and medieval saddles.

In order to better understand what ancient horse trainers wrote about, it is useful to familiarize yourself with the latest concepts used in animal psychology. Animal welfare is actually a state of physical and mental health achieved by an animal in complete harmony with its environment. A proper breeding system that ensures welfare allows the animal to meet its basic needs.[3] In addition to various laws and conventions that protect animal welfare, one of the most important welfare concepts is the list of five freedoms.[4] This document, although it does not have the force of law, perfectly explains what a person should pay attention to in his relationship with an animal.

The five freedoms speak of freedom from hunger and thirst, freedom from discomfort, freedom from pain, injury or disease, freedom to express natural behaviours and freedom from fear and distress. These freedoms were to be ensured by adequately feeding the animals, allowing them to be in their natural habitat, resting evenly with their work, providing medical care, keeping the animals in the company of individuals of the same species and adjusting activities, at the advent of the train. The document was published in 1979, and was seen as a major breakthrough in the way animals were treated. Historically, the freedoms listed in it have appeared many times in the works of ancient authors.

The history of approaches to horse training over the centuries

The first example of such a text is found on four clay tablets dating from the 15th - 14th century BC, wrote by *Kikkuli of Mitanni*. The author describes a 214-day horse training plan

[2] Milewska 2021.
[3] Hughes 1976, 4-11; Manteca, Mainau, Temple 2012.
[4] https://www.animalhumanesociety.org/health/five-freedoms-animals

for pulling war chariots. *Kikkuli* begins his work by calling himself '*master of horse training of the land of Mitanni*', land where the horse was domesticated around 3.5 thousand years BC. Advice found on the boards included tips such as putting a separate emphasis on working on muscle strength and a separate emphasis on working on condition.[5] Modern physiological science tells us that in the case of horses, these two things are trained completely differently and developing them in the same way reduces the effectiveness of training. The boards contain also instructions on the intensity of training, nutrition, training times, as well as caring for the hygiene of horses. *Kikkuli* follows three rules: taking care of the horse's psyche, pre-selection, gradually improving skills and endurance. Today we call that kind of training an aerobic training, and the whole approach presented by the author is part of modern horse training recommendations. *Kikkuli* recommended training young horses in a group and adjusting the pace of training to the individual's needs. He used interval training, gradually increasing the difficulty level of tasks, waiting until the horse was mentally and physically ready for the next stages. He attached great importance to nutrition and food portioning depending on the exercises performed on a given day, he emphasized the role of warm-up and described in detail the distances that horses should cover at subsequent stages of training. This approach is consistent with the so-called positive horsemanship, which assumes an individual approach to the individual, rewarding positive behaviour and not punishing negative behaviour or lack of progress. *Kikkuli's* instructions were so detailed that in the 20th century, it was decided to train Arabian horses according to them for 7 months. The experiment was conducted by Dr. Ann Nyland from the University of New England in Australia. According to the book she published describing the course of the experiment, the horses achieved results that are usually impossible to achieve without the use of doping substances.[6]

Other examples of ancient texts talking about horse training are the works of *Xepnophon* of Athens. He was a 5th century Greek military leader, philosopher, and historian. He is the author of numerous texts, but for that discussion the most important of them are *Peri hippikes* and *Hipparchikós*. According to *Xenophon*, a horse should be a friend of man, not a slave, and the trainer should devote as much time to it as to his own child. It is important to pay separate attention to mental and physical readiness to perform subsequent exercises. A horse should feel respect for a man, but it cannot result from fear, but from trust. Commands should be clear and correct behaviour should be rewarded.[7] We do not punish for mistakes. Everyday activities

[5] E.g. Nyland 2009.
[6] E.g. Nyland 2009.
[7] Głombiowski 1993.

should also be part of your training. *Xenophon* notes that some dressage figures resemble the sexual behaviour of horses and suggests practicing them as part of the animals' natural needs. According to the author, work should be a pleasure for the animal, and the trainer and the rider should work not only on the animal but also on themselves, on their own behaviour and character.[8] To summarize the ancient knowledge, horse training should emphasize the psyche, muscle strength, condition of the horse, and proper nutrition. Owner should allow horse to get rest and respect their needs. It's important to perpetuate, strengthen and improve each new behaviour. If we compare the theses propounded by ancient authors, with modern manuals of equestrian training, we can come to a surprising conclusion. Authors considered modern pioneers are repeating words written thousands of years ago. This is best illustrated by a chart showing the intrinsic elements of horse training according to Carl Hester, a 21st century horse trainer, juxtaposed with the elements whose importance was emphasized by *Kikkuli*.[9]

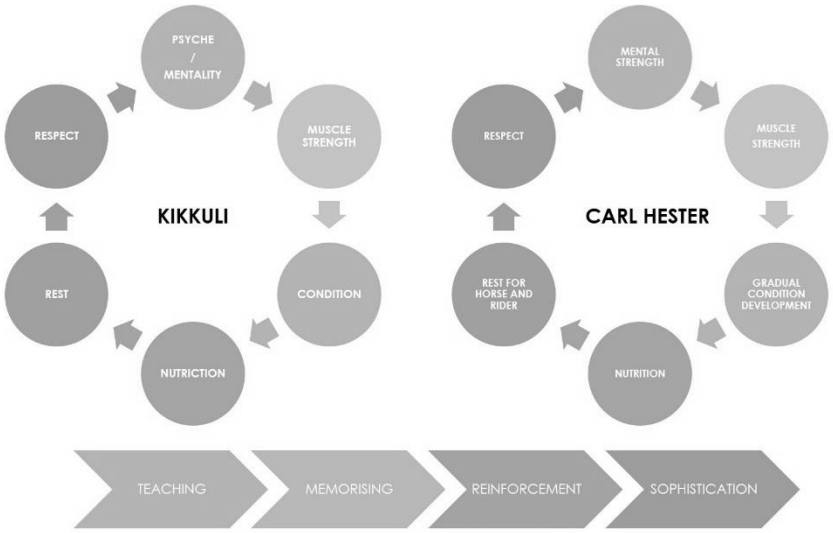

Illustration 1: Comparison of the most important elements of horse training according to authors from different eras

Why authors such as Carl Hester are now pioneers in their work if all of those techniques were used in ancient times? With the expansion of Rome, the Greek, almost philosophical approach to equestrianism was lost in favour of faster methods of working with the horse, which allowed to prepare the cavalry in a much shorter time. This was mainly due to the quality of the training effects, especially in terms of the approach to animals. This can be seen in the

[8] E.g. Widdra 2007.
[9] https://www.horseandrideruk.com/expert-advice/articles/train-carl-hester-dressage-made-simple/

equipment, both Roman and medieval. This is particularly visible in the Renaissance approach of the equestrian fathers, who, although referring to ancient creators, used brutal training methods, deliberately inflicted pain on horses to achieve better results, did not pay attention to the needs of animals and focused on the comfort of the rider.[10]

This is particularly visible in the Renaissance approach of the equestrian fathers, who, although referring to ancient creators, used brutal training methods, deliberately inflicted pain on horses to achieve better results, did not pay attention to the needs of animals and focused on the comfort of the rider. Fathers of equestrianism, who, although referring to ancient creators, used brutal training methods, including violence to achieve better results. For example, Frederico Grisone, author of '*Equestrian Rules*', who developed sharp curbs, cruel and hurtful, talks in his work about a light bit, but at the same time he believes that in the event of resistance, the horse must be subordinated. He is also an author of a two horrified advices for trainers: '*Put a lighted straw under the tail of a reluctant horse*' and '*To make a horse move, put a man with an angry cat, who, tied to a pole, will scratch his belly*'. Another renaissance author, Francois Robichon de Guerinière, believed that the aim of training a horse is to make it calm, efficient, obedient and comfortable for the rider.[11] Theses propounded from the Middle Ages, until the late 1920s, began to be replaced by a modern approach to animals, with the emergence of more acts protecting animal rights around the world. One of the earliest such documents was the Cruelty to Animals Act signed in 1876.[12] For centuries, the way we look at the welfare of animals has directly influenced the equipment created for them.

Evolution of saddle construction

The basic element of equestrian art is saddles, the design and even function of which have changed over the centuries. Starting with the Greeks, who rode bareback or on what today we would call a rug,[13] through Scythian saddles without trees, consisting of two pads, then Scythian saddles with trees.[14] Next stage in saddle's development was Roman saddle, prepared for long distance travels with luggage and Huno-Sarmatian saddles, developed especially for a comfortable travel and battlefield. That type of saddles was created according to needs of a horse and warrior. Then the saddles became heavier and constructed more to the needs of a man, and prestigious image, as in the Middle Ages. This trend continued in the Renaissance

[10] Jawna-Zboińska 2020, A series of lectures.
[11] Jawna-Zboińska 2020, A series of lectures.
[12] David Favre & Vivien Tsang 1993.
[13] https://www.comitatus.net/greekcavalry.html
[14] https://exarc.net/issue-2021-1/ea/reconstruction-roman-cavalry-saddle ; Mylnikov, Tishkin 2016, 47-55.

until the appearance of Ottoman saddles in Europe, whose aerodynamic shape influenced what modern saddles look like today.[15]

The heart of the saddle is what is under the outer pads, where the saddle directly attaches to the horse's back. This part is responsible for how the saddle sits on the horse, distributes the rider's weight and is responsible for the proper operation of the horse's entire musculoskeletal system. In many saddles, the tree plays a major role in this construction. The saddle tree is a frame that allows you to distribute the weight of the rider on the surface of the horse's back. It is located between the layer of leather that is in contact with the horse's back and the rider's seat.[16] Tree first time appeared in Scythian saddles. We do not know exactly when the Scythians introduced the tree. Archaeologists rarely come across well-preserved saddles that would allow the introduction of a tree in these areas to be placed in time. One of the best known examples of a Scythian saddle, is a saddle from the Yaloma II cemetery, on the basis of which a reconstruction was made of a saddle used between the 1st century BC and the 3rd century AD.[17] Scythian saddles at the beginning did not have a tree, gradually they were a better and better hardened piece of leather attached to the back. Gradually, however, they took on an increasingly aerodynamic shape, providing riders with high mobility while maintaining a good seat. The complete opposite of Scythian saddles, especially in terms of rider mobility, were Roman saddles. The Roman tree, on the other hand, is much more like a prototype of medieval tree, characterized by a very wide contact surface with the horse's back. Romans used much wider trees, and their saddles resembled more armchairs for covering long distances in the saddle than aerodynamic pads for the rider. Important for the Romans were massive bows that allowed them to hang luggage, which further destabilized the horse.[18] This trend developed later in the Middle Ages, until much lighter and more aerodynamic Ottoman saddles reached Europe, which were much closer to Huno-Sarmatian saddles, than European type saddles. The evolution of the shape of tree can be seen in the graph below.[19]

[15] Piotrovsky, B. 1973; Simpson, & Pankova, 2021.
[16] http://www.lucznictwokonne.pl/zurawiejki/kawaleryjskie/regul/instab/t1.html 10.04.2023.
[17] Mylnikov, Tishkin. 2016, 47-55.
[18] Watson, Moria 2022.
[19] Mylnikov, Tishkin. 2016, 47-55 ; Piotrovsky, B. 1973 ; Simpson, Pankova 2021 ; Stepanova 2016; Dmitrievna, Tkačenko 2010; Watson, Moria 2022.

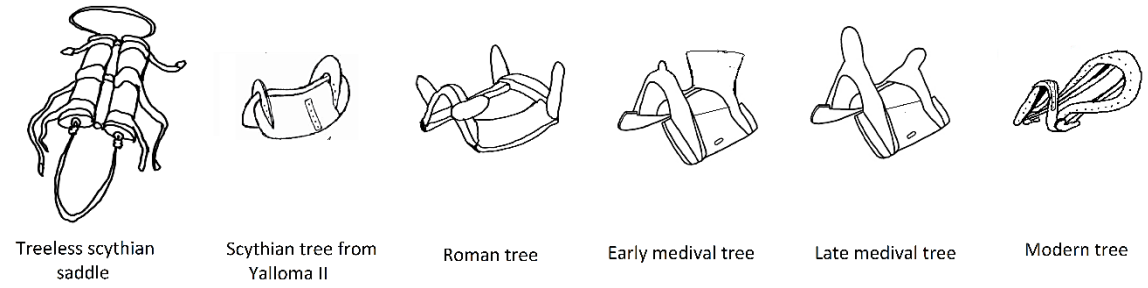

Illustration 2: The evolution of tree; authors: Hanna Milewska after Dario Wielec; Alexey Tishkin; Petter Connolly; and Irina Dmitrievna Tkačenko

It is impossible to analyse saddle construction without understanding the physiology of the horse. It is the specific structure of the horse's back, combined with the proper saddle design, that ensures the comfort of the rider and the proper work of the horse under saddle. Today, saddle fitters deal with the selection and fitting of the saddle. A well-fitting saddle should be between the shoulder blade and the last costal vertebra. This part of the horse's spine is best supported and best able to withstand pressure from above. If the saddle is too long, the girth is not properly fastened, or the whole thing shifts to one side, the horse's skeleton is not adapted to supporting it. The saddle moved forward rubs against the shoulder blade, which contributes to the horse's incorrect posture, discomfort and injury. Muscles also play an important role. It is on them, and not directly on the bones, that the weight of the saddle and the rider should rest. In the case of the horse, it is *latissimus doris* and *lumbo dorsal fasica*. The other muscles are involved in the movement of the horse and cannot be compressed while riding.[20] From the perspective of modern knowledge, tests conducted on both living and dead specimens, knowledge of x-ray and years of work by vets and physiologists, no one is surprised that 21st century saddles meet the physiological needs of horses. for archaeologists and historians, it may be surprising how many of these needs were also met by ancient saddles. Only Roman and medieval saddles, clearly impeded the natural movement of the horse. many times they rested on the shoulder, limiting its movement and with their weight caused pressure on the delicate muscles of the horse. Their front pad is constructed in such a way that there is no way that it would not overlap the horse's shoulder and cause discomfort. The space between the horse's pommel and spine is very important. The back must be able to work under the saddle and change its appearance as shown in the picture.[21]

[20] E.g. Kaleta 2017; Łojek and Łojek 2015; Milewska 2021.
[21] Watson, Moria 2022.

Which type of saddle is healthiest for the horse?

However, is it possible to check how these saddles affected the welfare of horses? We know from *Kikkuli* that if something hurts a horse, the animal is stressed, and a stressed animal cannot be effectively trained.[22] It was the need to maximize the effects of training that pushed animal psychologists and veterinarians to study the pressure that the saddle exerts on the horse's back. In my diploma thesis on animal psychology, I conducted a meta-analysis of the research conducted so far to answer the question of which saddle is the most comfortable for horses. For this purpose, I compared the results of 11 studies and looked for differences between the treeless saddle, the tree saddle and the tree saddle with wider pads. These saddles have their counterparts in history, successively Scythian, Huno-Sarmatian and medieval saddles. Saddles with wide pads may also correspond to some Roman saddles, but their properties are definitely better illustrated by medieval saddles that adhere to the horse's back with a much larger surface.

For horses, the sensation of pain can be checked in a number of different ways. First, it is natural for a horse to sweat under a saddle, but, with a well-fitting saddle, sweat patches appear symmetrically, all over the back. Studies also show that horses with back pain exhibit an abnormal pattern of back movement that, when properly analysed, can pinpoint the source of the pain.[23] In 1999, Chang and Seigreg, studying the cause of gastric ulcers in humans, discovered that in a healthy individual, the average pressure in the capillaries of the skin is about 3.33 kPa. When the external pressure exceeds 4.26 kPa, the blood vessels become clogged. If this condition persists for a long time, tissues are deprived of essential nutrients. This effect is reversible, but it takes time before the tissues regenerate. If, on the other hand, the pressure persists for a period of 2 to 7 hours' pressure sores form. Although these studies focused on humans, later researchers, inspired by them, began to look for the pressure that causes pain in horses. Thus, in a series of studies, three pain scales were developed: Warner (2002), Nyikos (2005), and the overlapping scales of Byström and von Peinen (2010). It was these scales that served as the benchmark, when comparing the force of pressure of saddles on the horse's back. It was these scales that served as a benchmark, when comparing the force of the saddles' pressure on the horse's back. The limits set by the researchers were considered the pain threshold, i.e. the amount of pressure on the horse's back that unquestionably causes the horse to experience pain.[24]

[22] Strzałkowska etc. 2014; Amin, Osma Shukiri Muhamed 2023.
[23] Wennerstrand et al., 2004.
[24] Milewska 2021.

Of the 11 studies reviewed, six were selected that contained figures relating to the pressure exerted by the saddle on the horse's back given in kilopascals (kPa). Pressure measurements were made using specialized pressure-sensing mats that acted as a chevron. Each result was then compared with the corresponding pain scale. The method of comparing the values was based on a zero-one system, since pain sensation, especially pain sensation analysed from the point of view of animal welfare, cannot be defined as less or more. If the cut-off value for a given scale was exceeded, this was a clear indication that the horse in a given situation was experiencing pain and thus increased suffering and decreased welfare. In the studies I analysed, a total of 69 horses were measured and 308 measurements were analysed. All studies are presented in the table below.

NUMBER	ARTICLE TITLE	AUTHORS	PUBLICATION DATE
1	Assessment of Saddle Fit in Racehorses Using Infrared Thermography	M. Soroko, P. Cwynar, K. Howell, K. Yarnell, K. Dudek i D. Zaborsk	2018
2	Comparison of pressure distribution under a conventional saddle and a treeless saddle at sitting trot	B. Belock, L.J. Kaiser, M. Lavagnino, H.M. Clayton	2011
3	Druckmessungen unter dem Sattel: Eine Studie mit einem elektronischen Sattel-Messsystem (Novel GmbH)	D. Werner, S. Nyikos, A. Kalpen, M. Geuder, C. Haas, H. D. Vontobel, J. A. Auer i B. von Rechenberg	2002
4	Effects of Large Saddle Panels on the Biomechanics of the Equine Back During Rising Trot: Preliminary Results	P. Martin, L. Cheze, P. Pourcelot, L. Desquilbet, L. Duray i H. Chateau	2016
5	Evaluation of pressure distribution under an English saddle at walk, trot and canter	B. Fruehwirth, C. Peham, M. Scheidl i H. Schobesberger	2004
6	Evaluation of the force acting on the back of the horse with an English saddle and a side saddle at walk, trot and canter	B. Winkelmayr, C. Peham, B. Fruhwirth, T. Licka i M. Scheidl	2006
7	Force and pressure distribution beneath a conventional dressage saddle and a treeless dressage saddle with panels	H. M. Clayton, K.A. O'Connor i L. J. Kaiser	2013
8	Relationship between saddle pressure measurements and clinical signs of saddle soreness at the withers	K. von Peinen, T. Wiestner, B. von Rechenberg i M. A. Weishaupt	2010
9	Saddle pressure measuring: Validity, reliability and power to discriminate between different saddle-fits	P. de Cocq, P.R. van Weeren i W. Back	2006
10	Saddle pressure patterns of three different training saddles (normal tree, flexible tree, treeless) in Thoroughbred racehorses at trot and gallop	S. N. Latif, K. von Peinen, T. Wiestner, C. Bitschnau, B. Renk i M. A. Weishaupt	2010
11	The Effect of Tree Width on Thoracolumbar and Limb Kinematics, Saddle Pressure Distribution, and Thoracolumbar Dimensions in Sports Horses in Trot and Canter	R. MacKechnie-Guire, E. MacKechnie-Guire, V. Fairfax, D. Fisher, M.Fisher i T. Pfau	2019

Table 1: Research analysed as part of a thesis at the Department of Psychology at the University of Warsaw titled: The effect of the type of saddle on the occurrence of back pain and lowering the wellbeing of horses. Analysis of the results of research on the pressure exerted by the saddle on the horse's back

For the pain scale of Byström et al, 2010 and von Peinen et al, 2010 (threshold value of average pressure under the entire saddle > 11kPa), out of 32 measurements, the pain threshold

was exceeded in 12 cases, which is 37.5% of the studied cases. Exceeding the threshold value for this scale is associated with the risk of ischemic damage below the saddle.

For the pain scale of Werner et al. 2002 (threshold value of average pressure under the whole saddle > 15 kPa; threshold value of average maximum pressure under the whole saddle > 34.5 kPa), out of 32 measurements of average pressure value, the pain threshold was exceeded in 12 cases (37.5%), and out of 19 measurements of average maximum pressure, the pain threshold was exceeded in 9 cases (47.37%). Exceeding the threshold value for this scale is associated with causing back pain across the horse's back.

For the Nyikos et al, 2005 pain scale, the pressure in the front, middle and back of the saddle was checked. In the front part of the saddle (threshold value of average pressure > 13.2 kPa; threshold value of average maximum pressure > 34.5 kPa), out of 12 measurements of the average pressure value, the pain threshold was not exceeded even once. Out of 9 measurements of mean maximum pressure, the pain threshold was exceeded in 4 cases (44.44%). In the middle saddle (threshold value of average pressure > 11.4 kPa; threshold value of average maximum pressure > 30.3 kPa), out of 13 measurements of average pressure value, the pain threshold was not exceeded even once. Out of 9 measurements of average maximum pressure, the pain threshold was exceeded in 2 cases (22.22%). Exceeding the threshold value for this scale is associated with causing back pain in the specific part of the horse's back where the value was exceeded. The results of the analysis are shown in the tables below.

Dependent variable	Tree less saddle (S1)	Tree saddle (S2)	Wide pad saddle (S3)	ANOVA analysis result	post hoc analysis result
Mean value of the average pressure exerted by the saddle, obtained in different gaits, in all compared tests (kPa and SD)	7.24 ± 1.39	10.54 ± 4.42	14.54 ± 3.42	F = 5.872 p = 0.005 p < 0.01 F(2,58)	S1:S2 p = 0,293 S1:S3 p = 0,002 S2:S3 p = 0,089
Mean value of the average pressure exerted by the saddle, obtained in various gaits, in the compared studies, excluding study no. 4 from the group of saddles with a tree (kPa and SD)	7.24 ± 1.39	10.64 ± 4.66	14.54 ± 3.42	F = 7.96976 p = 0. 001 p < 0.01 F(2,54)	S1:S2 p = 0,421 S1:S3 p = 0,001 S2:S3 p = 0,022
Mean value of the average pressure exerted by the saddle, obtained in the trot in all compared tests (kPa and SD)	6.9 ± 1.7	9.32 ± 3.89	13.38 ± 4.30	F = 3,332 p = 0. 051 p > 0.05 F(2,27)	S1:S2 p = 0,378 S1:S3 p = 0,022 S2:S3 p = 0,313
Mean value of the average pressure exerted by the saddle, obtained at the trot, in the compared tests, excluding test no. 4 from the group of saddles with a tree (kPa and SD)	6.9 ± 1.7	9.24 ± 4.45	13.38 ± 4.30	F = 6.096 p = 0. 006 p < 0.01 F(2,23)	S1:S2 p = 0,646 S1:S3 p = 0,006 S2:S3 p = 0,044

Table 2: The average pressure exerted on the horse's back by each type of saddle in a given gait

			Pain Scale Byström et al., 2010; von Peinen et al., 2010	Werner pain scale et al. . (2002)		Nyikos Pain Scale et al., 2005					
Research number	Saddle type	Gait type	The force of pressure on the entire area, the exceeding of which is associated with the risk of ischemic damage below the saddle	Pressure force on the entire surface of the saddle causing back pain		The force of pressure required to induce back pain - the front part of the saddle		The pressure force required to induce back pain - the middle part of the saddle		The force of pressure required to induce back pain - the back of the saddle	
			Wartość średnia > 11 kPa	M > 15 kPa	Maximum > 35 kPa	M > 13,2 kPa	Maximum > 34,5 kPa	M > 11,4 kPa	Maximum > 30,3 kPa	M > 10,0 kPa	Maximum > 31,0 kPa
4	Tree - standard pad	Standing trot	10.56	10.56		12.67		9.44		10.37	
		Sitting trot	8.71	8.71		4.78		8.33		11.22	
	Tree - wide pad	Sittring trot	10.67	10.67				10.37		11.11	
		Stending trot	8.62	8.62		4.07		8.22		11.56	
10	Wooden tree	Trot	5.8	5.8		6.3	25.7	4.5	19.9	5.8	3.9
		Gallop	7.5	7.5		8.5	33.7	3.2	13.3	1.2	1.7
		Full gallop	8.8	8.8		10.1	37.7	3.8	15.2	2	6
	Elastic tree	Trot	5	5		4.9	26.1	4.4	23.2	6.3	6.4
		Gallop	6.3	6.3		7.5	33.5	4	20	1.7	2.6
		Full gallop	7.5	7.5		8.7	37	5.4	25.8	3	12.2
	Treeless	Trot	5.2	5.2		5.1	26.9	5.1	32.7	6.1	30.1
		Gallop	7	7		7.4	36.3	3.1	15.8	1	32.6
		Full gallop	8.5	8.5		9.1	39	4	21.1	1.3	31.8
2	Tree	Sittring trot	6.3	6.3	20.7						
	Treeless	Stending trot	6.9	6.9	29.4						
3	Tree - standard pad	Stop	15.61	15.61	18.57						
		Walk	15.06	15.06	25.87						
		Sitting trot	15.33	15.33	37.29						
		Standing Trot	15.42	15.42	39.13						
		Left gallop	18.39	18.39	51.59						
		Right gallop	18.41	18.41	53.08						
	Tree - wide pad	Stop	15.42	15.42	20.92						
		Walk	12.92	12.92	23.5						
		Sitting trot	16.45	16.45	45.17						
		Standing Trot	17.38	17.38	37.75						
		Left gallop	17.5	17.5	47.04						
		Right gallop	17.38	17.38	41.79						
7	Tree	Sittring trot	7	7	29.4						
	Treeless	Stending trot	8.6	8.6	42.8						
8	Tree	Walk	7.8	7.8	13.4						
		Trot	9.8	9.8	21						
		Full gallop	10.9	10.9	24.7						

Table 3: Average pressure exerted on the horse's back by each type of saddle in a given gait, compared with pain scales. The painted boxes represent measurements where the pain threshold was crossed

Although the analysis did not show a statistically significant difference between a saddle containing a terra cotta and a saddle without one, the negative effect of wider pads on the horse's comfort under both a saddle with and without a terra cotta was shown. These pads are often used for the comfort of the rider, which immediately brings to mind the evolution of the saddle over the years. It is important to remember that a saddle that causes the horse pain, discomfort, mental suffering, restricts its mobility or contributes to other types of injury is an inappropriate saddle, preventing the well-being of the animal being trained.

The conducted meta-analysis showed that saddles with wide pads are always a worse choice than standard tree and treeless saddles. By far the smallest pressure on the horse's back was exerted by the indefinite saddle in each of the tested gaits, although the tree saddle also achieved good results. Knowing that these two types of saddles correspond to Scythian saddles, we can imagine how much more comfortable the horses used in antiquity compared to medieval horses. However, after comparing the obtained pressure forces with the pain scales known to us, we can see that in fact all saddles exceed the permissible values of pressure exerted on the horse's back, especially in gaits such as four-beat gallop and three-beat gallop. It should be remembered, however, that while a treeless saddle is actually lighter, the pressure is not evenly

distributed on it. Taking into account the fact that in ancient times saddles served for years, they were compacted and put on various horses, it is difficult to assume that they were comfortable for animals. That is why it is worth looking at saddles with a standard tree, which, although they exceed the permissible values, better distribute the rider's weight and are more resistant to distortions resulting from use.

Conclusions

The results of the study clearly show that saddles whose design is most similar to the Scythian terrestrial saddles best distribute the rider's weight over the horse's back. Taking into account both the design of ancient saddles and the texts written by horse trainers of the time, it is clear how much knowledge about horses was possessed in antiquity. An analysis of later saddles and texts shows that much of this knowledge has been lost, and it is only in modern times, thanks to the popularity of animal rights movements, that traditional horse training methods are being revived.

The study conducted provides a starting point for researchers of many professions, including archaeologists. Deepening our knowledge of what saddle design, is best for the welfare of horses, shows us both the state of knowledge and the approach to these animals that guided saddle designers in a given era. Researchers of the past, seeing the similarity of given types of saddles to saddles tested with pressure measuring mats, can shed new light on the knowledge of our ancestors about anatomy and animal welfare. Such an interdisciplinary comparison, can allow us to understand what the relationship between man and horse looked like, in ancient times. In the future, it is possible to reuse pressure measuring mats to measure the actual pressure exerted on the horse's back, by saddles from specific eras prepared by reenactors.

By combining many research methods, many approaches, and interdisciplinary analysis of the attitudes of the ancients towards productive animals, we learned not only that animal welfare was important to our ancestors, but also that the training methods they proposed were much more focused on animal welfare than methods still used in some equestrian circles. In addition, we learned that by combining the work of archaeologists, reconstructors and animal psychologists, we can assess to what extent the saddles used in ancient times were designed with the comfort of horses in mind.

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