Small Ruminant Research 219 (2023) 106885

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Reactions of Alpacas to Shearing and Accompanying Procedures

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ARTICLE INFO

Keywords:
New world camelids
Behaviour
Handling
Restraint
Stress

ABSTRACT

Europe's demand for high-quality alpaca products is rising, including animal welfare as one important aspect of process quality. Shearing and associated procedures like restraint and handling can impact welfare negatively to a varying degree depending on exact conditions. This study researched behavioural stress reactions of alpacas related to shearing procedures in one experiment and one observational study under field conditions in Peru. The experiment investigated acute behavioural stress-reactions of alpacas to shearing by comparing the behaviour of alpacas that were shorn while they were restraint lying on the bare wooden floor (N = 19, Floor, the common procedure), while lying on a soft mattress (N = 20, Mattress) or that were held standing and not shorn (N = 19, NoShear). Animals were caught one by one and randomly assigned to the three treatments. In Mattress and Floor, animals were restraint by fixing a rope to the hind limbs and holding the front limbs; NoShear animals were led to the shearing place, held there for 3 min and then released. Animal vocalisations were recorded directly by one observer; struggling and other animal behaviours and human handling behaviour were analysed from video recordings. The observational study investigated the potential mid-term stress of the whole situation by behavioural observations of alpacas before being gathered for shearing and when back on pasture (N = 5 herds). Animal behaviour did not differ between the Mattress- and Floor group, and only small differences in human handling could be seen in the experiment. The NoShear group showed fewer and shorter flight attempts, less defensive movements with the limbs, head, and torso and fewer animals were screaming. There were no significant differences regarding duration of fixation or of shearing between the two shearing treatments. In the observational study, the feeding activity of alpacas was higher after shearing than before, but the other basic activities (walking, standing, lying with or without rumination) were not affected. In conclusion, animals experience higher stress when being shorn rather than just being held at the shearing place, although stress during shearing seems relatively independent from using a soft mattress or not and the handling without shearing is stressful as well. Results of the observational study show the importance of providing sufficient food after shearing and keeping the procedure's duration short.

1. Introduction

Peru hosts 4.5 million alpacas (*Vicugna pacos*), about 85 % of the worldwide alpaca population, and produced 4352 t of fibre in 2020 (MDAR, 2021), of which about 90 % is destined for the export market (Gutierrez et al., 2018). Europe is a substantial importer of alpaca fibre (CBI Ministry of Foreign Affairs, 2016), with increasing concern of consumers regarding process quality of animal products, emphasising the need for good animal welfare (Von Borell & Sørensen, 2004; European Commission, 2016). Therefore, the welfare of alpaca is becoming an area of concern for the textile industry, reflected in recent initiatives for certification/labelling of farms producing alpaca fibre according to animal welfare and ecological aspects. For instance, the Responsible Alpaca Standard was launched in Peru in April 2021. This international, voluntary standard addresses animal welfare in the alpaca supply chain and chain of custody of alpaca fibre material from certified farms to the final product (Textile Exchange, 2021).

The annual shearing event is one area of concern. Shearing itself is characterised by different features known to elicit stress: close human handling in animals not used to it (Waiblinger et al., 2006), separation from the herd (Pollard and Littlejohn 1995), unusual noise (Morgan and Tromborg, 2007), and strong restraint for shearing (Waiblinger et al.,

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https://doi.org/10.1016/j.smallrumres.2022.106885
Received 22 December 2021; Received in revised form 6 November 2022; Accepted 28 November 2022
Available online 12 December 2022

2020). Lying on a hard surface in an unnatural position can be another stressor. Stress during shearing can vary depending on the exact method of restraint (Wittek et al., 2017; Waiblinger et al., 2020): being restraint lying on the ground on a soft mattress or a table with legs tied up by ropes in an outstretched position elicited higher levels of stress than being restrained in a standing position. Further there were some indications that being restraint on the table (which had a hard surface and was elevated) caused a somewhat higher stress level as compared to restraint on the ground on a soft mattress (Waiblinger et al., 2020). In Peru, it is widespread to restrain animals on the bare ground, such as a wooden floor, for shearing. The use of a soft mattress might improve comfort for the animals and thus reduce stress. Besides shearing per se, the accompanying procedures likely induce stress as well. In Peru, these include moving the animals to the shearing facility and gathering them in corrals, often with high animal density, where they stay without food and water, partly overnight in cases when gathered on the day before shearing. In wild South American camelids, guanacos (*Lama guanicoe*) and vicunas (*Vicugna vicugna*), that are caught and sheared as well, the level of behavioural and physiological stress reactions was affected by the duration of handling and the exact way of catching (Arzamendia et al., 2010, Carmanchahi et al., 2011; Taraborelli et al., 2011). However, to our knowledge, no study on behavioural changes in alpaca caused by the annual shearing event as a whole, and under Peruvian farm conditions, has been performed so far.

Stress generally induces behavioural and physiological changes with behaviour being a sensitive indicator (Olsson et al., 2018). Several behaviours are well-established as signs of fear or stress, such as flight, avoidance, defence and stress vocalisations (Olsson et al., 2018). In South American camelids, behaviours that were related to and thus can be used to assess stress levels include: screaming, escape attempts, kicking and struggling during handling/shearing itself as an immediate stress reaction, as well as changes in feeding, vigilance or social behaviour in the mid-term (Arzamendia et al., 2010; Taraborelli et al., 2011; Marcoppido et al., 2018; Waiblinger et al., 2020). Behavioural reactions were well associated with physiological ones, such as cortisol, heart rate or heart rate variability (Marcoppido et al., 2018; Waiblinger et al., 2020).

This study aimed to investigate behavioural stress reactions of alpacas related to the annual shearing event under field conditions in Peru. In detail, the study's first aim was to compare the behavioural stress reactions of alpaca restraint as usual on the bare wooden floor with the reaction of animals where a soft mattress was used. We expected stronger behavioural reactions like vocalisation, defensive movements and flight attempts when alpaca were restraint on the floor without a mattress. Secondly, this study aimed to disentangle the effect of restraint and shearing (with or without mattress) from the potential stress of only the accompanying handling, including close human handling in the short term. Stronger behavioural reactions were expected in animals restrained and shorn than in animals that were not shorn and were held standing, thus experiencing similar close human contact and having experienced all other procedures such as gathering and corralling. The third aim was to compare the behaviour of alpacas on pasture before being gathered for shearing and after coming back from the shearing event as an indicator of the potential mid-term stress of the whole shearing event. We predicted changes in maintenance behaviour in the period after shearing compared to before.

2. Methods

The study was divided into one experiment in immediate reactions to restraint and shearing taking place at the shearing facility of the San Pedro de Racco Cooperative (Peru) and one observational study on mid-term effects of the shearing event on behaviour on two private alpaca farms in the area of Cerro de Pasco (Peru) in November and December 2018.

The study was approved by the institutional ethics and animal welfare committee of the Veterinary University of Vienna in accordance with Good Scientific Practice (GSP) guidelines and national legislation, the Peruvian National Act No. 30407 "Ley de Proteccion y Bienestar Animal" (Act for the Protection and Well-being of Animals).

2.1. Experiment on immediate reactions to restraint and shearing

2.1.1. Animals, treatments and procedures

The cooperative is located at an altitude between 4253 a 4446 masl and has an extension of 4347 ha. About 2000 white alpacas Huacaya were kept on an extensive, pasture-based system. Besides alpacas, also sheep and llamas were kept. The alpacas are managed in smaller herds, accompanied by a shepherd. One of these herds with 254 alpacas was used for the experiment.

In the morning of the day before shearing, the herd was moved to a small corral near their pasture where workers separated 149 animals assigned to shearing from the rest of the herd. The selected animals were kept in the corral for the identification process. Out of this 149 alpacas, 69 animals (all female, ranging between 2 and 8 years) were chosen randomly for the experiment from all females that had been shorn at least once before, captured and marked by spraying their left ear with red colour and, together with the other 80 animals, released to another pasture nearby. For random selection, all animals fulfilling the selection criteria were selected and marked until 69 animals were reached. Sample size selection was based on previous studies differentiating between shearing methods with 15 animals and sample size calculations using a biologically meaningful effect size. In the evening of the same day, the 149 animals were moved on foot from pasture to the shearing facility and kept there overnight in a wooden shelter (rectangular, around 120 m^2) without feed and water. On the morning of the next day (=the day of the experiment), the marked animals for the experiment were separated from the other animals and kept in another pen of the wooden shelter (rectangular, around 32 m^2) from where they were caught randomly one by one and moved to the shearing place. The shearers were hired personnel, whereas the permanent staff of the cooperative was handling the animals.

At the shearing place, the 69 alpacas were assigned to the following three treatments (N = 23 each):

Mattress: Animals were led to the shearing place, laid down on a soft mattress (foam covered by plastic, measurements 1.30 m x 0.70 m x 10 cm) by the shearer and the handler, restraint by fixing a rope (fixed to the wall) to the hind limbs and holding the front limbs manually.

Floor: Procedure as in mattress, but with the animal not lying on a soft mattress, thus on the wooden floor.

NoShear: Animals were led to the shearing place, held for 3 min by hand and then released; animals were not shorn.

The treatments Mattress and Floor were applied for answering our first research question if use of a mattress would alter stress reactions, while treatment NoShear was applied for answering our second research question where we aimed to disentangle the effects of restraint and shearing (with or without mattress) from the potential stress of only the accompanying handling, including close human handling in the short term.

The first animal was allocated to the treatment Mattress, and then treatments were alternated in the same order, i.e. Mattress, Floor, NoShear, until the last animal. After shearing/restraint, animals were released to an adjoining corral. Throughout the experiment, the team of one shearer and one person handling the animal stayed the same. The same electric shearing equipment was used for all animals.

2.1.2. Behavioural observations

All observations were performed by one observer (first author) standing about one-metre distance from the animal. The animalś behaviour during the procedure of restraint/shearing was observed by continuous recording directly (vocalisations; screaming and growling) and from video (other behaviours: moving head, moving torso, moving limbs, pushing, flight attempt, going down). Human behaviour, the duration of being fixated and of shearing were also observed from the videos. For definition of behaviours see supplementary material Table S1. The observation started when the animal stepped into the door frame of the shearing terrace and ended with the animal leaving the terrace by jumping or stepping off. Duration of fixation was defined as the moment of (forced) lying down of the animal until the moment when the animal is no longer fixated at the legs/held. Duration of shearing was taken from the first start of the shearing machine touching the animal until the shearing machine leaves the body after all fibre was removed. Videos were recorded with a Go-Pro camera Hero 3, fixed to the observer's head with a harness. The animal behaviour observation program BORIS v. 6.2.4 (Friard and Gamba, 2016) was used for recording the behaviours from videos.

2.1.3. Data analysis

Data were analysed with SPSS Version 25. One animal escaped from the shearing pen, and therefore data of 68 animals (23 Mattress, 23 Floor, 22 NoShear) were finally available for vocalisations. Due to the failure of the camera battery, video material of 11 animals was missing leading to a reduced sample size (20 Mattress, 19 Floor, 19 NoShear) for all other behaviours and periods. To correct for varying lengths of observation, durations or frequencies of behaviour were divided by the length of observation in seconds and the result multiplied with 180, thus resulting in the occurrence of behaviour per 3 min. When analysing vocalisations, we focused on screaming because animals that growled did also scream except for two animals, more animals screamed than growled, and screaming is a clear indicator of high-intensity stress. Screaming was dichotomised into screaming yes/no, because most animals did not vocalise at all, especially in NoShear. Similarly, other behaviours that occurred only rarely were dichotomised. These behaviours were analysed by a Chi^2-Test. Some of the behaviours were characteristic for NoShear respectively one of the shearing treatments because animals were restricted in their behavioural expression during restraint. To ease comparison between NoShear and the shearing treatments, all behaviours that were active defence or escape reactions were summed together into 'D_activeEscape' (see Table 1); for behaviours that were events (i.e. only frequency recorded, no duration), one event equalled 1 s. Frequency or duration of behaviours were analysed with non-parametric statistics for independent data (Mann-Whitney U) comparing Mattress and Floor to test for the first hypothesis and by comparing these two with NoShear for the second hypothesis. Bonferroni correction for testing NoShear against two other treatments was applied when testing the second hypothesis.

Table 1

Results of the Mann-Whitney-U test for comparing frequencies (F) and durations (D) of animal behaviour in the treatments Mattress (N = 20) and Floor (N = 19) for testing the first hypothesis and comparing these two treatments with NoShear (N = 19) for testing our second hypothesis. P-Values without Bonferroni-correction are shown. All p-values which are still significant after Bonferroni-correction are shown in bold.

	Mattress – Floor		Floor – NoShear		Mattress – NoShear	
Animal behaviour	p	Z	P	Z	p	Z
D_flight_attempt	0.633	-0.478	**<0.001**	-3.616	**0.001**	-3.390
D_pushpull	0.266	-1.113	**0.001**	-3.465	**<0.001**	-4.050
F_head	0.481	-0.704	0.188	-1.318	0.383	-0.872
F_limbs	0.465	-0.731	**<0.001**	-4.771	**<0.001**	-4.911
F_torso	0.954	-0.057	**<0.001**	-3.583	**<0.001**	-4.119
D_activeEscape[a]	0.736	-0.337	**0.002**	-3.095	**0.003**	-2.922
D_lying	0.216	-1.237	NA[b]		NA	

[a] Sum of all behaviours above.

[b] NA. not applicable because the behaviour can only be shown in NoShear animals that went down voluntarily.

2.2. Observational study on mid-term effects of the shearing event on behaviour

2.2.1. Animals and procedures

The study was conducted with five herds on two private alpaca farms, one in the village Sanjo and the other one in Cachipampa, Pasco region. The farm in Sanjo owns about 200 alpacas Huacaya and the farm in Cachipampa about 180 alpacas Huacaya. Both alpaca farms managed their animals in several herds, which were kept on large pastures near the house. The herds were composed according to sex and fibre quality and included animals of different ages. In Cachipampa, the study included a female herd of 87 animals (herd 1, h1) and one male herd of 51 animals (herd2, h2). In Sanjo, a herd of 10 males (herd 3, h3), a herd of 87 females (herd 4, h4) and a third one of 135 females (herd 5, h5) were observed. All male alpacas were uncastrated. As shearing took place on the farms, animals could be taken from the pasture to the farms within 10 min of walking. Shearing was performed by hired shearers, whereas all the handling was done by the animals' owners. The alpacas were then kept in a small fenced area (around 60 m^2 in Sanjo and 65 m^2 in Cachipampa) right next to the shearing place, where they were then taken out one by one to be shorn. After shearing, the animal was put back in the fenced area to wait until the last animal was shorn. Later the whole herd was taken back to the pasture. Not all animals in each herd were shorn because some had too short fibre, leading to mixed herds with animals shorn and not shorn after shearing.

2.2.2. Study design and behavioural observations

A repeated measures design was used, i.e. behaviour of alpacas was observed before they had been gathered for shearing (pre-shearing) and when back on pasture (post-shearing). Animals were back on pasture about 30 min after the shearing event was finished; in herd 5, it was 17 h later. Herd observations (pre- & post- shearing observation) were performed for one hour each, with direct observations conducted using scan sampling of the whole herd in 5 min intervals for basic activities (lying, feeding, standing, walking, vigilant while walking or standing). To allow for observations pre- and post-shearing during a comparable time of the day the pre-shearing observations were conducted on the day before shearing and post-shearing observations generally directly after the shearing event in the morning of the next day, thus 22–25 h after pre-shearing observations. However, shearing of herd 5 just ended in the late afternoon and the post-shearing observation took place the next morning, i.e. 45 h after pre-shearing.

All observations were performed by two observers (one performing observations in Sanjo, the other in Cachipampa) with the help of binoculars to keep distance and thus not disturb the animals. To allow for the observations the herds were virtually divided into 4–6 smaller focus groups, and each group then was observed for the same amount of time (10 or 15 min, i.e. three or four scans), adding up to one hour in total. Due to wide and uneven/mountainous pastures and steadily moving animals, not all of them were visible at all times. In this case, after the observation time of one group was done, the observer walked to find the other group(s) and then started the next observation.

2.2.3. Data analysis

Data were analysed with SPSS Version 25. Standing and walking vigilant were observed very rarely so that they were added to standing or walking, respectively, and not analysed separately. The proportion of scans where a specific behaviour was shown was calculated separately for the pre- and post-shearing period and compared by use of either t-test for paired data (walking, feeding) or Wilcoxon test using the exact function (standing, lying).

3. Results

3.1. Experiment on immediate reactions to restraint and shearing

3.1.1. Animal behaviour

There was no difference between Floor and Mattress in any of the animal behaviour variables (Table 1, Fig. 1) but NoShear clearly differed from the other two treatments with much less and thus in total shorter flight attempts and less defensive movements of the legs or torso but higher durations of animals pushing forward, sideward or backwards during fixation (pushpull) (all $p < 0.01$, Table 1, Fig. 1). Accordingly, NoShear animals showed lower duration of defensive and escape movements in total (D_activeEscape, Table 1, Fig. 1). Only two NoShear animals screamed (out of 22), while nine animals in both Mattress and Floor (both N = 23) did so, thus differing in the Chi^2-Test ($\chi^2(2)= 6.47$, $p = 0.04$; see Fig. 1 for frequencies of screaming). Seven of 19 NoShear animals went down during the observation for a duration of 15 s up to the whole three minutes, five of 19 Mattress and three of 20 Floor animals went down in the short period before being put down by the handler; thus treatments did not differ in the number of animals showing

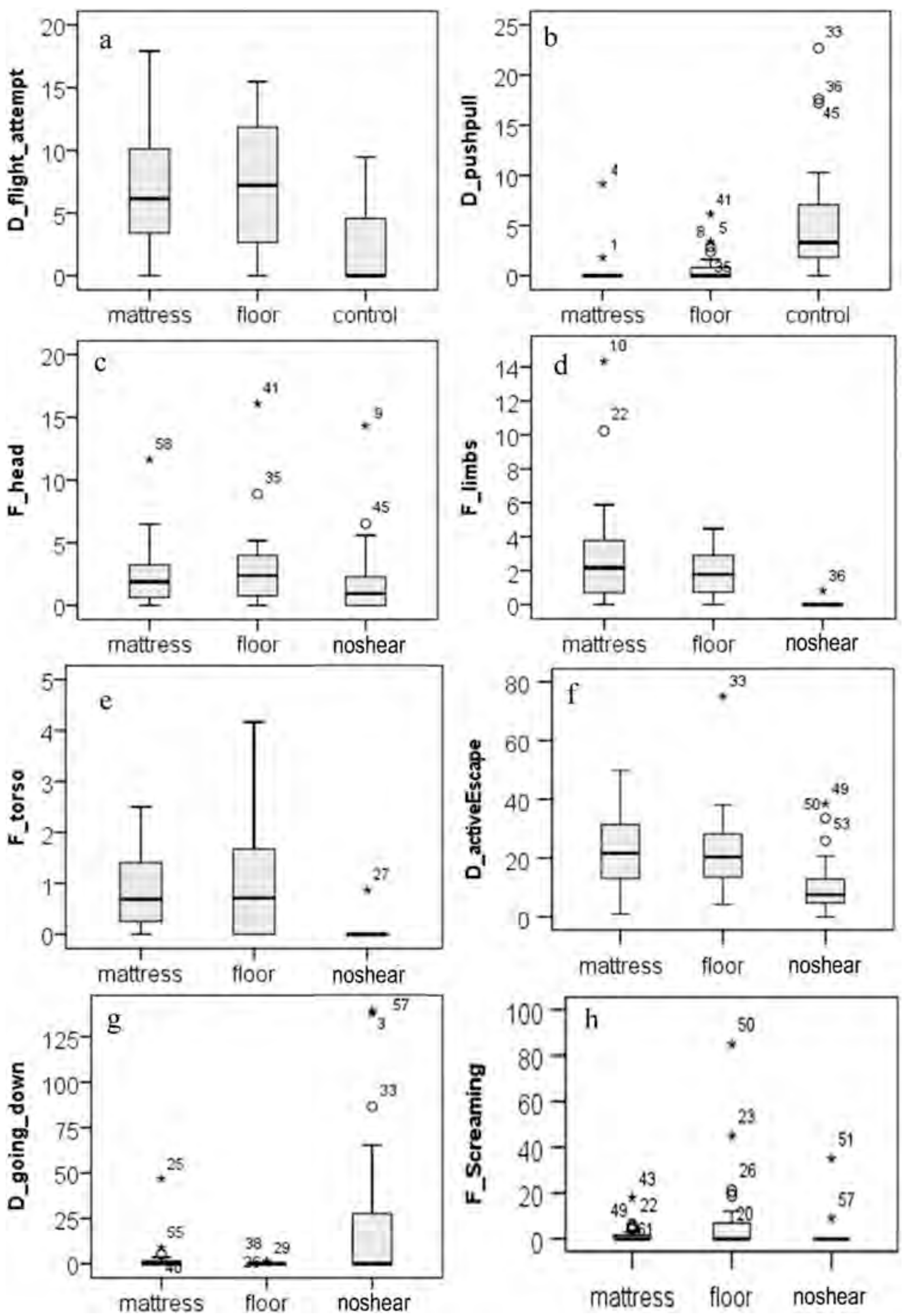

Fig. 1. Boxplots of durations (D, in seconds/3 min) of flight attempts (a), pushpull (b), the sum of active escape reactions (f) and going down (g), as well as frequencies (F) of defensive movements with the head (c), limbs (d), torso (e) and of screaming (h) in the three treatments Mattress (N = 20 / 23 for screaming), Floor (N = 19 / 23) and NoShear (N = 19 / 22).

this behaviour (χ^2(2)= 2.43, p = 0.30). Eight Mattress animals stayed lying on the ground for some time (2–36 s) after being released from fixation before standing up and leaving the shearing place; four alpacas in the Floor treatment stayed lying for 4–17 s; Mattress and Floor did not differ (χ^2(1)= 2.24, p = 0.4). No comparison with NoShear was performed because animals generally were not lying on the ground before restraint stopped.

3.1.2. Human behaviour

Some differences in frequencies and durations of how animals were held and handled were observed between Floor and Mattress: a higher duration of holding one or both ears (held_ear) and longer duration of fixating the animal by holding it around the neck (held_neck; Table 2, Fig. 2) and a higher frequency of lifting_up was observed in the Mattress-treatment compared to Floor (Table 2, Fig. 3).

Bringing the animal down on the floor and fixating it there for shearing required some specific handling behaviours that did not apply for holding and fixating the NoShear animals when standing. Therefore, these behaviours were not compared between NoShear and Mattress or Floor (see Table 2). Some differences were found in behaviours that were applicable in all three treatments: The handlers held the animals at the tail (held_tail) and neck (held_neck) for longer in the NoShear treatment as compared to Mattress and Floor (Table 2, Fig. 2) quasi replacing the above mentioned behaviours that are typical for restraint during shearing. Handlers used voice or gesture to make animals standing up after fixation had stopped (Rousing) in two Mattress animals, five Floor animals and no NoShear animal, thus treatments tended to differ in the Chi^2-Test (p (2)= 5.802, p = 0.055); standardised residuals (st.r.) indicated higher occurrence in Floor (st.r. = 1.7) and lower in NoShear (st.r. = −1.5). Handlers rarely pulled alpaca at one or both ears (number of animals that experienced it at least once: Matress/Floor/NoShear, 3/2/1), or used slapping slightly (3/2/2) or slapping or kicking more forcefully (1/3/1) in all three treatments.

Duration of shearing, fixation and observation time did not differ between Floor (192.40 ± 23.86 s shearing, 250.31 ± 46.08 s fixation, 293.66 ± 53.33 s observation) and Mattress (185.33 ± 31.84 s shearing, 268.15 ± 28.71 s fixation, 277.52 ± 53.17 s observation), but observation and fixation were shorter in the NoShear treatment because observation was set for 3 min in advance (fixation 179.52 ± 3.56 s, 199.31 ± 15.07 observation).

Table 2
Results of the Mann-Whitney-U test for frequencies (F) and durations (D) of human behaviour comparing Mattress (N = 20) and Floor (N = 19) and these two treatments with NoShear (N = 19.). P-Values without Bonferroni-correction are shown. All P-values which are significant (P ≤ 0.05) after Bonferroni-correction are shown in bold, tendencies are shown in italics.

Human behaviour	Mattress - Floor		Floor - NoShear		Mattress - NoShear	
	p	Z	P	Z	p	Z
D_held_ear	**0.049**	-1.967	0.480	-0.707	0.259	-1.129
D_held_neck	**0.011**	-2.557	**<0.001**	-4.777	**<0.001**	-4.761
D_held_tail	*0.056*	-1.911	**<0.001**	-4.439	**<0.001**	-4.715
D_pushing	0.971	-0.037	0.894	-0.133	0.829	-0.215
D_put_ground	0.899	-0.127	NA		NA	
D_head_legs	0.199	-1.285	NA		NA	
D_held_down	0.697	-0.389	NA		NA	
D_held_legs	0.249	-1.152	NA		NA	
D_positioning	0.465	-0.731	NA		NA	
D_sitting_on	0.735	-0.339	NA		NA	
F_lift_up	**<0.001**	-4.869	NA		NA	
F_stretching	0.384	-0.871	NA		NA	

[1]NA. not applicable because the behaviour is related to putting or holding the animal down on the floor for shearing and thus typically not shown in NoShear.

3.2. Observational study on mid-term effects of the shearing event

During herd observations alpaca were mainly feeding both before (mean±SD: 0.79 ± 0.042 in proportion of all scans) and after shearing (0.93 ± 0.033), but proportion of feeding was even higher after shearing (t = −4.7: p = 0.009). One herd could only be observed at the day after shearing (17 h later) but feeding activity was also higher with 0.93. Walking and standing were not affected (p > 0.1), although numerically they were observed less often post-shearing (walking: mean±SD, 0.05 ± 0.02; standing: median, min-max. 0.02, 0–0.03) than pre-shearing (walking: 0.09 ± 0.05; standing: 0.05, 0.02–0.2), in line with the increase in feeding. Lying was observed least often both pre-shearing (median. min-max. 0.02, 0–0.13) and post-shearing (0. 0–0.1).

4. Discussion

4.1. Immediate reactions to restraint and shearing

4.1.1. Effect of a Mattress

Having a mattress to lie on or lying directly on the wooden floor did not affect alpaca behaviour in our study, thus not supporting our first hypothesis. Alpaca being shorn when restraint on the ground on a soft mattress or on a table on a wooden surface hardly showed differences in behavioural and physiological reactions, while applying these restraint methods without shearing suggested restraint on the table to elicit a somewhat higher level of stress (Wittek et al., 2017; Waiblinger et al., 2020). In our study the overall stress of the handling and shearing (novel environment, close human contact with quite intrusive behaviours: being lifted and put down on the ground, then being restraint there in an unnatural and vulnerable position with stretched leg, being moved around and finally, being shorn, that is being touched with a noisy, vibrating machine nearly all over the body) may have been too strong in both treatments to allow for differences; i.e. there may have been a ceiling effect. Nearly half of the animals in Mattress and Floor were screaming loudly, an indicator of intense stress in South American camelids (Arzamendia et al., 2010; Taraborelli et al., 2011; Waiblinger et al., 2020) and active escape or defence attempts (such as escape attempts, struggling with the leg), being as well indicators of stress (Arzamendia et al., 2010; Taraborelli et al., 2011; Marcoppido et al., 2018; Waiblinger et al., 2020; Windschnurer et al., 2020), were also frequent. By using a mattress, we expected to improve comfort and thus welfare by reducing pressure on body parts, especially bony structures and joints, when the animal is put down on the floor as well as lying on it and being moved/rolled from side to side. We expected contact to a hard floor may lead to a higher level of discomfort or even pain, especially in animals with lower body condition score, where bony structures are less covered and get more protruding (Cebra et al., 2014). High levels of stress are associated with reduced sensation of pain (Moberg, 2000) thus potential higher comfort of the mattress may have been obscured and animals might have experienced higher welfare only later after stress levels decreased should there have been fewer traumatic lesions. It would be interesting in future studies to investigate such potential effect by, for example, evaluating locomotion or the rate of abortions after shearing. In addition, external validity is limited (as usual for many experimental studies) because we studied only one herd of animals with one pair of handler/shearer. We cannot exclude that under different overall conditions and stress levels potential differences in alpaca reactions to shearing on the floor or a mattress may occur also on the short-term.

Handling behaviour differences between Mattress and Floor likely reflect peculiarities when using the mattress, which handlers were not used to, was relatively small and was not fixed on the ground. Therefore, the handler sometimes had to readjust the position of animals, lifting it onto the mattress (again), for example after the mattress slipped away while the handlers were trying to lay the animal on it. Sufficient fixation of the mattress or a mattress of sufficient weight would avoid the need of

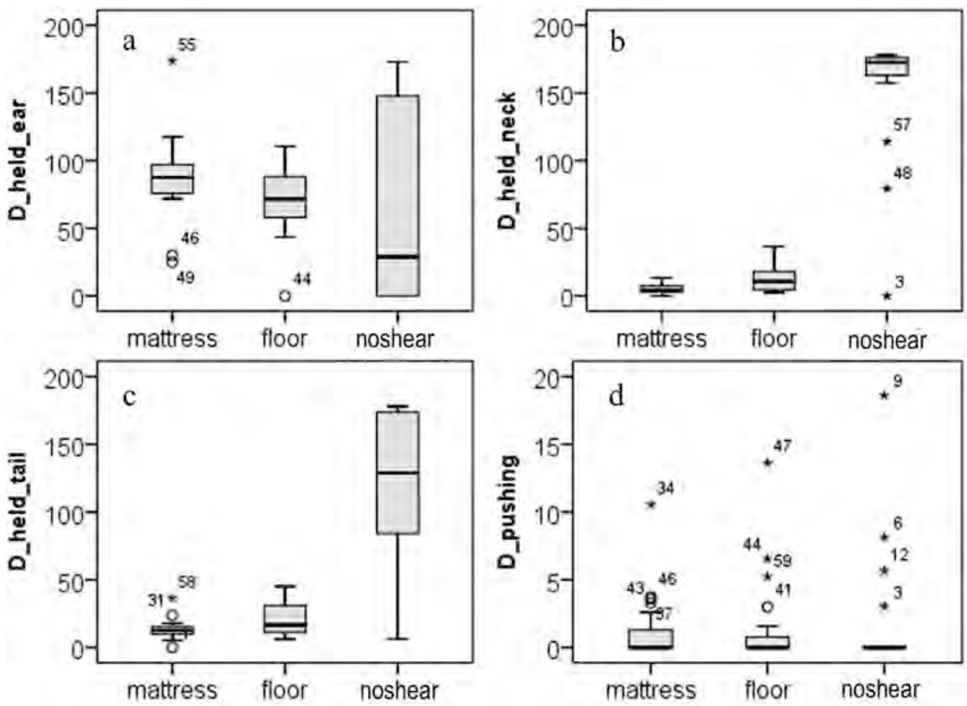

Fig. 2. Boxplots of durations (D, in seconds/3 min) of behaviours of the handler that were applicable in all three treatments Mattress (N = 20), Floor (N = 19) and NoShear (N = 19) for holding the animal at the ears (held_ears, a), at the neck (held_neck, b), at the tail (held_tail, c) and pushing the animals (pushing, d).

such readjustments that can add on the aversiveness for the animals. The longer duration of holding one or two ears and shorter duration of holding them at the neck in Mattress compared to Floor may reflect differences in how the handler could position himself close to the animals or that the animals in the treatment differ in their initial movement and thus the need for restraint. In addition, it has to be noted that the handlers were not used to the mattress while shearing on the floor was a routine procedure. Future studies may benefit from sequential analysis and comparable experience of human handlers for both methods. The differences in handling behaviours used may have contributed to the lack of a difference in animal behaviour between mattress and floor as well.

4.1.2. Effect of shearing and restraint on the ground

Alpaca in the NoShear treatment showed less active defensive and escape behaviours; further fewer NoShear animals (only two) screamed than the animals that were shorn either on the Floor or Mattress. This indicates lower levels of stress in NoShear (see discussion on indicators above), in line with our hypothesis. The factors and handling behaviours contributing to the high level of fear and stress during shearing and restraint were mentioned already before – the animals undergo the whole handling situation without any control over the situation causing high levels of stress (Greiveldinger et al., 2009; Koolhaas et al., 2011). However, although to a lower extent, also NoShear animals showed behaviours indicating fear and stress, namely active escape behaviours. Also in the NoShear- group animals had to be fixated and thus experienced close human presence and some level of restraint, otherwise they would have searched for distance to the humans and company of their conspecifics. Handlers fixated alpaca in the NoShear group by holding, sort of hugging, the animal around the neck while standing next to the animal, sometimes the handler held the alpaca by one or two ears and/or by the tail, especially when the animal moved a lot. Resting on knees or lying down in sternal recumbancy (i.e. the behaviour names ‘going down’) occurred mainly in NoShear – the other two treatments had only little time to do so before they were put down on the ground, nevertheless there was no significant difference between treatments. Lying down on the ground is a behaviour alpaca often show in situations of stress such as isolation (Pollard and Littlejohn, 1995) or when being touched and restraint by humans (Windschnurer et al., 2020). An improved relationship of the alpacas to humans with habituation or even positive conditioning to human proximity and touch may be one measure in reducing the aversiveness of handling and shearing (Windschnurer et al., 2020, for review Waiblinger et al., 2006). In addition, training of handlers and by this improved handling behaviour may further reduce stress as show in other species kept extensively (Ceballos et al., 2018).

4.2. Mid-term effects of the shearing event

The observational study on maintenance behaviour of five herds of alpaca before and after the shearing event provides for the first time data on mid-term effects of the shearing event, although preliminary due to the low sample size of only five herds. The animals were mainly feeding during the pre-shearing observation but feeding increased even further by 10–30 % post-shearing. In previous studies reduced feeding was observed in response to stress in alpacas (Pollard and Littlejohn, 1995, Waiblinger et al., 2020). However, the alpacas in the study of Pollard and Littlejohn (1995) were isolated, Waiblinger et al. (2020) observed less feeding in the first two hours after more stressful restraint outstretched by ropes as compared to being held while standing; the study was conducted in summer in Austria and Germany with moderate to hot temperatures and no pre-post shearing comparison was performed. In contrast, in our study the alpacas were back in their home environment on pasture with their familiar herd and faced quite rough climatic conditions in the high Andean region with temperatures only few degrees above zero. Higher feeding behaviour observed in our study may indicate that hunger is increased after shearing because of having been deprived from feeding for around 2–6 h and/or higher energy demand due to the increased conductance of the coat due to shorter hairs. The latter argument is supported by the fact that one herd could only be observed at the day after shearing. i.e. 14 h later, but feeding activity was still higher. Shearing negatively affects the insulating property of

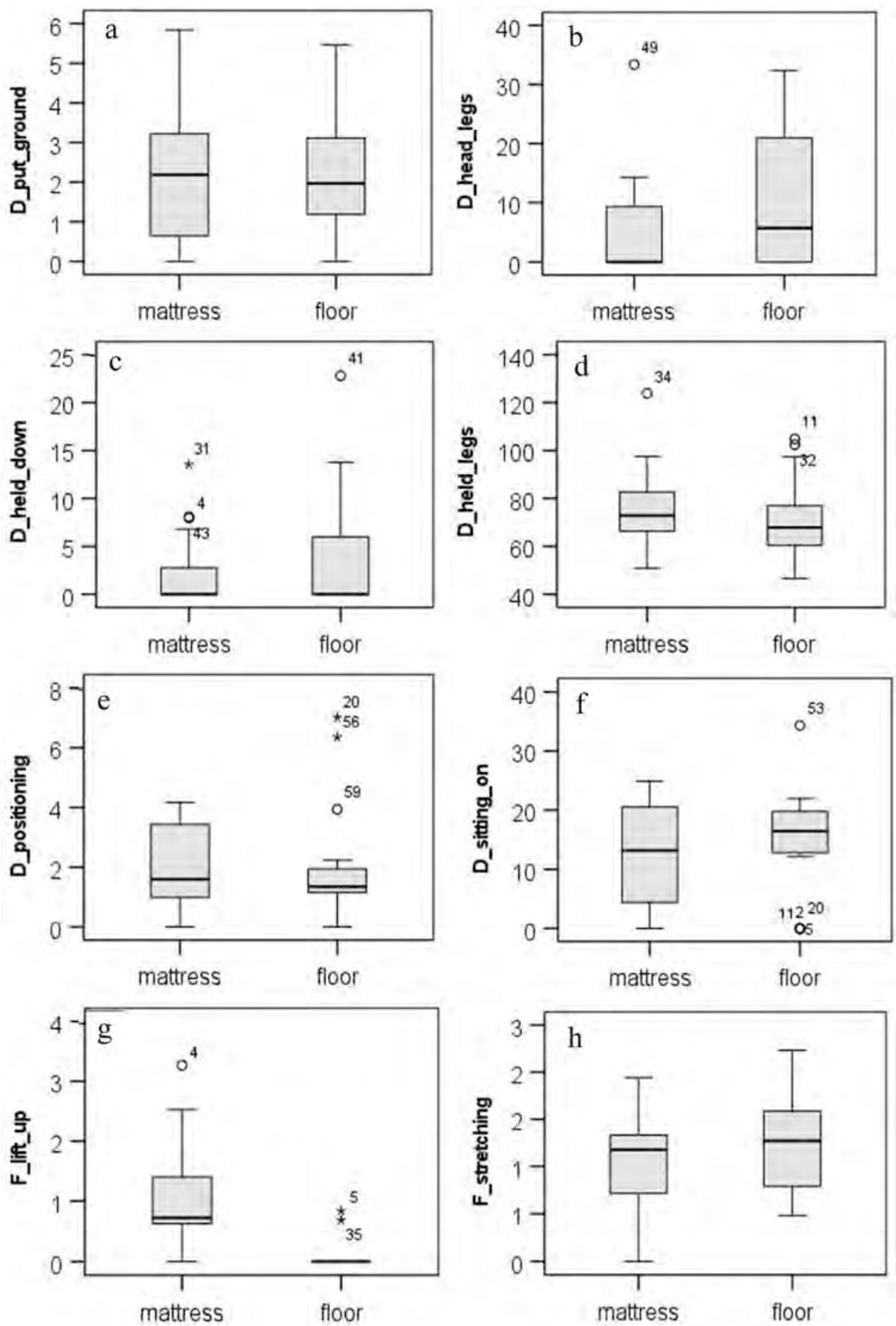

Fig. 3. Boxplots of durations (D, in seconds/3 min) of handler behaviours putting the animal on the ground (put_ground, a), holding the animals head between legs (head_legs, b), holding the animal down on the ground (held_down, c), holding the animals legs (held_legs, d), positioning the animal (e) and sitting on the animal (sitting_on, f) as well as frequencies (F) of lifting the animal for positioning it on the mattress or floor (lift_up, g) and stretching (f) by pulling at the animals' legs in the two treatments Mattress (N = 20) and Floor (N = 19).

the hair coat and has thus a strong impact on the thermoregulation of the animal so that alpaca may suffer from severe cold when they lack sufficient protection of an insulating hair coat in harsh climate (Gerken, 2010). Increased heat loss can be compensated by increased internal heat production via a higher metabolic rate, which requires higher energy intake (Gerken. 2010) which is in line with the increased feeding activity in our study. Shorn sheep preferred floors with lower conductivity (straw) over higher conductivity floors and did reduce their lying times if housed in pens without straw compared to unshorn sheep (Færevik et al., 2005). In our study there was only slight numerical reduction in lying that could not be confirmed statistically. The time of day of observation in the morning to noon hours was covering the main feeding times as reflected in our data. thus effects on lying may have been less pronounced. Longer observation times, at best 24 observations by using automatic devices. might be better appropriate for this behaviour, but were not feasible in this study. Vigilance was observed very rarely so that it was not analysed separately. Potential changes due to stress during the shearing event thus could not be confirmed. Vigilance during confinement increased in vicunas in a capture-shearing event with increasing waiting time and thus increased stress (Arzamendia et al., 2010), but animals were not observed after being released. Another factor that may have contributed to a lack of difference in behaviours other than feeding may be the fact that not all animals of the herd were shorn. This may have weakened a potential effect. Thus future studies might benefit from individual identification of alpacas which is however difficult under field conditions. Further, including indicators of physiological stress. e.g. faecal cortisol metabolites, and potential long-term consequences of acute stress due to the shearing event itself or higher energy demand and potential thermal stress thereafter on health and reproductive success including different management practices related to the shearing event (including large differences largely in the total duration that alpaca are confined and deprived of feed and water) could help to further understand and improve this situation.

5. Conclusion

The results of our study indicate that shearing and accompanying procedures induce behavioural changes indicative of stress. Results of the experiment on immediate effects indicate that being handled and hold by humans at the shearing place is already stressful for alpacas but that shearing and the associated, more invasive handling, elicits higher levels of stress reflected in stronger behavioural reactions. This stress during shearing seemed to be so high that it was relatively independent from using a soft mattress or not, although there may be positive effects on joints and tissue health of the animal, which we did not study but merit further research. The observational study on mid-term effects indicates behavioural changes likely due to increased energy demand to compensate higher heat loss after shearing and hints at the importance of sufficient feed and of considering climatic conditions when shearing to help maintaining the animal's health and welfare.

Conflict of interest

None.

Acknowledgements

We are very grateful to Alma Cayetano and Jorge Mendoza for their help during data collection. We would also thank the participating farmers, farm manager and staff for supporting this study. We acknowledge funding by the University of Veterinary Medicine, Vienna and the Universidad Nacional Agraria La Molina in Lima.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.smallrumres.2022.106885.

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