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Assessment of Welfare in Transhumance Yak Hybrids (Chauris) in the Lower Himalayan Region of Nepal

Sujan Sapkota [1], Richard Laven [1,*], Shanker Raj Barsila [2], Nikki Kells [1], Kristina Ruth Mueller [1] and Dhurba DC [3]

1 School of Veterinary Sciences, Massey University, Palmerston North 4442, New Zealand; S.Sapkota1@massey.ac.nz (S.S.); N.J.Kells@massey.ac.nz (N.K.); K.Mueller@massey.ac.nz (K.R.M.)
2 Faculty of Animal Science, Veterinary Science and Fisheries, Agriculture and Forestry University, Rampur 44200, Nepal; srbarsila@afu.edu.np
3 Veterinary Hospital and Livestock Service Expert Centre, Charikot 45500, Nepal; dc.dhurba2015@gmail.com
* Correspondence: R.Laven@massey.ac.nz

Abstract: In order to develop a yak/chauri-specific welfare assessment protocol, we sent a set of 31 potential welfare measures to 120 Nepalese experts and asked them to identify the measures that they thought would be useful and propose additional useful measures. Eighty-three experts responded, with 13 measures being identified by >50% of respondents as likely to be useful. These thirteen measures plus one new measure (hematology) were included in an assessment protocol that was tested in the second phase of this study in five chauri herds in two districts in northern Nepal. Animal-based evaluations along with sampling for mastitis, intestinal parasites, and hematology were undertaken during or just after morning milking. Resource- and record-based measures were assessed through structured interviews, with verifications on-site where possible. No chauris exhibited poor body conditions, skin injuries, significant locomotion issues, or significant subclinical mastitis. Fecal testing suggested a high prevalence of intestinal parasites at the herd level, while blood testing suggested no evidence of hematological abnormalities. However, for both results, we need more data to use these effectively as measures of welfare. The resource-based assessment revealed significant challenges across all resources, and veterinary services were reported as being inadequate. A high estimated annual mortality rate (10–21%) needs further investigation. This protocol provided a useful start towards developing a welfare assessment protocol for yak/chauri and identified issues that need addressing to optimize chauri welfare.

Keywords: yak; chauri; welfare assessment protocol; welfare measures

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1. Introduction

Consumer concerns about animal welfare have driven an increasing interest in systematically assessing the welfare of livestock, particularly intensively reared animals such as permanently housed dairy cattle [1], cage-housed layer chickens [2], and pigs farrowing in crates [3]. There has been less interest in less intensive systems such as pasture-based dairy and beef cattle [4,5]. This is, in part, because of the perceived naturalness of those systems, but it is increasingly being recognized that the natural environment can result in poor welfare conditions and that we need to systematically assess the welfare of pasture-based livestock in order to provide evidence that the claims of higher animal welfare in these systems are robust [6,7]. Furthermore, most of this interest in the systematic assessment of farm animal welfare has focused on commercially farmed livestock rather than livestock that are farmed on a subsistence or semi-commercial basis, even though increasing commercialization may actually be positively associated with welfare outcomes [8].

Almost all yaks (*Bos grunniens*) and their hybrids, chauris (types: *Bos taurus* (♂) × *B. grunniens* (♀) (Dimjo chauris) and *B. grunniens* (♂) × *Bos indicus* (♀) (Urang chauris)), are reared under a transhumance system [9] and farmed on a subsistence or semi-commercial basis [10]. So, it is not surprising that there are few published studies on the systematic assessment of yak welfare [11,12]. This lack of a systematic assessment is accompanied by a general lack of information on yak welfare. The latter is likely to be due to the limited economic importance resulting from their semi-commercial/communal status and, in most areas outside of Tibet, their small numbers relative to other livestock. For example, in Nepal, there are ~50,000 yaks/chauris but more than 64 million cattle and 30 million buffaloes [13]. Furthermore, in all areas, including Tibet, the remote locations in which yaks are kept and the transhumance system that is used to access seasonal grazing grounds mean that access to yaks (and even chauris) is often difficult. Nevertheless, yaks do play a significant role in the economy and sustainability in regions where they are common, and yak products can be an important part of the local experience for tourists [14], so assessing yak welfare and ensuring that it is optimal is likely to be of benefit in such areas.

Although we have limited data on yak welfare, it is clear that they face increasing challenges in many areas including nutrition, access to water, parasite burden, and heat stress [11]. Perhaps the most important of these is a shortage of forage in their rangelands [15] that is due to both climate change (which alters the growth rates of traditional forage and competing weeds) [11] and competition for land with other uses [11,16].

The welfare of yaks is closely linked with the wellbeing of yak herders [17]. Socioeconomic changes in the prestige associated with yak herding as well as its profitability [18,19] have significantly decreased herder wellbeing and are, thus, likely to have had negative impacts on yak welfare. However, it is not just climatic and socioeconomic changes that are likely to be negatively affecting yak welfare. Longer-term problems such as a lack of proper treatment facilities and limited knowledge and skills of yak herders, combined with traditional farming practices and a lack of support from governments [19], are also likely to be negatively impacting yak welfare.

We, thus, need more data on the welfare of yaks and their hybrids so as to optimize their welfare (and the wellbeing of yak herders) and ensure the sustainability of yak herding in the future. To accomplish this on an ongoing basis will require the development of an outcome-based welfare assessment program. The first step in developing such a program is to obtain expert and stakeholder perspectives on the key issues around yak welfare [20]. This approach should provide comprehensive information regarding the key welfare challenges that yaks and chauris are likely to encounter and, thereby, help to select welfare measures that are likely to be practicable and achievable in the challenging geographical conditions in which yaks and chauris are found. The second step in developing the program is to take the selected welfare measures and test their practicability and feasibility in farms.

The two aims of this study were, thus, the following: (1) identify, with the help of local Nepalese experts, the measures that are likely to be useful for assessing the welfare of yaks/yak-hybrids in Nepal and then (2) test the practicality and feasibility of assessing those measures in a selection of chauri herds grazing in the lower Nepalese Himalayas.

2. Materials and Methods

2.1. Identification of Measures for Inclusion in the Welfare Assessment

This process was undertaken in two phases. The first phase identified the assessment measures to be included in our survey directed at local Nepalese experts. As the welfare assessment was intended for use during milking and immediately afterwards, the animal-based measures for inclusion in the survey were principally sourced from our previous time-limited welfare assessment of dairy cattle in New Zealand [4]. Of the 13 measures included in our dairy protocol, all of them except for ingrown horns and blind eyes (not known to be a problem in yaks/chauris) as well as heads up (not relevant in a transhumance system) were put forward. These measures were supplemented with material from a study that is, as far as the authors are aware, the only published peer-reviewed welfare assessment of yaks [12]. This material came from a thesis on the challenges and opportunities to sustainable yak farming in Bhutan [21]. Additional material from this thesis was also used in the identification process, particularly what had been published in a paper on the future of yak farming [22], as was material collected during our recent review of the impact of climate change on yaks [11], which included a section on the likely welfare impact of climate change on this species. This resulted in thirty-one measures being included in the survey (fifteen animal-based, eight resource-based, six record-based, and two management-related measures; Table 1).

Table 1. List of welfare measures included in the survey with the vote obtained from the survey respondents for inclusion (%) and the study that they were selected from. Selected welfare measures in bold (obtaining >50% vote) are only provided with their method of assessment.

	Welfare Measures	Assessment Method	Respondents (Total n = 83) Recommending Inclusion (%)	Selected From
Animal-based measures	**Body condition score**	using [23]. Poor BCS $\leq$ 3.5.	70 (84%)	[4,12]
	Skin injury/swellings	Presence/absence of visible abrasions, cuts, hairless patches, and swellings.	53 (63%)	[4,12]
	Endoparasite burden	Sample collected from fresh feces from the floor and stored in an icebox. Qualitative fecal examination (present/absent) using a simple fecal floatation method [24].	50 (60%)	[12,25]
	Lameness score	>1 recorded as lame [26].	45 (54%)	[4,12]
	Mastitis	California Mastitis Test. Scores > 1 correspond to mastitis [27].	42 (51%)	[12]
	Rumen fill score		27 (33%)	[4]
	Body cleanliness		26 (31%)	[4]
	Positive behaviors		25 (30%)	[4,12]
	Nasal discharge		22 (27%)	[12]
	Ocular discharge		20 (24%)	[12]
	Agonistic behavior		17 (21%)	[4,12]
	Coughing		13 (16%)	[12]
	Diarrhea		10 (12%)	[12]
	Avoidance distance		9 (11%)	[12]
	Broken tails		1 (1%)	[4]
Resource-based measures	**Access to drinking water at pasture**	Farmer response at the interview. Cross-checked if a water source was present within 500 m of the milking site.	70 (84%)	[4,12]
	Protection from climate extremes	Farmer response at the interview. Cross-checked if shelter/shade was present within 500 m of the milking site.	61 (74%)	[4,11,12]
	Availability of veterinary services	Farmer response at the interview.	53 (64%)	[21]
	Availability of sufficient forage at pasture	Farmer response at the interview.	52 (63%)	[21]
	Cleanliness of waterpoints		34 (41%)	[21]

Table 1. *Cont.*

	Welfare Measures	Assessment Method	Respondents (Total n = 83) Recommending Inclusion (%)	Selected From
	Distance between grazing pastures		29 (35%)	Author selection
	Tracks and terrain conditions		23 (28%)	Author selection
	Availability of bridges		17 (21%)	Author selection
Management based measure	Stockperson handling (during milking)		24 (29%)	[4]
	Any training on yak/chauri farming and handling?		19 (23%)	[21]
Record-based measures	**Number of yaks that die in a herd per year (any cause)**	Farmer response at the interview (incidence calculated using current herd size estimates).	60 (73%)	[4,21]
	Number of yaks that die in a herd per year (extreme weather and accidents)	Farmer response at the interview (incidence calculated using current herd size estimates).	60 (73%)	[21]
	Number of yaks that die in a herd per year (diseases and plant poisonings	Farmer response at the interview (incidence calculated using current herd size estimates).	55 (67%)	[21]
	Are you satisfied with the veterinary support? (accessibility vets/technicians; medicine availability)	Farmer response at the interview.	42 (51%)	[21]
	Do you routinely vaccinate your herd?		36 (44%)	Author selection
	Number of mastitis cases per year		31 (38%)	Author selection

An online survey (see Appendix A) was sent using Google Forms to a convenience sample of 120 Nepalese veterinarians and animal scientists. All the invitees had at least four years of experience in the field, were known to the first author, and were linked to him via a social media page. The invitees were contacted via Facebook Messenger. The response was voluntary and only the first author knew the identity of the invitees (and who had responded). The online survey was available for 3 months, with at least three reminders (follow-up messages and Messenger calls). For each of the 31 proposed measures, the respondents were asked whether they would include it in a welfare assessment. Each individual measure was assessed on its own merit. The proportion of respondents who included a measure was calculated, and measures were incorporated into the assessment protocol used for the feasibility study if >50% of the respondents had indicated that they would include it in a welfare assessment. The participants were also given the opportunity to suggest additional measures that were not included in the list. Once the survey period was completed, all the additional measures suggested by the respondents were examined by the authors, and, if the authors thought that they would be useful, potentially achievable, likely to provide further information on yak welfare, and could be incorporated into a time-limited assessment protocol, they were included.

2.2. Feasibility Study

For logistical reasons unrelated to this study, the measures identified in phase one were evaluated for feasibility on-farm in November 2022. The timing of this assessment meant that yaks could not be easily reached as they were still being kept on pastures at around 4000 m. In contrast, in November, chauri herds move down from their high-altitude summer pastures to their more accessible lower winter pastures. The preliminary welfare protocol was, therefore, assessed in a convenience selection of five chauri herds in two regions of Nepal (Dolakha and Rasuwa). In Dolakha, the committee members of the Yak/Chauri Farmers Association were contacted with the help of the district veterinary office, and herd owners grazing within a 2 h travel radius of the district veterinary office were identified. In Rasuwa, local farmer leaders were contacted directly by the authors themselves, who identified target farms based on a farmer's willingness to participate and the location of the herd being accessible within 2 h of travel from the local town. Three herds were selected in Dolakha and two in Rasuwa.

The assessment process began during morning milking, as soon as the chauris were tied to a pole for milking. The animal-based assessments were principally performed during milking, with milk sampling for the mastitis assessment being carried out when the chauris were being milked by the farmers, followed by fecal sampling for the evaluation of intestinal parasites. Once milking was complete, ~5 mL of blood was collected from the jugular vein into EDTA tubes (K3EDTA, Sanli Medical, Liuyang, China). These tubes were gently mixed, placed in an icebox, and then transported to the laboratory for testing using a ProCyte Dx Hematology analyzer (Idexx, Bangalore, India) within 12 h of collection. The cattle algorithm was used for this analysis. For the mastitis, blood, and fecal examinations, we aimed to collect samples from at least 50% of the milking herd members. The final animal-based assessment was lameness scoring, which was undertaken once the chauris were released after milking. Details on the method of assessment for these measures are provided in Table 1.

The resource-based and record-based measures were then assessed using a questionnaire-guided interview (Appendix B) with the farmers. All the interviews were conducted by the first author. For the resource measures, a farmer's response was cross-checked by the assessor if the resource was accessible. For example, on the Dolakha farms, the measure "access to water" was assessed only via the questionnaire as the chauris were being milked deep inside the forest, whereas, in Rasuwa, the sources of drinking water were visible and accessible.

3. Results

3.1. Survey Results

Of the 120 Nepalese experts invited to complete the survey, 83 (69%) responded. Table 1 lists the measures included in the survey. Of the fifteen suggested animal-based measures, only five were selected by more than 50% of the respondents (i.e., >41/83) (see Table 1). For the resource-based measures, the equivalent figures were 4/8 and, for the record-based measures, 4/6. Neither of the management-related measures were selected.

A total of 15 different additional measures were suggested by the local experts (see Table 2). The most suggested measure was the assessment of hoof condition/foot lesions, but even this measure was suggested only by 5/83 respondents. After the authors' discussion, the measurement of the complete blood count was added to the list of welfare measures. Therefore, the feasibility study included a total of 14 measures.

Table 2. Additional welfare measures suggested by the survey respondents.

Suggested Animal-Based Measures (n)	Suggested Non-Animal-Based Measures (n)
Wound score and size (1)	Stocking density (1)
Complete blood count (2)	Amount of concentrate/day (2)
Blood parasites (1)	Milk production (1)
Mineral status (1)	Separate walking route (2)
Hydration status (2)	Recent change in productivity (2)
Hoof condition/foot lesions (5)	Breeding record (2)
Ectoparasites (1)	
Limb swellings (1)	
Body weight (2)	

n = number of respondents suggesting the measure.

3.2. Feasibility Study Results

The locations of the selected herds within Nepal are shown in Figure 1, and their demographics are summarized in Table 3. In our study, the herds in Dolakha were at an altitude range around 2800–2900 m, whereas the herds in Rasuwa were at an altitude around 2200 m.

Figure 1. Map showing the locations within Nepal of the farms where the welfare of chauris was assessed.

Table 3. Herd demographic information and number of samples collected per herd.

	Dolakha			Rasuwa	
	Herd 1	**Herd 2**	**Herd 3**	**Herd 4**	**Herd 5**
Herd size	18	20	20	14	16
Milking herd size	7	12	9	5	5
Mastitis check	7	8	4	5	5
Fecal collection	7	7	6	5	5
Blood sample	5	5	5	4	4

3.2.1. Animal-Based Measures

In Dolakha, the herds were mixed, including Urang and Dimjo specimens, whereas, in Rasuwa, the chauris were all of the Urang type. In all the herds assessed, there were no chauris with poor body conditions (i.e., score ≤ 3.5), skin injuries, or poor locomotion scores (score > 1).

The number of samples collected for the fecal examination, the mastitis test, and hematology are shown in Table 3. On the two Rasuwa farms, all the samples were collected from all the animals used for milking, whereas, in Dolakha, this was not possible (see Table 3). In addition, across the three Dolakha farms, we were unable to sample ≥50% of the milking herd members for mastitis on one farm (Herd 3) and for hematology on another (Herd 2).

3.2.2. Mastitis Testing

Across the five herds, 29/38 animals were tested for subclinical mastitis. None of the tested chauri had a CMT > 1, although five (three in Dolakha and two in Rasuwa), had a score of 1 (all in just one quarter).

3.2.3. Parasite Prevalence

Of the 20 fecal samples collected from the chauris used for milking in Dolakha, 12 were positive for gut parasites (giving a prevalence of 60%), whereas all the fecal samples from the two herds in Rasuwa were positive (see Appendix C), giving a prevalence of 100%.

3.2.4. Hematology

The mean and approximate 95% prediction limits (mean ± two standard deviations) of the results from the ProCyte Dx Hematology analyzer are presented in Table 4. As far as the authors are aware, there have been no published full hematology analyses carried out on chauris, so our results are presented alongside equivalent results from four previous studies in yaks and reference data from cattle obtained using a similar hematology analyzer [28]. The data from these previous yak studies are too limited for a statistical comparison, but, except for the total leucocyte count and the hemoglobin concentration, the mean values from the current study are within the range of the mean results found in yaks (the approximate prediction intervals are appreciably different in many cases, but this is likely to be related to the small size of the yak studies cited in Table 4). Compared to the reference data in cattle, there were marked differences in our results, with many of the mean values observed in the current study being close to or outside the reference limits identified by Herman et al. [28].

Table 4. Hematological values obtained in the study and their comparison with previous studies on yaks and reference data from cattle obtained using a similar analyzer.

	Current (n = 23)	**Yak[1] (n = 7)**	**Yak[2] (n = 7)**	**Yak[3] (n = 7)**	**Yak[4] (n = 6)**	**Cow[5] (n = 152)**
Measure	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**
Red blood cells (10^{12}/L)	4.9 (3–6.8)	6.4 (4.6–8.2)	4.7 (3.6–5.8)	6.9 (3–10.9)	7.6 (0–16.3)	6.2 (4.7–7.7)
Hemoglobin (g/L)	106 (66–146)	137 (103–171)	111 (85–138)	111 (101–121)	120 (51–188)	106 (80–132)
Hematocrit (%)	28.2 (15.7–40.6)	38 (30–46)	27.2 (20.6–33.9)	35.7 (29.3–42)	N/A	30 (20–40)
Mean corpuscular volume (fl)	57.8 (43.2–72.4)	N/A	58.2 (44.7–71.8)	52.2 (33.2–71.2)	N/A	50 (41.4–58.6)
Mean corpuscular hemoglobin (pg)	22 (15.4–28.8)	N/A	23.7 (19.4–28)	16.4 (7.5–25.3)	N/A	17.1 (14.3–19.9)
MCHC (g/L)	384 (275–492)	N/A	408 (359–458)	313 (250–376)	N/A	343 (324.4–361.6)
Total leucocyte count (10^9/L)	10.5 (1.8–19.4)	6.6 (4.2–9)	9.7 (6–13.4)	7.1 (4.7–9.5)	6.7 (4.5–8.9)	7.2 (4–10.4)
Neutrophil (%)	27.7 (9–48.6)	42 (18–66)	31.8 (18–45.7)	27.8 (24.4–31.1)	29.2 (2.7–55.7)	2.7 (0.5–4.9)
Lymphocyte (%)	62.3 (33.7–90.7)	46 (26–66)	52.1 (40.8–63.4)	60 (55.2–64.8)	60.7 (36.2–85.2)	3.1 (1.5–4.7)
Monocyte (%)	3.7 (0–5.7)	N/A	6.9 (0–14.1)	1.3 (0–3.8)	3.8 (0–8.6)	0.6 (0.2–1)

Table 4. *Cont.*

	Current (n = 23)	Yak[1] (n = 7)	Yak[2] (n = 7)	Yak[3] (n = 7)	Yak[4] (n = 6)	Cow[5] (n = 152)
Measure	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**	**Mean (95% PI)**
Eosinophil (%)	9.4 (1–17.3)	N/A	8.2 (0–16.4)	10.5 (2.3–18.7)	6 (0–14.7)	0.7 (0–1.7)
Basophil (%)	0.8 (0–1.6)	N/A	0.4 (0–1.2)	0.5 (0–2)	N/A	0.1 (0.1–0.1)
Platelets (K/μL)	101.5 (42–160.8)	N/A	N/A	N/A	N/A	N/A

Yak[1]: [29]; Yak[2]: [30]; Yak[3]: [31]; Yak[4]: [32]; Cow[5]: [28]; and 95% PI: approximate 95% prediction interval calculated as the mean ± 2SD.

4. Resource- and Record-Based Measures

The assessment of the resource-based measures showed that there were significant issues in all the herds (See Table 5). The herds in Dolakha were situated deep within the forest, which provided some protection from heat, wind, rain, and snow. In contrast, the herds in Rasuwa were situated in an open area, making them more vulnerable to such weather events. However, none of the herds, regardless of their location, had access to proper shelters that could safeguard them from the adverse effects of extreme weather conditions.

Table 5. Summary of the welfare assessment outcomes for resource- and record-based measures on transhumance chauris from five herds.

	Dolakha			Rasuwa	
Measures	**Herd 1**	**Herd 2**	**Herd 3**	**Herd 1**	**Herd 2**
Access to drinking water in the pasture	No	No	No	No	No
Availability of sufficient forage	No	No	No	No	No
Availability of veterinary services	Poor	Poor	Poor	Poor	Poor
Protection from extreme climate	Forest	Forest	Forest	None	None
Proportion of deaths per year (any cause) (%)	17	15	10	21	13
Proportion of deaths per year (accidents: for instance, falling from the tracks and cliffs) (%)	11	5	5	7	0
Proportion of deaths per year (natural calamities and weather related: for instance, landslide, flood, hailstone, and thunderstorm) (%)	0	0	0	0	0
Satisfied with current veterinary support?	No	Do not want	No	No	No

In both districts, the farmers reported that the availability of veterinary services was poor as the veterinary facilities (hospital and manpower) were concentrated in the district headquarters. Four out of the five respondents stated that they were not satisfied with their current veterinary support, with the fifth responder stating that they did not want such a support. The farmers reported that 10–21% of their chauris died every year (See Table 5), although no deaths were reportedly due to extreme weather or, despite all of them having reported a lack of sufficient forage, starvation.

5. Discussion

The aim of this study was to select potentially useful welfare measures that could be applied in the time-limited welfare assessment of hybrid yaks (chauris) and then test their feasibility and applicability in transhumance chauri herds in Nepal.

The process through which we were able to achieve this included several challenges. The most important of these was the limited information available related to the welfare of yaks. We, thus, took a mixed approach towards identifying suitable welfare assessment measures, combining measures from the limited literature on yak welfare with measures used in a similar program in pasture-based dairy farms [4], along with the authors' knowledge of yak/chauri farming. We then consulted with local Nepalese experts to identify which of our suggested measures they thought were appropriate for the assessment of yaks raised in a transhumance system.

Our approach to expert consultation was a simplified single-stage process, differing from the Delphi process, which employs multiple stages to achieve consensus, both at an overall and an individual measure level [33]. In addition, unlike the approach taken by Whay et al. [34], we did not ask our experts to rank the measures based on their perceived importance but just to select potentially suitable welfare measures from a list alongside suggesting some additional measures. We used this simplified approach because we had limited time for the consultation and because our principal aim was to feasibility test a limited protocol. This also meant that we only chose measures for which there was >50% support from our experts.

This selection process resulted in a limited set of measures. Compared to the dairy protocol developed for New Zealand, which had 32 measures, and Dorji et al.'s [12], which had 18 measures, we only had 14 measures in our yak/chauri protocol. This meant that the protocol was achievable within the time limits set (milking time) but limited the comprehensiveness of the welfare assessment carried out (especially of resources) compared to the system applied in New Zealand. One key difference between our dairy protocol and our yak/chauri protocol was the inclusion of animal-based sampling (milk, feces, and blood) in the latter. This added considerably to the time, which meant that, although the herd size in our study was very small compared to that in New Zealand, the assessment time was similar. Approximately half of the assessment time was taken up by blood sampling, mainly due to the poor handling facilities available. Nevertheless, we believe that the animal-based sampling of milk, feces, and blood is likely to be extremely useful to yak/chauri herds as a form of regular health checkups for animals who have very limited access to veterinary services, providing useful information on general animal health and treatment opportunities.

Traditional herding practices limit the ease of undertaking a welfare assessment, with chauris being milked early in the day and returned to their pastures before dawn (and milking being completed before 6:30 am when temperatures begin to increase). This constraint is similar to that observed in New Zealand in farms that milk cattle once a day, with most of these farms carrying out milking early in the morning to avoid the heat of the day. However, the additional challenge for yaks/chauris is that the location of these herds is often a significant distance away from infrastructures. For example, in Dolakha, the herds were camped on the grassland patches deep inside the forest, which meant that it required farmers a 30–40 min walk to reach the herd from the road (in the dark). The welfare assessment could be carried out during the afternoon milking process, when the time pressure to set the chauris free and back to the pasture is less pronounced, but this creates logistical problems for the laboratory testing of the samples, especially for the hematology assessment. Sampling in the afternoon means that the blood samples have to be stored and kept cool overnight, as reaching even local laboratories on the same day before they close is unlikely to be possible. An alternative to travelling in the early morning would be for the welfare assessor to stay the night with the herd so that assessment could be completed relatively easily during the morning milking process.

The farmers in our study were concerned about the assessment interrupting their daily routine. Webster [35] stated that welfare assessment measures and processes should be as non-intrusive as possible. Our process aligned with this suggestion, as our assessment started with the least intrusive animal-based measures, such as the observation for injuries. However, our sampling did interfere with their routine, even though we left the most intrusive sampling procedure (i.e., blood) until after milking had been completed. The initial attempt was to obtain as many samples as possible (at least 50% of the milking herd members). However, the lack of handling facilities prolonged the sample collection process, which resulted in the owners, especially in Dolakha, being worried about our assessment disrupting the normal daily routine of the animals, particularly in terms of them returning to the pasture. Further feasibility testing and working with herders is required to establish how we can sample at least 50% of the milking herd without concerns about disrupting their daily routine.

This was a small-scale feasibility study with only five farms being assessed at a time of year that had not been chosen based on the likely presence of welfare issues, so it is important not to over-interpret the findings. For example, all the chauris observed on all five farms were found to be in good conditions. It is likely that this is because they had just come down from their high-altitude summer pastures, which generally have reasonable quantities of nutritious grass and herbs. A more appropriate time to assess the BCS would be in late winter to early spring (February to April), when the animals' body condition is typically poorer due to feed scarcity over the winter [11,36]. This timing presents an opportunity to evaluate their susceptibility to ailments due to reduced immunity [30,37] while also allowing for easier access to the herds [30].

We found no evidence of clinical lameness in any of the chauris. This is consistent with the findings of Dorji et al. [12], who reported a lameness prevalence of 0.5% in female yaks, but needs further confirmation in more chauri herds, especially in those which use shelters. This is likely because female yaks in milking herds do not walk long distances on a routine basis, unlike the male yaks used in transporting goods to local towns and tourist destinations.

The assessment of mastitis by means of visual examinations combined with the California Mastitis Test (see Table 1) revealed that none of the chauris assessed had mastitis. This was not an unexpected result because yaks and their hybrids traditionally have a lower incidence of mastitis compared to cattle [38]; however, a recent study by Biswas et al. [39] identified subclinical mastitis in 16% of the quarters of a yak herd. The significant impact of mastitis on milk quality and safety combined with the importance of milk and its products to yak herders [39] suggests that the benefits of testing for mastitis when there are issues may more than justify the high proportion of tests during which no problems are identified.

Endoparasites are known to be a significant and increasing problem in yaks and chauris [11]. Our testing identified a high proportion of positive fecal samples and so supports the above conclusion. It would have been better if we could have performed a quantitative parasitological test (eggs per gram) to determine the severity of the infection; however, the qualitative assessment of fecal samples is the common standard approach of the laboratory to which we sent our samples. Our data strongly suggest that we need more quantitative data to better understand the endoparasite burdens in yaks and chauris.

This is, as far as the authors are aware, the first published report on hematology data in chauris. Our hematology data show that chauris' hematology is much more similar to that of yaks than to that of cattle. Unfortunately, as Table 4 shows, hematological studies on yaks are very limited, so we lack data to properly use hematology to monitor and identify health problems in both chauris and yaks. We need more baseline data that take into account season and altitude as well as chauri type. Barsila et al. [9] showed that hemoglobin concentrations in chauris and yaks change with altitude and with the time spent at that altitude and that the Dimjo chauris in their study had higher hemoglobin levels than the Urang chauris. Furthermore, the analyzer we used has not been validated for either yaks or chauris. Our data show that the differences between chauris and cattle are large enough to require specific validation..

Our resource assessment relied on subjective evaluations and questionnaires, limiting the scope of our investigation. However, we included key resource-based measures. Our findings indicated inadequate access to water, pasture, and veterinary services across all the herds. In transhumant systems, these resources fluctuate with seasonal movements. During our assessment, as the chauris descended to lower altitudes in preparation for winter, we noted a decrease in pasture abundance and natural water sources compared to the summer levels. Addressing these resource deficits is crucial for maintaining chauri welfare, particularly in terms of supplying alternative sources of water and feed. Proximity to local towns during chauris' descent did not significantly improve the access to veterinary services as the available services were still inadequate.

The record-based measures in our study, such as an annual herd mortality rate of at least 10%, reflected poor welfare conditions. However, these records, primarily based on the farmers' recollections, may be biased and also include deaths from non-welfare-related causes like leopard attacks, highlighting the challenges in accurate welfare assessments in natural settings.

6. Conclusions

Overall, the 15 welfare measures selected endorsed by Nepalese experts provided some useful information on yak welfare, and the protocol was feasible to carry out as a single time-limited welfare assessment, at least in lowland pastures. However, the protocol needs to be tested at different altitudes of the transhumance journey, across different points in time, before it can be recommended as a convenient welfare assessment tool in yaks/yak hybrids.

In the small sample assessed, animal-based measures such as BCS, injury, lameness, and mastitis were satisfactory at the time of assessment. However, parasitic infestation was a welfare concern in all the herds assessed. It was clear that yak farmers are in need of better and more accessible veterinary services. The feasibility of providing mobile veterinary services with regular health checkup camps should be investigated, as should the provision of alternative winter-feeding strategies and pasture reseeding. Yaks are particularly sensitive to climate change's effects, especially wildfires in their pastures and forests, so addressing climate change is likely to improve yak welfare (though it will take a global effort to achieve this rather than a purely local one).

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Data Availability Statement: All data generated and analyzed during this study are included in this published article.

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Appendix A

Questionnaire survey on the selection of suitable welfare assessment measures for a single-visit welfare assessment of yaks reared under the transhumance system.

Name:. . .. . Job position:. . .. .
Experience(in Years):. . .. .
Questions:
1. In your opinion, which of the following animal-based measures should be selected for a single-visit welfare assessment of yaks/chauris reared under a transhumance system? (Note: you can select multiple options)
1. Body condition score
2. Rumen fill score
3. Skin injury/swellings
4. Ocular discharge
5. Nasal discharge
6. Coughing
7. Mastitis
8. Gait condition
9. Parasitic infestation
10. Diarrhea
11. Avoidance distance
12. Agonistic behavior
13. Positive behavior (allogrooming, rubbing/scratching, playing, self-licking, tail wagging)
14. Body cleanliness
15. Broken tails
2. In your opinion, which of the following resource- and stockpersonship-based measures should be selected for a single-visit welfare assessment of yaks reared under a transhumance system? (Note: you can select multiple options)
1. Access to drinking water in the pasture
2. Cleanliness of waterpoints
3. Availability of sufficient forage at the pasture
4. Distance between grazing pastures
5. Protection from extreme climatic events like rainfall, hailstorm, heat, and cold.
6. Availability of bridges
7. Availability of veterinary services
8. Tracks/Terrain Conditions
9. Stockperson handling (stockpersonship-based measure)
3. In your opinion, which of the following record-based measures (farmers' estimates) should be selected for a single-visit welfare assessment of yaks reared under a transhumance system? (Note: you can select multiple options)
1. Number of yaks that die in a herd per year.
2. Number of yaks that die due to diseases and plant poisonings.
3. Number of yaks that die from extreme weather events/natural calamities (landslide, flood, hailstone, thunderstorm) and accidents (falling from the tracks and cliffs).
4. Number of mastitis cases per year.
5. Do you vaccinate your yaks?
4. Are you satisfied with the veterinary facilities?...
5. Any training on yak farming?..
6. Any animal-based measures you would like to add which are not in the list?..............

7.	Any resource-based measures you would like to add which are not in the list?............
8.	Any management-based measures you would like to add which are not in the list?...............
Questionnaire interview:	
1.	Do you have a provision/source of drinking water within 500m of the milking site?
2.	Do you have a provision of shade/shelter for protection against extreme climatic events like rainfall, hailstorm, heat, and cold?
3.	Do you have a veterinary hospital/treatment center nearby?
4.	Do you have sufficient availability of forage at the pasture?
5.	Proportion of yaks that die in a herd per year (any cause) ………………………………………………………………………………
6.	Proportion of yaks that die in a herd per year (extreme weather events and accidents) …………………………………………………
7.	Proportion of yaks that die in a herd per year (diseases and plant poisoning) ………………………………………………………....
8.	Are you satisfied with the government veterinary facilities (timely accessibility of veterinarians or veterinary technicians and availability of medicine and vaccinations, when needed)?

Appendix B

Summary of rapid on-field test (California Mastitis Test) of mastitis in five chauri herds in the Dolakha and Rasuwa district.

Mastitis Rapid Test						
			Quarters			
Place	**S.N.**	**Herd**	**FR**	**FL**	**BR**	**BL**
D	1	1	0	0	0	0
D	2	1	0	0	0	0
D	3	1	0	1	0	0
D	4	1	0	0	0	0
D	5	1	0	0	0	1
D	6	1	0	0	0	0
D	7	1	0	0	0	0
D	8	2	0	0	0	0
D	9	2	0	0	0	0
D	10	2	0	0	0	0
D	11	2	0	0	0	0
D	12	2	0	0	0	0
D	13	2	0	0	0	0
D	14	2	0	0	0	0
D	15	2	0	0	0	0
D	16	3	0	0	0	0
D	17	3	0	0	0	0
D	18	3	0	0	0	0
D	19	3	0	0	0	0

Mastitis Rapid Test						
			Quarters			
Place	S.N.	Herd	FR	FL	BR	BL
R	20	1	0	0	0	0
R	21	1	0	1	0	0
R	22	1	0	0	0	0
R	23	1	0	0	0	0
R	24	1	0	0	0	0
R	25	2	0	0	0	0
R	26	2	1	0	0	0
R	27	2	0	0	0	0
R	28	2	0	0	1	0
R	29	2	0	0	0	0

Appendix C

Summary of fecal examination using the floatation method for determining the presence/absence of parasites in chauris.

S.N.	District	Herds	Result	Parasites
1	Dolakha	1	p	strongyle
2	Dolakha	1	p	strongyle
3	Dolakha	1	n	
4	Dolakha	1	n	
5	Dolakha	1	p	strongyle
6	Dolakha	1	n	
7	Dolakha	1	p	strongyle
8	Dolakha	2	n	strongyle
9	Dolakha	2	n	
10	Dolakha	2	p	trichuris
11	Dolakha	2	p	trichuris
12	Dolakha	2	n	
13	Dolakha	2	n	
14	Dolakha	2	p	trichuris
15	Dolakha	3	p	strongyle
16	Dolakha	3	n	
17	Dolakha	3	p	strongyle
18	Dolakha	3	p	trichuris
19	Dolakha	3	n	
20	Dolakha	3	p	stongyle
21	Rasuwa	1	p	Moneiza, tricostrongylus
22	Rasuwa	1	p	Monizia
23	Rasuwa	1	p	Trichostongylus

S.N.	District	Herds	Result	Parasites
24	Rasuwa	1	p	strongyle
25	Rasuwa	1	p	Monizia
26	Rasuwa	2	p	Monizia + strongylus
27	Rasuwa	2	p	strongyloid
28	Rasuwa	2	p	Monoiza
29	Rasuwa	2	p	Trichostongylus
30	Rasuwa	2	p	Monizia

Note: p means positive for parasites; n means no presence of parasites.

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