LANDTECHNIK 75(1), 2020, 24–33

DOI:10.15150/lt.2020.3229

LANDTECHNIK
AGRICULTURAL ENGINEERING

Analysing demands for the clear widths of lattice bars in horse husbandry

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At bars, used in various places in horse husbandry, horses can hurt themselves when retracting their heads or hooves after pushing them through the interspaces. In order to reduce the risk of injury, the clear widths and material thicknesses of bars should be chosen so that horse heads and hooves either cannot pass between the spaces or can be retracted safely. However, research to date has not provided any reliable information on bar width (vertical and horizontal) that is safe for horses. Grid bar width used in practice and recommended in the literature is based on empirical values and technical material properties. In this study, heads and hooves of 480 horses (233 mares, 204 geldings and 43 stallions) of 23 breeds were measured for making statements about the suitability of standard bar width, when considering the anatomy of the horse. It turned out that for vertical bars, an interspace of no more than five centimetres can be considered to be safe for all horses of a height of 110 centimetres and an age of two years and more. With horizontal lattice bars, a clear width of exactly 17 centimetres proved to be safe. This applies to all horses of a height of 148 centimetres and an age of two years or more. The clear widths of panels must be considered critical for horse welfare. When horses, for example, try to eat outside the panels and put their head through the bars, they may get stuck.

Key words:
Horse keeping, bar distance, risk of injury, management, individual box housing

Horses can injure themselves when putting their heads or hooves through bars that are used in various places in horse husbandry, e.g. as top grids in box partitions or in so-called panels for the construction of mobile boxes (BMELV 2009, Hoffmann 2009, Zeitler-Feicht 2018). In order to reduce the risk of injury and the risk of getting stuck between bars, the clear width and material thickness of the bars must be selected so that horse heads and hooves either do not fit between the open spaces or can be retracted safely (BMELV, 2009, Hoffmann, 2009, Zeitler-Feicht 2018). The danger of getting stuck is enhanced when horses deform box walls and their bars by kicking with a force of up to 8722 N. It is suspected that some horses use even greater force (Wachenfelt et al. 2013) and that the bars could be severely deformed as a result. However, previous research has not provided any reliable information on bar width (vertical and horizontal) that is safe for horses. The guidelines used in practice (BMELV 2009, Hoffmann 2009, Deutsche Reiterliche Vereinigung e.V. 2017) are based on empirical values and technical material properties (stiffness, stability, etc.).

In „Leitlinien zur Beurteilung von Pferdehaltungen unter Tierschutzgesichtspunkten“(BMELV 2009), a clear width of 6 to 30 centimetres is described as unsuitable for horse husbandry. “Orientierungshilfen Reitanlagen- und Stallbau“ (Hoffmann 2009) recommends a maximum clear width of 5 cm for vertical lattice bars and a clear width of approx. 17 cm for horizontal lattice bars. In „Richt-

received 29 July 2019 | accepted 4 November 2019| published 31 January 2020

linien für Reiten und Fahren, Band 4 - Grundwissen zur Haltung, Fütterung, Gesundheit und Zucht“ (Deutsche Reiterliche Vereinigung e.V., 2017) a clear width of up to 5 cm for vertical bars and a clear width of exactly 17 cm for horizontal bars is recommended. The clear width of horizontal lattice bars must be exactly 17 cm, as a hoof cannot be pulled out of the lattice bars at a smaller clear width.

We aimed in analysing the suitability of standard bar width and in making recommendations for practical use of vertical and horizontal bars in horse husbandry on the basis of the anatomy of the horses. Therefore, we measured 480 horses of 23 breeds at the point of largest head circumference and hoof width. The following research questions arose:

- Does a clear width of up to 5 cm for vertical bars allow for safe housing of horses with a minimum height of 110 cm and a minimum age of two years, so that hooves do not slip or get caught when horses kick the bars?
- Does a clear width of exactly 17 cm for horizontal bars allow for safe housing of horses with a minimum height of 110 cm and a minimum age of two years so that their heads cannot get stuck between the bars?

Materials and methods

The evaluation was done with 480 horses of different breeds corresponding to the constitution types warmblood, coldblood, thoroughbred, small horse and pony (Petersen et al. 2013, Pirault et al. 2013, see appendix). Only horses with a minimum height of 110 cm and an age of at least two years were considered (BMELV, 2009, Deutsche Reiterliche Vereinigung e.V., 2017, Hoffmann, 2009). These limits were set because recommendations in the literature (BMELV 2009, Deutsche Reiterliche Vereinigung e.V. 2017, Hoffmann, 2009) refer to them. Eight parameters were collected for each horse. We considered the head circumference by measuring the width of the head at the end of the zygomatic bone, and the width of the head in front of the zygomatic bone, the front hoof width, the rear hoof width as well as general information on the horse (breed, year of birth, sex and withers height.

Determination of head circumference

The circumference of the head was determined at two different points, to an accuracy of 0.1 cm. On one hand, the width of the upper jaw was determined directly below the rostral end of the cheekbone strip (measuring point is drawn in yellow in Figure 1a): This measuring point is referred to in the following as the “head width v. J.”. In the following, “head width J.” is the width between the zygomatic bone strips (Figure 1a). These points were chosen because horses can stretch their nose through bars when the clear width is greater than the head width v. J. (to the rostral end of the zygomatic bone), and can fit their entire head through bars when the width is greater than the head width J. (beyond the zygomatic bone).

Determination of hoof width

To determine the hoof widths, one front and one rear hoof per horse were measured at their widest point (Figure 1c). This measure was chosen because horses only slide through the bars when the widest part of the hoof fits through the bars (Versbach, verbal communidation, 15/05/2017; Schmid, verbal communication, 04/12/2017). The width of the hoof was also measured to an accuracy of 0.1 cm.

Figure 1: Measurement of head circumference and hoof width. a) Points for measuring head width v. J. (yellow) and head width J. (blue), b) Measuring flap with protective device for determining head width, c) Measuring point for determining hoof width

Determining the height at the withers

All recommendations for the clear widths mentioned in previous publications were given in relation to the horse's height measured at the withers. The height at the withers measured at the highest point of the withers. The withers are the transition from the forehand to the middle hand and extend from the "second to the ninth thoracic spinous process". Whereby the fifth and sixth spinous process normally is the highest point at the withers. (KLEVEN, 2009). The withers are marked in Figure 2, at the point where the rod of the measuring stick is placed.

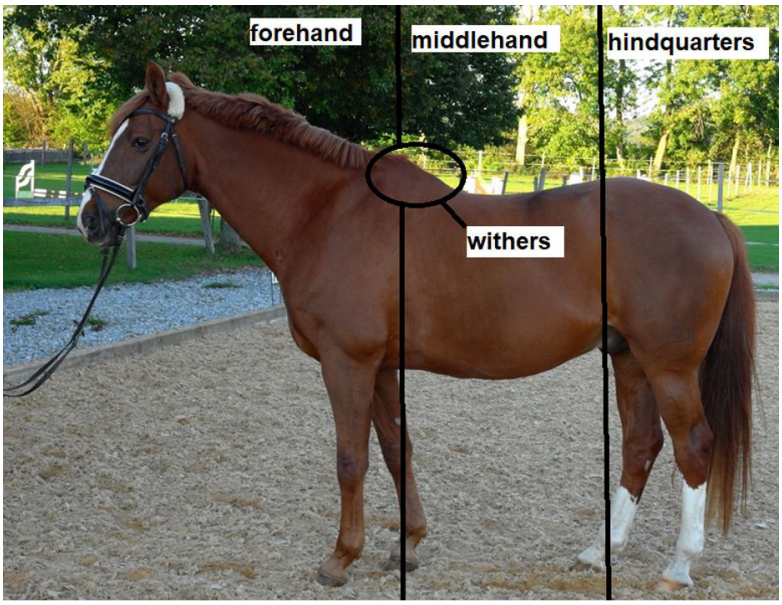


Figure 2: The horses' withers; horizontal lines demonstrate the division of the horse's body into forehand, middle-hand and hindquarters

Measuring instruments

The height at the withers of the horses was determined with a standard measuring stick, the width of the hooves with a measuring tape. A measuring pad was used to determine the width of the horses' heads (Figure 1b). The measuring pad had a measuring range of 2 to 32 cm and a measuring accuracy of 0.1 cm. Its beak length was 17 cm. To prevent the horses from injuries caused by the beaks of the measuring pad during the measurement, each beak was wrapped with two layers of foam insulation material (Figure 1b). To stabilize the film, the outer layer was fastened with cable ties. The ends of the cable ties pointed outwards and were cut flat and rounded so that the horses would not injure themselves. This protective device resulted in a measurement deviation of 0.9 cm from the actual head width of the horses, which was subtracted from the measurements.

Data acquisition and processing

All data were recorded in Excel. First, the data set was evaluated as a whole. In a second step the data was reorganized with regard to the horses' height, i.e. the distance from the withers to the ground. Six different height measurement groups were defined. Our measures were based on the division of the ponies into three different groups determined by the FN (Deutsche Reiterliche Vereinigung e.V., 2015). The FN distinguishes between K ponies (up to 127 cm), M ponies (128–137 cm) and G ponies (138–148 cm, 149 cm with iron) (Deutsche Reiterliche Vereinigung e.V., 2015). This division was adopted for our study, with the only difference that for the K ponies a height dimension lower than 110 cm was additionally specified. Analogous to the classification of the ponies, we defined the following classification for the horses: K horses: 149–159 cm withers height, M horses: 160–169 cm withers height, G horses: from 170 cm withers height. This new classification of horses from 149 cm height at withers allows for a differentiated examination between horse breeds.

In a third approach, the data set was evaluated with regard to the breeds. We considered particular breeds when twelve or more animals had been measured. In total, we measured horses of seven distinct breeds. For the remaining breeds, of which less than twelve animals were measured, the animals were clustered in breed groups due to the genetic similarity of breeds and the resulting similar constitution types (Pirault et al. 2013). We considered a total of eleven breed groups for the evaluation.

Data evaluation

The statistics program "R" (R Studio) and the package R-Commander were used to evaluate the data. Graphical representations of the data were created with Microsoft Excel. Not all the samples were normally distributed (K-S test). Therefore, we applied a Spearman rank correlation test for non-parametric data to determine whether there was a relationship between the variables head width J. and stick dimension, as well as head width v. J. and stick dimension. The results of the correlation tests were then corrected for alpha errors after multiple testing with a Bonferroni's Holm correction. All test procedures used were two-sided and the significance level was set at 0.05.

Results and discussion

The determination of the mean values for all 480 horses showed that the horses at the rostral end of the cheekbone strip (head width J.) had an average head width J. of 18.5 cm (median = 18.5, min. = 14.2, max. = 22.8). On the soft part of the head directly in front of the rostral end of the cheekbone strip (head width v. J.) the horses showed an average head width v. J. of 14.9 cm (median = 14.9,

min. = 11.4, max. = 19.3). A more detailed analysis of the head widths J. revealed that 90% of all horses measured had a head width J. greater than 17 cm. This ensures a clear width of exactly 17 cm for these horses with horizontal bars.

As the analysis of all the measured horses showed that the clear width of exactly 17 cm is not a safe distance for all the horses, it was necessary to further subdivide the horses according to height groups (Figure 3). It can be seen that the distance of exactly 17 cm is safe for the K, M and G horses and for the G ponies, since for all four groups the minima, i.e. the smallest values of the respective groups, were greater than 17 cm. This is not the case for the K and M ponies. The clear width of exactly 17 cm is suitable only for 32% of the K ponies and 90% of the M ponies.

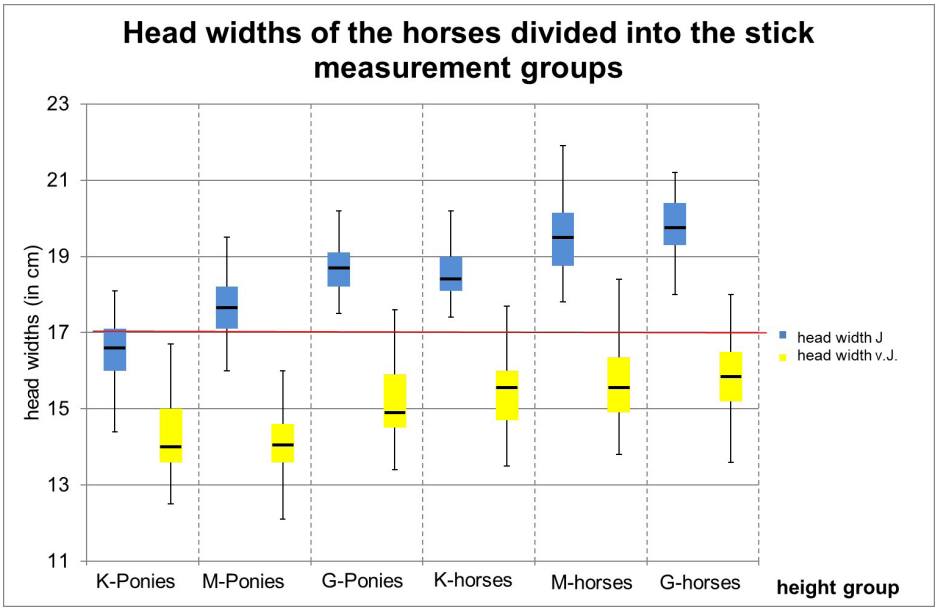


Figure 3: Head widths of the horses divided into the height group; the red line marks the clear width of 17 cm

The clear width of exactly 17 cm is also suitable for the breed groups a) Arabians, b) German Sporthorses, Hanoverian, Oldenburger, Trakehner, c) Haflinger, d) Noriker, Black forest horse, Tinker, Südd. KB., e) PRE and f) Quarter Horses (Figure 4). All remaining breed groups contain animals whose head width J. was less than 17 cm. Also for these groups, the percentage of horses for which exactly 17 cm is a safe clear width was determined (Figure 5).

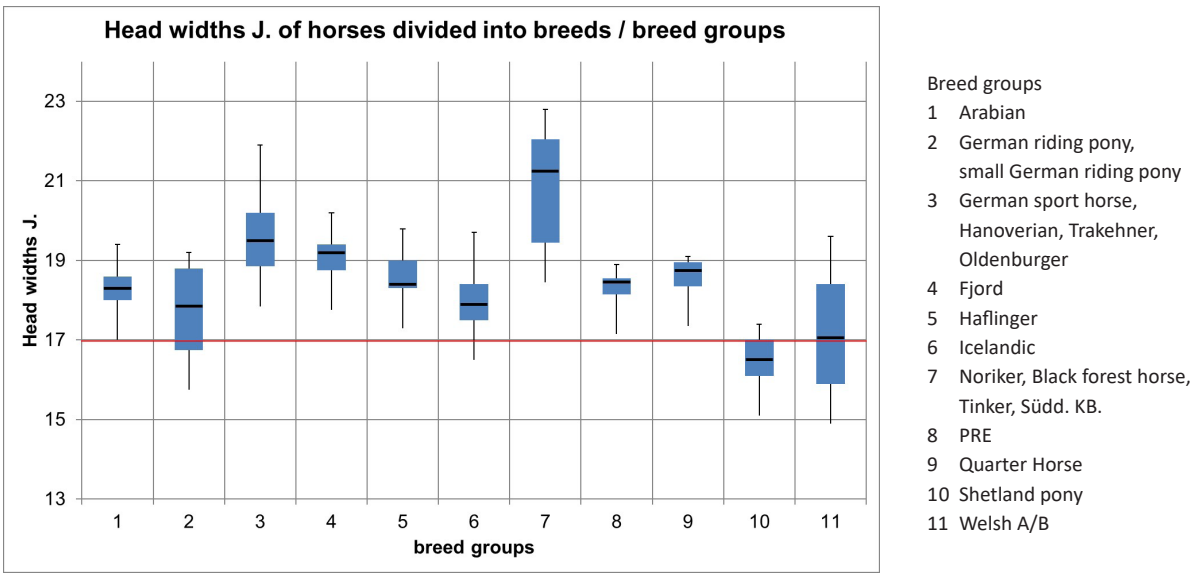


Figure 4: Head widths J. of horses divided into breeds/breed groups; the red line marks the clear width of 17 cm

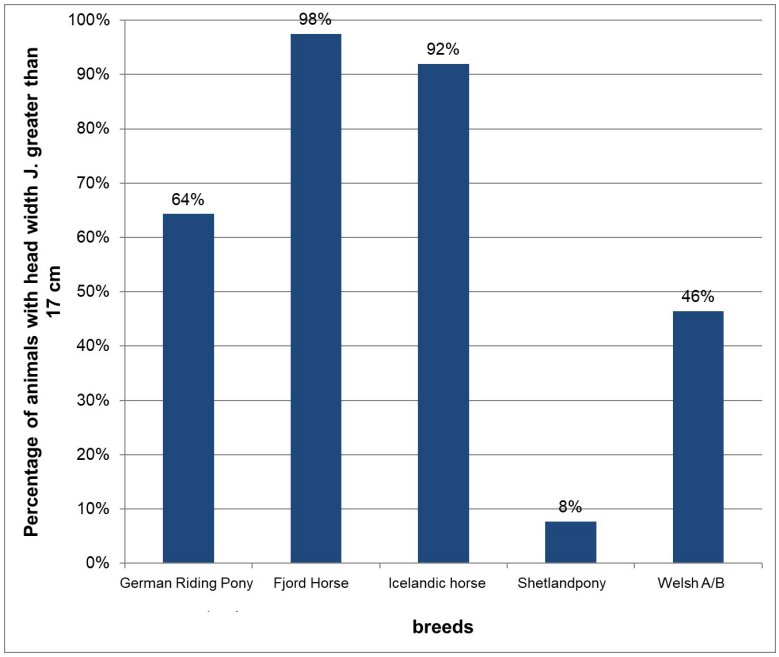


Figure 5: Percentage of animals for which exactly 17 cm clear width are suitable, although the median clear width and/or the minimum head width J. is not suitable for the breeds/breed groups in general

Relationship between head widths and floor dimensions

After determining the mean values of the head widths for the height groups, the question arose whether there is a correlation between these parameters, i.e. do horses with a large height have a large head? Here, the correlation analyses showed a strong positive relationship between the height of the horses and their head width J. (Spearman rank correlation test: $n = 480$, $r_s = 0.71$, $p < 0.001$), i.e. the head width J. increased with the height of a horse. This correlation was still significant after

the Bonferroni correction according to Holm. The horses' height also increased with increases in the head width v. J. (Spearman rank correlation test: n = 480, r_s = 0.53, p < 0.001). The slightly weaker correlation was still significant after Bonferroni correction after Holm.

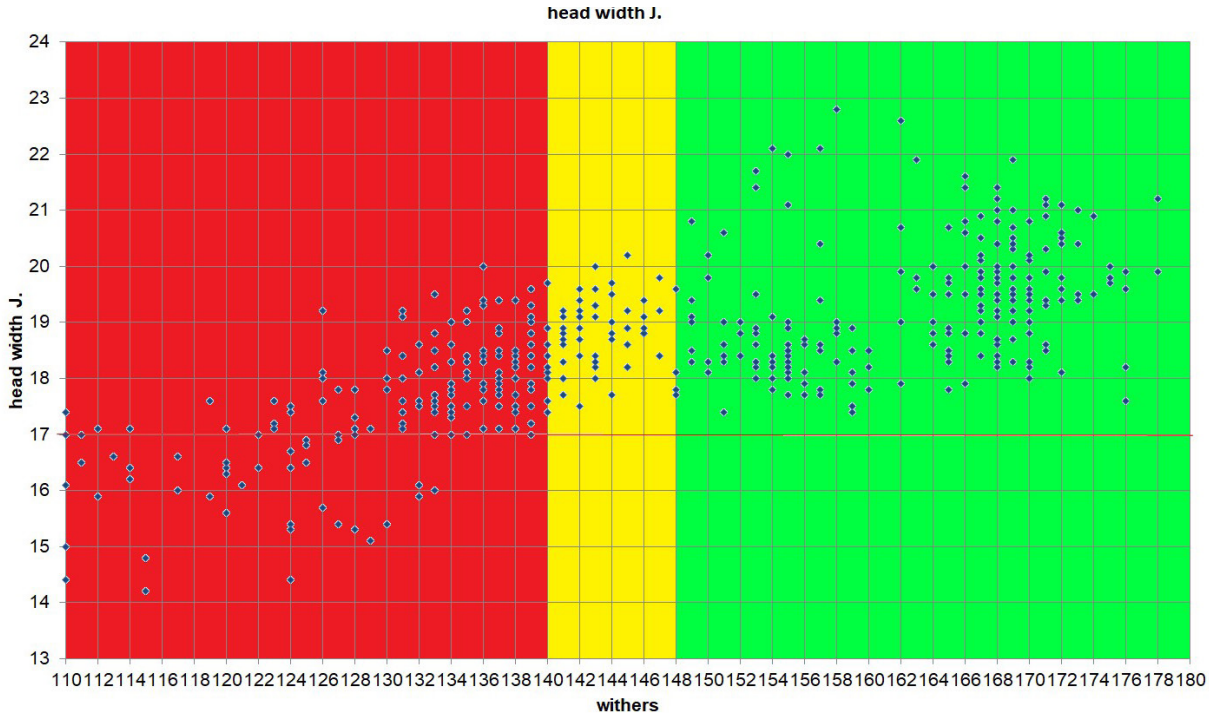
Height limit

Due to the high significance of the correlation between the head widths and the horse's height, the question can be posed whether there is a height limit above which the bar width of exactly 17 cm can be claimed a safe width in relation to the horses' head width J. For the horses of this study, it turned out that all heads of those horses that were larger than 140 cm were wider than 17 cm at the beginning of the cheekbone strip. This allows us to make the statement that the distance of exactly 17 cm of clear width is safe for all horses with a body height greater than 140 cm, so that they do not get stuck between the bars with their heads.

However, since the recommended bar width should be generalizable, we recommend 17 cm bar width only to be safe for horses larger than 148 cm. From the height of 148 cm, the horse's heads are certainly much wider than 17 cm. As a rule, it can be assumed that the clear width of exactly 17 cm should also be suitable for horses with a height between 140 and 148 cm. Due to the great phenotypic diversity of horses, it must be assumed, however, that there are some horses that have a height of more than 140 cm and yet have a head width J. smaller than 17 cm and are therefore unsuitable for housing in lattice bars with a clear width of exactly 17 cm. In order to minimise the risk of injury for the horses between 140 to 148 cm, each case should be checked whether the width between the horizontal bars is suitable.

For horses with a height of less than 140 cm, it is not possible to determine a valid width between horizontal bars. However, potential reductions of the bar width for keeping ponies smaller than 140 cm should be treated with caution as the animals may then get stuck between the bars with their hoofs, as some pony breeds have narrow heads relative to their body size, but still have large hooves. Based on these findings, the use of horizontal bars should be avoided for keeping ponies. In the following illustration, the corresponding results are colour-coded for horses with the three-body height ranges which are safe (green), intermediately safe (yellow), and unsafe (red) when kept in a bar width of 17 cm (Figure 6).

As already briefly described in the introduction, horizontal lattice bars are also frequently used for panels. These are produced for cattle by well-known companies and applied to the horse sector without adaptation. The distances of the horizontal bars used here are between 20 and 21 cm very often (Texas Trading). As visualized in Figure 6, the 20 or 21 cm clear width of the horizontal bars is not risk-free for all horses. In order to check the suitability of the panels for keeping horses, we evaluated the data set in this respect. It turned out, that 418 of the 480 horses had a head width J. narrower than 20 cm. This corresponds to 87% of the horses in the present study. In 459 of the horses of the present study, the head width J. was smaller than 21 cm. This corresponds to 95% of the horses from this study.



Red: Clear width of 17 cm for horizontal lattice bars is not suitable
Yellow: Suitability of 17 cm clear width must be checked on a case-by-case basis
Green: Clear width of 17 cm for horizontal lattice bars is suitable

Figure 6: Representation of all 480 horses measured with their head width J. in relation to their height, according to the correlation analysis

Checking the clear width for vertical bars and the hoof width

The average front hoof width for the horses was 12.3 cm (median = 12.3, min. = 8.2, max. 16.5). A width of 11.9 cm was measured for the hind hooves (median = 11.9, min. = 8.1, max. = 16.2). This confirms the recommendations from "Orierungshilfen Reitanlagen- und Stallbau" (Hoffmann 2009) and "Richtlinien für Reiten und Fahren, Band 4 – Grundlagen zur Haltung, Fütterung, Gesundheit und Zucht" (Deutsche Reiterliche Vereinigung e.V. 2017) of 5 cm of clear width of vertical bars, as the minimum hoof width of both the front and rear hooves is more than three cm larger than the recommended 5 cm and horses with these hoof widths cannot kick through lattice width of 5 cm. In addition to the appropriate bar width, it should be noted that "bars/tubes [...] (F.O.) may be difficult to deform under load" (BMELV 2009, p. 23). Forces of up to 8,722 N (Wachenfelt et al. 2013) occur when horses kick against box walls. In practice, this means that the material thickness of lattice bars must also be taken into account. Vertical rods should be at least 0.75 to 1 inch thick, even at a suitable distance, i.e. not more than 5 cm, as the pipes can break or bend if they are hit or kicked by a horse's hoof. It is therefore important that the pipes are "welded to at least 80 per cent in concealed holes" (Hofmann 2009) and not only attached to the metal frame with the aid of welding points (BMELV 2009, p.23).

Conclusions

In summary, the present study provides a clear picture from which concrete conclusions or recommendations can be derived for bar width in horse husbandry:

1. In the case of vertical lattice bars, a clear width of up to a maximum of 5 cm can be considered as safe for all horses from a height of 110 cm and an age of two years.
2. In contrast, a clear width of exactly 17 cm can only be considered to be safe for horses from an age of two years with horizontal lattice bars with a height of 148 cm and more.

The clear widths of commercially available panels must be judged to be critical. Here, the results have shown that their bar width constitutes a considerable danger for many horses. Even though the currently common use of cattle panels is practicable and inexpensive for manufacturers, a clear width of exactly 17 cm for the rod spacing of the panels would still be desirable. If this were the case, such panels could be described as safe for horses with a minimum height of 148 cm.

In addition, we recommend the "Leitlinien zur Beurteilung von Pferdehaltungen unter Tierschutzgespunkten" to include a more detailed description of the clear widths for bars suitable for horse husbandry. To date, only a clear width of six to 30 cm has been described as unsuitable for horse husbandry (BMELV 2009). It would be better to point out that, in the case of vertical bars, a clear width of up to a maximum of 5 cm can be considered safe for all horses with a minimum height of 110 cm and an age of two years. Horizontal lattice bars with a clear width of exactly 17 cm should only be recommended from a height of 148 cm and an age of two years. As described in the previous paragraph, it should also be clarified that the use of horizontal lattice bars should not be used in pony husbandry, or that suitability must be checked in each individual case.

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Acknowledgements

I would like to thank all horse owners who have made their horses available to me for surveying. I would also like to thank everyone who contributed to the preparation of this publication.