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ORIGINAL ARTICLE

The welfare and access to veterinary health services of mules working the mountain trails in the Gorkha region, Nepal

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ABSTRACT. Working equid populations are mainly present in low to middle-income countries, their work directly contributing to the lives of people reliant on their presence. Although assistance from working equids is important to support people and their communities in these regions, their welfare is often poor. This study aims to provide insight into the welfare status of mules distributing supplies in the Gorkha region of Nepal; a population of working equids which has been largely overlooked and under recorded. The welfare of mules was assessed via the Equid Assessment Research and Scoping (EARS) tool using a trained assessor; livelihood surveys gathered basic demographic and ownership information; and semi-structured interviews gained the perspectives of 26 key informants. Mule body condition was found to be ideal in many cases, but their management was in the majority of cases inappropriate; characterised by integumentary trauma from equipment use and inhumane handling, unsuitable dietary provision, and insufficient access to water. This difficult situation was compounded by inadequate access to suitably qualified, experienced veterinary professionals able to offer appropriate levels of support. Organisations aiming to improve welfare in these remote locations need a multifaceted approach where owners are facilitated and empowered to improve the welfare of their own equids; in addition, industry professionals are encouraged to improve training and provision within veterinary services.

Keywords: working equids, equid welfare, EARS, veterinary services, welfare assessment, equid behaviour, diet, harnessing equipment.

INTRODUCTION

This prospective study will document the welfare of mules distributing supplies along the mountain trails of the Gorkha region of Nepal; an under recorded mule population and environment. Using a combination of qualitative and quantitative data collection the welfare issues around working mule management including diet, access to water, harness equipment, behaviour and owner access to veterinary services will be investigated.

Throughout history, equids have been used for work alongside people. Though the industrial revolution overcame their usefulness in most higher income countries as mechanisation took over (Alves, 2018; Heinberg, 2006), their importance in low- to middle-income countries (LMIC) has persisted. The global equid population is estimated to be approximately 112 million (FAO, 2019; Norris *et al.*, 2021), of which around 43% can be found in Asia (Mitra & Valette, 2017). Working equids continue to be an economic necessity for the poor communities they support in LMIC (Alves, 2018), though they are now in decline in some areas where people can afford to give mechanisation precedence (Starkey, 2010).

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There is heavy reliance on working equids within remote, hard to access mountain communities (Rodrigues *et al.*, 2017), where they contribute to food security, income, traction, transport, sustainable agriculture, employment, and social status (Bettencourt *et al.*, 2015; Brooke, 2021). Though there are many positive benefits of animal ownership it does not come without risks; the transmission of zoonotic diseases in the absence of adequate animal and human health programmes (Bettencourt *et al.*, 2015), lack of owner awareness and lack of access to basic services increases risk of harm from disease transmission (Stringer, 2014). Many of the world's poorest people live in remote rural communities (FAO, 2022) and a lack of access to resources can have a real impact on the health and welfare of domestic animals (Letsoalo *et al.*, 2000; Wild *et al.*, 2021), people, on the wider environment and wildlife (Pinillos *et al.*, 2016).

Animal Nepal (AN), a non-governmental organisation (NGO) aiming to improve animal welfare throughout Nepal, has been operating in the Gorkha district since 2016 offering owners free advice, vaccinations and treatments for their working mules. Despite their presence, the prevalence of injuries, wounds and disease continues to pose a serious threat to mule health and welfare (AN, 2016). To understand the scale of the challenges facing working equids operating in this region this study utilised previously evaluated methodology (Kubasiewicz *et al.*, 2022; Nye *et al.*, 2021; Watson *et al.*, 2020). The Equid Assessment Research and Scoping (EARS) tool (Raw *et al.*, 2020) is used to assess welfare, livelihood surveys gather demographic information, and semi-structured interviews gain insight into owner perspectives about the management, health and care of their mules.

MATERIALS AND METHODS

We used a mixed methods approach based around semi-structured interviews (SSIs), livelihood surveys, and equid welfare assessments using the EARS tool (Raw *et al.*, 2020). Prior to each interview, livelihoods surveys gathered basic data from participants regarding both their own demographics and mule ownership or handling. All interviews and assessments with owners were undertaken whilst owners and equids were at rest. The sites varied but most were in communal areas within village boundaries while a few were conducted in owner's yards.

STUDY SITE AND ACCESS

Fieldwork was conducted 12th November to 25th November 2018 in Gorkha, Nepal. This region was chosen due to its proximity to Kathmandu where a partner organisation, Animal Nepal (AN), is located. AN provided logistical support, working knowledge of the study area and interpreters able to communicate in local dialects and who were also fluent in English.

The Gorkha study sites comprised the communities of Arkhet Bazar, Soti Khola, Maccha Khola, and Tatopani. Gorkha is a region characterized by mountains and steep sided inter-mountain valleys, where subsistence farming takes place alongside hospitality businesses supporting the mountain tourism trade. Most villages were accessible only on foot, with the exception of Arkhet Bazar and Soti Khola, although the types of vehicles that could access these villages were limited to off-road vehicles and some trucks/ buses (excluding livestock vehicles).

PARTICIPANT RECRUITMENT

Participants, both human and mule, were secured in some locations whilst attending veterinary intervention clinics organised by AN, whilst others further up the trails had to be sought on an *ad hoc* basis within each village environment. There were no time limits for our interactions with people and mules, though owners/ drivers did sometimes have to leave for work. All interviews were conducted with individual owners/ drivers apart from one mule owner/ driver group who were interviewed together. Participation was voluntary and unpaid, inclusion criteria being that a person was a mule owner, driver or trader and over 18 years old. Consent was obtained verbally and audio-recorded.

Human population density in the region is very low; the number of mule owners/ drivers was thus limited. This created opportunity for longer interviews, where participants' availability permitted.

DATA COLLECTION

Quantitative data – livelihood surveys. Each survey was recorded electronically on a digital device using an Open Data Kit (ODK) Collect (Hartung *et al.*, 2010) form containing pre-set questions (see supplementary materials). Questions recorded demographic information such as age, gender, ethnic group, religion, job role and income, and details about mule ownership. Data were uploaded to a UK based server when reconnected to the internet. The survey formed part of a comprehensive survey for use in a wider project but for the purposes of this article basic demographics of age, gender, job role and the main issues that concerned owners about their mule health and welfare are included.

Quantitative data – EARS assessments. Welfare assessments were conducted by one trained assessor (TW) on a total of 166 mules (geldings = 156, stallions = 10), belonging to 17 owners following the scoping protocol for the EARS tool. For full guidelines on the EARS scoping methodology see Raw *et al.* (2020). Not all sections of EARS were used but are part of a wider study; the sections of EARS pertinent to this study have been added to supplementary materials.

Due to the nature of the field study locations some mule owners removed their animals for work before assessments could be undertaken, and a group of mule owners were interviewed after work without their animals present; so, assessments were not completed for the equids of all owners. Body condition was scored using a scoring system developed specifically for donkeys (Thiemann *et al.*, 2018), where 1 = poor (very thin), 2 = moderate (underweight), 3 = ideal, 4 = overweight (fat), 5 = obese (very fat). There are currently no body condition scoring systems developed specifically for mule assessment, the donkey body condition scoring system has been found to be sufficiently accurate for use until a system is designed for mule assessment (Burden, 2012). Where possible, welfare assessments were performed whilst interviews were taking place. Data were inputted into an ODK Collect (Hartung *et al.*, 2010) form on a digital device (phone or tablet). ODK Collect is a data collection app, used to gather raw data in a convenient way onto any digital device. Data was transferred to the UK server once the equipment reached an internet connection.

Quantitative data were uploaded to the software package R version 4.1.3. (RCoreTeam, 2022). Data were explored using Tidyverse, which enables data visualisation and the plotting of graphs (RCoreTeam, 2022; Wickham, 2021). We present the results as a percentage of the total number of people that answered that questions, and percentage of mules that were assessed and presenting for each particular aspect of EARS.

Qualitative data – semi-structured interviews. Semi-structured interviews (SSIs) were conducted by TW and LMK, and lasted between 20 – 54 minutes with twenty-four mule owners/ drivers including one mule trader, and two veterinary technicians; interview length was dependent on the availability of owners. SSIs gave scope for richer data capture of the personal experiences of those working

with mules. Core questions (see supplementary materials) based on pre-determined themes formed the initial basis of interviews, but as owners relaxed and spoke freely unexpected themes emerged inductively. Participants were allocated a code to ensure all data were anonymised. SSIs were conducted in Nepalese via Nepalese interpreters from AN, from questions given in English by LMK and TW. They were recorded by Dictaphone and translated during the recordings. Qualitative data were uploaded and analysed using the software package Nvivo (Nvivo 12 qualitative data analysis software, V.12.5.0, QSR International). During coding, although some themes were predetermined, an iterative inductive approach allowed analysis and identification of new emerging themes; saturation was reached when no new codes were being generated. For this article themes concerning mule welfare, access to veterinary services, and behaviour were included.

RESULTS

LIVELIHOOD SURVEYS

Twenty out of the 24 equid owning participants (83%), including one mule trader, expressed their primary job role as being a mule owner; the remaining four (17%) expressed their primary job role as hotel or shop owner, these four relied upon mule drivers to handle their equids.

Length of ownership varied from 1 year to 20 years, with the mean being 8.4 years. Twenty one percent (n=5) of mule owners were female. The largest cohort of mule owners 67% (n=16) were in the age range 30-50 years old, 25% (n=6) were 18-30 and 8% (n=2) were over 50 years old.

Owners reported that colic 28% (n=6), nasal discharge 24% (n=5), trypanosomosis 24% (n=5), lameness 19% (n=4), and tetanus 5% (n=1) were the main concerns affecting their mule health and welfare.

EARS WELFARE ASSESSMENTS AND QUALITATIVE DATA

All of the assessed equids were mules, there were no other equid species observed in this region whilst undertaking the study. Mules were assessed during their rest periods either before or after work. The primary role of all the mules was as a pack animal carrying goods for distribution to households and businesses along the trails as part of mule trains handled by either their owner or a hired driver. Mules were used to transport goods which were too heavy for people to carry such as bags of rice or oil, and building supplies including bags of sand and cement, and reinforcing rods (to make houses more resistant to earthquakes). Inhabitants did not own a mule for any reasons other than work, and all those without mules relied on mule trains to distribute heavier or bulky goods which were difficult to transport on foot.

BEHAVIOUR

Equids were afforded some degree of social contact; while at rest mules were tethered to a long rope line connecting a group of familiar equids at intervals along its length, each group belonging to an individual owner. Equids were able to touch their immediate companions and some were able to mutual groom. Five percent (n=3) showed minimal injuries which seemed to be of equid origin e.g., bites on neck and face. Some owners did recognise that their mules bonded or had particular companions they preferred to work alongside which would help the stability of the group when managing them.

> […] but in the morning when he saw he was dead [a mule] and there was another mule which was his partner, his partner was always walking with him, he can't walk without him and now he gets lost. (Mule owner)

Counter to this we observed the mule trader separating bonded companions for sale and, despite any mules being separated exhibiting stressed behaviour (becoming highly mobile, straining at their tethers and vocalising), the mule trader continued keeping bonded mules apart.

Mules were assessed for behavioural responses; 49% (n= 81) were either aggressive, head shy, showed the whites of their eyes, and/or showed startle/ unpredictable responses to assessor approach; 51% (n=85) were friendly on initial approach, though 4% (n= 6) of these then showed unpredictable or sudden movements whilst being assessed. There was some relationship between body condition and behaviour; mules showing ideal body condition exhibiting positive relaxed behaviours compared to those with thin/ moderate or very thin/ poor condition (Figure 1). Of the 2% (n =3) equids exhibiting apathetic behaviour, all showed other signs of ill health having open wounds, nasal and eye discharge; one mule was in particularly poor health being expected to continue working with a broken hind leg and wounds infested with flies; particularly warble flies. One mule, on closer inspection by a veterinary surgeon, was suspected to be suffering from glanders.

AGE OF MULES

Over half the mules (54% n=88) could not be aged due to their aversive or aggressive behaviour or being removed by the owner before being assessed. Of those that could be assessed 44% (n=34) were over five years old, 24% (n=19) were over three years old but under five years old, and 31% (n=24) were over one but under three years old. Only one animal assessed was over 20 years old.

INTEGUMENTARY TRAUMA

Eight percent (n=14) of mules could not be assessed for integumentary trauma either due to aversive behaviour or

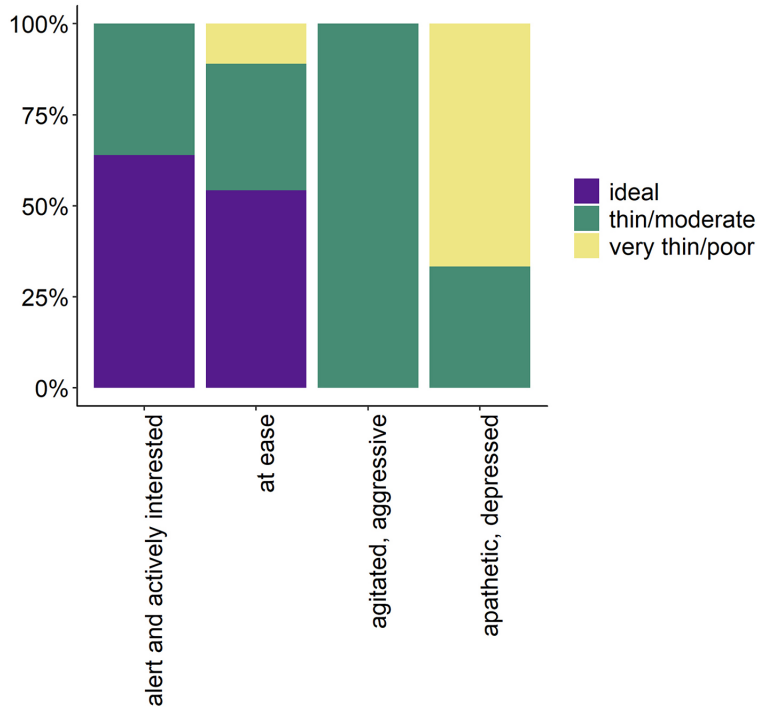

Figure 1. Proportion of mules (n=166) according to their body condition for each behavioural state

because of equipment covering their bodies. Of the 92% (n=152) which could be assessed for skin alterations, 92% (n=140) showed some form of integumentary trauma. All these mules had scars and/or open wounds on the upper midsection of their backs associated with packsaddle placement (Figure 2). Eighteen percent (n=28) had scarring or wounds around the base of their tails from crupper use. Four percent (n=6) of mules which did not have skin alterations in either of these locations had scarring around the pectoral area consistent with breast collar/strap equipment. Two percent of mules (n=3) showed wounds in areas of the body (hindquarters) where mule handlers were seen using stones to drive their mules forwards or change their direction; the injuries were consistent with the use of excessive force (Figure 2). One percent (n=2) had open wounds on the labial commissures of the mouth from ill fitted or poorly designed bits (the metal bar of a bridle inserted in an equids mouth to aid control).

Of the 33 (22%) animals exhibiting open wounds (Table 1), 50% had wounds located in the upper midsections of their bodies. Eighteen percent (n=6) of open wounds were located on the hindquarters, mainly associated with crupper use which is considered an essential harness equipment for pack animals working steep terrain. The integumentary trauma we recorded was highlighted by the local veterinary technician as being an issue of concern.

> I see the wounds in the tail, the back […] It happens because of the tight belt (crupper and girth), taking heavy loads for a long time, they don't get a proper rest, so I think if we do those things like, loosen the belts and clean and see whether the belts are old or not, and get [mules] rested, then I think we can solve that. (Veterinary technician)

Most open wounds (94%) were localised (n=31) with one mule showing diffuse lesions of unknown origin in vertical stripes down all four legs. Seventy eight percent (n=25) of open wounds were of partial thickness, 16% (n=5) were full thickness and 6% (n=2) were superficial. All wounds in the partial and full thickness categories were associated with equipment failure, in fact almost all integumentary trauma was related to pack saddle use (Figure 3). Superficial wounds were associated with self-trauma (3% n=1) or direct injury (3% n=1) from ectoparasites such as flies and leeches.

Table 1. Location of skin alterations – open wounds (n=32) in mules.

Location of wounds	Number of mules	Percentage
Upper Midsection	16	50
Hindquarters	6	19
Lower Midsection	5	16
Front Legs	3	9
Head	2	6
Total	32	100

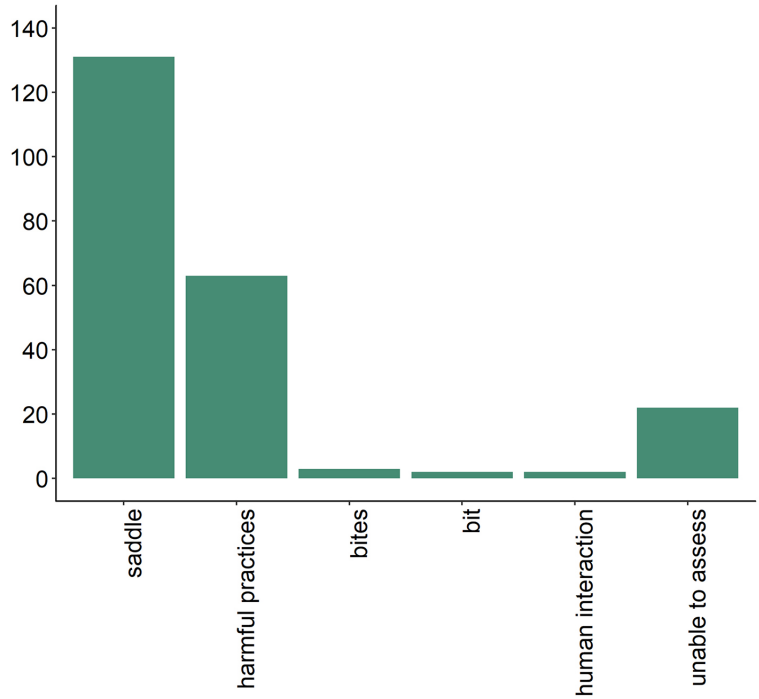

Figure 2. Causes of skin integumentary trauma in 166 mules assessed.

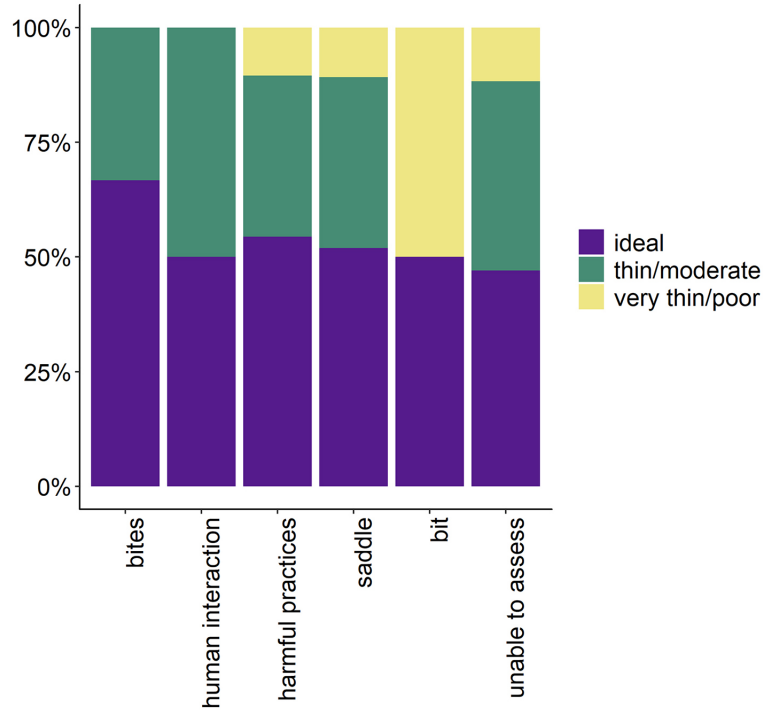

Figure 3. Distribution of mules according to their body condition and cause of wounds.

All mules were subject to tethering whilst not in work – each mule was tied, via a rope attached around one front pastern, at a distinct interval along a rope connecting all the mules owned by each individual owner. Forty percent of mules (n=67) showed skin alterations such as areas lacking hair in the location, and 9% (n=3) had open wounds on the front legs associated with these harmful practices (though one had bleeding legs from leeches). A further 9% (n=3) had wounds associated with insect bites and associated eye rubbing where mules tried to relieve the irritation.

Approximately 50% of mules with wounds for which we were able to determine the cause were of ideal body condition. The majority of the remaining mules **(40%)** were thin/ moderate in all categories, 10% of mules were in very thin/ poor condition (Figure 3).

BODY CONDITION AND DIET

Fifty two percent (n=87) of mules presented with ideal to fair/ lean body condition, 34% (n=56) presented with thin/ moderate, 9% (n=15) were thin/poor, the remaining mules (4% n=7) could not be assessed due to aversive behaviour (Figure 4). Highly calorific, starch-based foods were offered by owners at distinct time intervals, once in the morning and once at night, with no access to forage until late in the afternoon when equids were given a limited opportunity to graze.

There was limited access to water when mules were working, and owners failed to offer mules sufficient water at rest times; despite mules ingesting exclusively dry, cereal-based feed via nosebags, they were not offered water before starting work. After work, mules were tethered and offered water from buckets handed round by owners; mules were not given an opportunity to drink until satiated. Every evening mules were usually tethered by a short rope within the confines of their owner's yard with no free access to water during this time. Throughout the day, access to water was either absent or very limited as mules were continually driven on whilst working or were tethered away from water sources when resting.

In Soti Khola, a mule owner ran a pipe from a stream to a large vessel placed at the exit/ entry point of the village giving access to all mule owners to permit their mules to stop and drink any time they were passing. Despite this opportunity, many owners/ drivers were witnessed driving their mules fast past the water point without allowing them to drink (TDS, field notes, 2018).

HOOF CONDITION AND LAMENESS

Of the 151 mules assessed for lameness, 95% (n=144) showed no apparent lameness. The remaining 5% (n=7) were lame but still working, despite three being severely lame and barely able to bear weight; a score of 5 using the American Association of Equine Practitioners (AAEP) lameness scale where '5: Lameness produces minimal weight bearing in motion and/or at rest or a complete inability to move' (Keegan *et al.*, 2010). Two percent of mules (n=4) had signs of hoof neglect or disease; the rest appeared in good condition.

OTHER SIGNS OF ILLNESS

Though integumentary trauma was very visible and occurred in the majority of mules, during the livelihood surveys when owners were specifically asked what they felt were the main issues with their mules, integumentary trauma was not reported as being an issue. During interviews all owners expressed their stress about losing mules to illness, particularly about the costs of replacement.

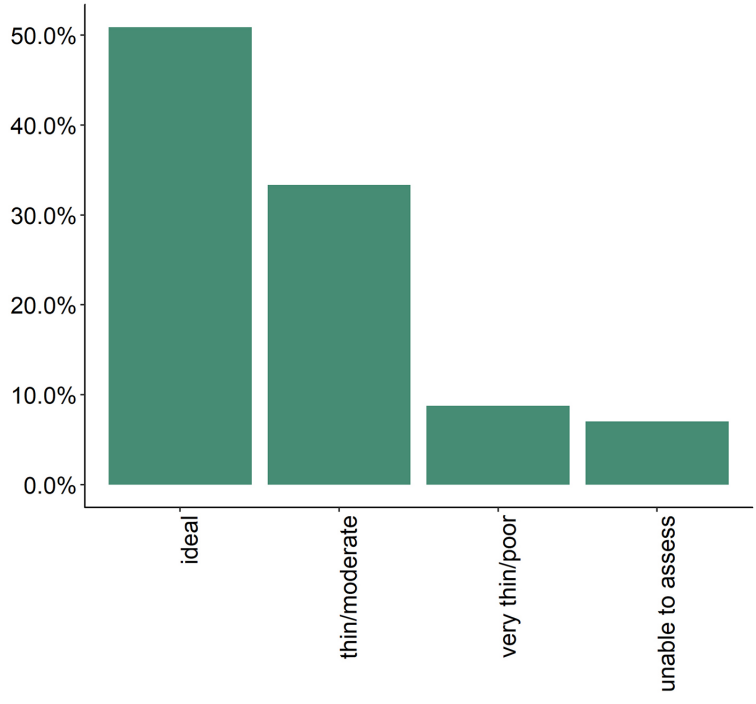

Figure 4. Distribution of the assessed mules (n=166) according to their body condition

> I am worried, we will have lots of tensions [if a mule dies] because one mule costs one Lakh[1] to 85,000 or 95,000 [Nepalese Rupees] so I lose that money [when each mule dies], and when I have lots of tension, I drink. (Mule owner)

They expressed concerns about the dangers of working the mountain trails.

> In the high up hills, there are certain places where the stones fall down continuously […] and the terrain is so slippery that they [the mules] fall down [the steep slopes]. (Mule owner)

One female owner had lost six out of her thirteen mules when she employed a driver to work her mules for her on the routes, the mules mainly died falling on the slopes but others from drinking contaminated water and from heat stroke. She suspected the mule driver was not taking due care of her mules and had been driving them too fast and hard, she had since employed a new driver.

> We have to make him [mule driver] act more responsibly and make him aware of the routes and the walking styles of our mules […] because of his [the mule driver] irresponsibility and lack of understanding [of mule needs] my six mules fell down and died, I did not want to keep him so I replaced him and now he [the new mule driver] is ok. (Mule owner)

During welfare assessments, suspected trypanosomosis (from onsite veterinary assessment but not further diagnostic tests) was the most common cause of illness recorded by the assessor (Table 2). Though not recorded during assessments (as the episodes happened with mules outside of assessments), the AN vet and assessor treated mules suffering from impaction colic with regularity during the field work. Some mules were recorded exhibiting pica of equid dung and soft plastics such as that used for bags and sheeting (TDS, field notes, 2018).

Table 2. Other signs of illness in mules recorded during assessments.

Other signs of illness	Number of Mules	
Trypanosoma	10	37
Nasal Discharge	7	26
Eye discharge	6	22
Infestation of *Oxyuris equi* in limbs	2	7
Blindness (in one eye – mule still at work)	1	2
Glanders (suspected due to enlarged lymph nodes in neck, veterinary checked)	1	2
Total	27	100

VETERINARY SERVICE PROVISION

Though there was some veterinary support given by Animal Nepal, this was largely through occasional but regular field clinics given in Soti Khola. These clinics cannot provide the more routine services which owners caring for animals require on a more frequent, sometimes daily basis, for instance if an animal is sick. Routine veterinary services were being provided by the placement of veterinary technicians at two of the villages in the study area, Soti Khola and Macchkhola. Their service provision was limited to administration of over-the-counter medicines not requiring prescription; having to depend on other input when prescribed medication was required by either calling a qualified veterinarian over the phone for guidance or through the occasional visits by veterinarians via field clinics (with NGOs).

Both technicians had specialised training of 15 months duration which focused on other livestock and companion animals; the equid related training consisted of one week and was given by another organisation in Kathmandu after the main course had ended. Supervision occurred during the training period but once qualified the technicians were expected to operate alone from their posting with only limited support from veterinarians via the telephone.

> I have to do the diagnosis of the disease according to the symptoms and try to find out what should I give and what should I not give, I learned lots of the things from my seniors [veterinarians], according to that I implement that in the field and I try, if I don't get it [understand the symptoms or possibly if the animal does not respond to treatment] I call my seniors and ask, and I then go back out and try to do my best in the field. (Veterinary technician)

Despite this being the case, they did admit to treating animals with drugs requiring prescription, without a veterinarian giving permission.

> Normally - I can't [treat trypanosomosis] without a prescription but I know the signs and symptoms, so I can give the medicine. (Veterinary technician)

The veterinary technicians treated 2-3 mules per day, although they raised concerns that the numbers of mules they were seeing was increasing as the cost of buying mules was decreasing from one Lakh to below 80,000 rupees, sometimes even 50,000 rupees. When asked about the common issues they saw they believed internal parasites

[1] One Lakh or 100,000 Nepalese Rupees is equivalent to approximately 640 GBP/ 800 USD.

were now being treated more regularly by owners because of their advice so they infrequently treated mules suffering from worm burdens; they most regularly dealt with colic, trypanosomosis and glanders. They also raised concerns about equipment failure, rough terrain and inhumane handling practices.

> […] they walk on the rocks so they have joint pain and pain in the feet, and some of the harness are not good so they get the harness wound, and some even get the wound because the small boys throw stones at them to control the animals so I see that type of wound […] I keep on telling them, if the harness is very old I suggest to them to change it and when the harness is not too tight or lose, I suggest to make it lose or make it tight depending on the situation and I treat the wound that happened due to it and I keep on telling the boys don't hit your mules with the stone and they keep on telling me, when I'm angry, I'll do that. (Veterinary technician)

When a mule becomes ill or injured, owners will try to access services in either Macchakhola or Soti Khola, where the two veterinary technicians are based, however, as the veterinary technicians' knowledge is limited often owners will still have to phone a veterinarian for advice, and this adds further challenges as connectivity is not always guaranteed in the mountains.

> As soon as our mules started to get sick, if there is a phone connection, sometimes there is no phone connection, as soon as we receive a connection, then we talk to doctor [vet] and we follow his treatment, but sometimes we have to use our own herbal medicines. (Mule owner)

The lack of veterinarians being physically present was clearly an issue when mules fell ill, but owners also raised concerns about the mule related knowledge and expertise of veterinarians if they did attend to their mules.

> Previously there used to be a doctor [veterinarian] who used to come here and couldn't handle [the mules], and would tell us to handle [the mules], but people from [Animal] Nepal they come there and handle [the mules] themselves, and treat the mules, so we feel like they are the real doctors [veterinarians]. Previous ones are not. (Mule owner)

Both veterinary technicians felt that there was some difficulty in persuading owners to adhere to advice or to give their mules adequate time for recovery after illness.

> I keep telling them, but I don't think lots of them listen to me; if there is a fever and I give medicine to them and in the morning the fever is gone, they take their animals to work, so they don't listen to me – what else can I do? […] I see a lot of them and I feel like the owner thinks they should carry the loads until they can't, that's the difference between the mules and other animals, other animals if they are sick other animals get rest, but mules never get a rest. (Veterinary technician)

Some participants had little or no experience of keeping mules before buying them to start their goods distribution businesses, and guidance on treatments they receive may or may not be good for mule welfare.

> Now at the time, I don't know anything about what is this urinary stop [the mules stop urinating]. Later I came to know [learn what the problem was] after talking with my friends even I know that now they need the medicines which will recover them. (Mule owner)

This particular mule owner lost one group of mules to this issue, all collapsed and died. Sometime after this event his peers explained what treatment should have been administered to his mules to aid their recovery.

DISCUSSION

We present a small but representative sample of the mule populations in this sparsely populated region of Nepal. Mule roles in Ghorka region were quite specific; mules were used purely to distribute goods, and did not include other purposes such as draught power to cultivate, saddle animals for carrying people, or for carrying manure, fertilizers, wood or other household goods, unlike other studies of rural equid use (Arriaga-Jordán *et al.*, 2005; Arriaga-Jordan *et al.*, 2005; Von Keyserlingk, 1999). Most mules were geldings, which fits with the findings of Saez *et al.* (2013) and Tadich *et al.* (2008) where geldings were preferred to mares and stallions due to their ease of handling. Our findings conflict with other studies (Ali *et al.*, 2015; Frohlich *et al.*, 2020; Pritchard *et al.*, 2005) where stallions were most commonly used due to lack of veterinary service provision where castration would pose a significant risk to welfare. Lack of access to veterinary provision is also an issue in the mountains of Nepal, but as all equids are imported from elsewhere there may have been easier access to castration services at point of origin in India and this could explain the prevalence of geldings in our study.

Nearly half the mules had negative responses when interacting with the assessor, which may indicate a lack of experience or indeed a lack of positive experiences when being handled or approached by people. The remaining half were mainly friendly, though some showed some nervousness after the initial response when being more closely interacted with. This reaction is not altogether surprising as mules are prey animals

and survival behaviours may surface when interacting with unfamiliar stimuli or if an equid has either limited or negative associations when interacting with people (Burn *et al.*, 2010; Hausberger *et al.*, 2008). Most mules had some form of integumentary trauma which could still be causing discomfort or have been painful previously, the association of pain with being harnessed and handled would increase the potential of mules reacting negatively or aversively, escalating adverse owner handling which would exacerbate mule fear responses (Pritchard *et al.*, 2005). There seemed to be some relationship between body condition and behaviour where mules exhibiting ideal body condition displayed more positive behaviours compared to those with thin/ moderate and thin/poor condition. This could indicate a fragile mule-owner relationship in mules with less-than-ideal body condition, perhaps through financial insecurity, inadequate knowledge, or fear of handling (of both human and mule) and a resulting lack of adequate care (Kubasiewicz *et al.*, 2022). Three mules showed apathetic behaviour, a negative welfare state where energy is being conserved due to a lack of available reserves (Upjohn & Wells, 2018) limiting an animal's responsiveness to stimuli and often associated with the presence of additional debilitating health conditions, pain, exhaustion (Pritchard *et al.*, 2005), stress or learned helplessness (Burn *et al.*, 2010; Hall *et al.*, 2018; Swann, 2006); in our study one mule had a broken leg and others had nasal and eye discharge which indicated a potential infection, glanders was suspected. Apathetic behaviour can lead to negative labelling by owners where the equid is seen as lazy or stubborn and may result in owner handling becoming more physically severe (Swann, 2006).

Only one mule was assessed to be approximately twenty years old. Limited numbers of older animals may reflect a short life span for mules in the mountains or because of replacement by owners as mule work efficiency decreased as they aged (Luna *et al.*, 2017; Saez *et al.*, 2013), counter to previous studies where equids were working beyond 20 years of age (Arriaga-Jordan *et al.*, 2005). However, considering over half the mules in our cohort study could not be aged, it could indicate that mules avoiding assessment were older and, therefore, more handling-averse from being caught and worked hard every day (Hall *et al.*, 2018). Of those remaining, over half were under five years old, which supports the findings of other research where equids are forced to work before being fully mature (de Aluja, 1998; Upjohn & Wells, 2018; Watson *et al.*, 2020). Ideally equids should not begin work before four years of age when their body reaches zootechnical maturity (Abdelbaset-Ismail *et al.*, 2016; Saez *et al.*, 2013). The mules in this study had already worked in India before being put to work in the mountains which means their bodies had been put under musculoskeletal strain before being fully developed, promoting permanent damage (Abdelbaset-Ismail *et al.*, 2016; Upjohn & Wells, 2018).

Integumentary trauma was present in nearly 90% of the mules assessed, which is higher than seen in other studies. It is generally accepted that harnessing creates many of the injuries in working equids (Ali *et al.*, 2016; Farhat *et al.*, 2020; Frohlich *et al.*, 2020; Luna *et al.*, 2017; Mohamed *et al.*, 2021) when the harness equipment is not well fitted to the mule's body (Cousquer, 2015). Lack of harness care and cleaning can be associated with trauma from harnessing equipment (Burn *et al.*, 2008; Farhat *et al.*, 2020), and the use of non-breathable materials (particularly in such dusty, gritty conditions) would exacerbate rubbing when mules sweat or work in wet conditions. The majority of pack saddles used non-breathable padding created from either nylon or plastic sacking. Owners claimed to use this arrangement only during monsoon to keep mules dry whilst working, however, our fieldwork was undertaken during the dry season and these materials were still being used. Wounds were also visible in the tail and lower midsections of mules where crupper and girth equipment were fashioned from alkathene (hard plastic) pipe, nylon or similar non-breathable materials. These remote regions may lack competent harness makers who are skilled at using locally available resources to supply equipment within the constraints of owners on limited budgets (Heleski *et al.*, 2015; Upjohn & Wells, 2018). In the absence of adequate veterinary knowledge of harnessing, as noted in other studies (McLean, 2012), this leaves owners with minimal knowledge or understanding of harnessing principles to create or modify their own harnessing equipment, having adverse welfare consequences for the working equids. However, solely supporting communities to adjust and design better fitting equipment cannot succeed in isolation where the cause of general welfare issues is not also addressed (Pritchard *et al.*, 2018; Swann, 2006; Upjohn & Wells, 2018).

Although some scarring or hair loss was seen from tethering, few mules had open wounds from this practice, which could indicate that the materials being used were fit for purpose such as being soft, wide, breathable, clean and correctly tensioned. It could also be an indication of the settled social structure of the groups tethered together (Christensen *et al.*, 2011; Fureix *et al.*, 2012) or a lack of salient resources (food, water, mares) to compete over (Pierard *et al.*, 2019), which would reduce aggressive and associated avoidance interactions meaning straining at tethers was minimised, this is corroborated by the lack of conspecific bite injuries seen during assessments. Companion bonding was highlighted by some owners as being important for their mules, appreciating that some mules worked better or kept in close contact with specific mules. This may suggest some owner understanding of their mules' management needs, or possibly just that owners were unable to afford to regularly purchase and replace mules, a process which would disrupt the social cohesion.

A small percent of mules in our study showed open wounds due to inhumane handling practices which is lower

than in other studies (Ali *et al.*, 2016; Farhat *et al.*, 2020). Handlers were seen using stones to direct their mules but the lack of obvious injuries on most of the mules in regions of the body targeted in this practice may mean that direct contact was usually avoided by most handlers indicating some degree of understanding and communication skills between owners/ drivers and mules which avoided conflict and escalating maltreatment (Farhat *et al.*, 2020). Low numbers of mules showed lameness or hoof deformity counter to other studies (Pritchard *et al.*, 2005). Such a low number of mules showing signs of hoof neglect or disease may be due to some owners trimming, some mules being trimmed by the veterinary technicians, or could indicate some form of self-trimming from movement probably due to the coarse rocky terrain the equids were driven over every day (Frohlich *et al.*, 2020).

Numerous concerns were raised by owners regarding the welfare of their mules including the use of drivers to work their mules who may not have the expertise, commitment (as the mules do not belong to them) or the 'interdependent relationship' (Pritchard *et al.*, 2005) to look after the mules well. This is a subject area of interest in other livestock sectors where it is widely understood that the attitudes, behaviour, personalities and levels of stress of people working with livestock has a pivotal role in animal welfare (Coleman *et al.*, 2003; Hansen & Osteras, 2019; Lensink *et al.*, 2016). In many studies a recurring theme highlights that disconnection between pay, knowledge, skills and ultimately stockperson morale can have significant impacts on the productivity and wellbeing of the livestock in their care (Daigle & Ridge, 2018; Losada-Espinosa *et al.*, 2020; Waiblinger *et al.*, 2006); under a one health/ one welfare perspective (Pinillos *et al.*, 2016) the health and wellbeing of both is inextricably linked (Valadez-Noriega *et al.*, 2018). Owners also expressed fears about working the trails, indicating fear and anxiety about falling rocks, loose substrates, and natural hazards which caused fatalities in their mules and would be a constant concern with regards to their own safety, the loss of income, and financial burden of replacement costs if they lose mules. Intriguingly, all owners failed to mention concerns about integumentary trauma considering it was the most obvious and prevalent issue seen in all the mules. People often completely rely on the income from their equids in these remote communities (Rodrigues *et al.*, 2017), so perhaps as mules could continue working with integumentary trauma it was less of a concern than other welfare issues.

Although the diet of mules in this study were sufficient to support the maintenance of body condition in at least half of the cohort, the type and intervals for food intake are not appropriate for long-term health and welfare. Calorific, starch-based foods given without adequate access to water (Wild *et al.*, 2021), and in the absence of limited access to adequate foraging opportunities to ingest foods of higher water and fibre content, can lead to gastrointestinal disturbances such as colic (Cohen *et al.*, 1999; Curtis *et al.*, 2019). Colic was reported by owners as being of concern and was witnessed and treated by the authors during the fieldwork. This type of dietary provision can contribute to the development of abnormal oral behaviours (Hothersall & Casey, 2011; McBride & Long, 2001; Nicol *et al.*, 2005) and in this study mules were frequently observed exhibiting coprophagia or pica of other mules' dung and soft plastics (TDS, fieldnotes, 2018). This practice (with faeces only) is a common and important behaviour in foal development (Lindenberg *et al.*, 2019; Siskova *et al.*, 2006) but rare in adults. When observed in adults, coprophagia may be indicative of a deficient diet of high concentrate, low protein and low fibre (Boyd, 1988; Hanis *et al.*, 2020; McDonnell, 2003). In this study mules had very restrictive high concentrate diets and limited access to foraging opportunities either at liberty or from forage materials offered by owners. Coprophagia may increase the risk of ingestion of internal parasites (Hanis *et al.*, 2020; Studzinska *et al.*, 2020), and may also be a contributing factor in the colic episodes recorded during fieldwork, which in a population of equids with limited access to veterinary services is of concern.

There are substantial difficulties for mule owners when trying to access veterinary support in these remote regions and with such limited or patchy access to veterinary services there is heavy peer to peer reliance and knowledge sharing, which is of high importance when considering mule welfare. Lack of access to adequately trained veterinary health professionals is a common issue in LMICs, leaving domesticated animals, particularly working equids, vulnerable to ill health and poor welfare (Frohlich *et al.*, 2020; Schott *et al.*, 2019; Upjohn *et al.*, 2014) and at the mercy of owners potentially lacking in mule management understanding where peer to peer knowledge sharing may exacerbate poor welfare (Nye *et al.*, 2021; Watson *et al.*, 2020). Though two veterinary technicians were embedded within two villages on the trails, working equids did not feature in their specialised training; further additional voluntary equid training was sought by the technicians after graduation via an external organisation. Though they are only permitted to provide non-prescription remedies their daily services veer into delivery of prescription-only treatments, sometimes diagnosing and treating if symptoms are recognised; and often only when treatments failed to relieve symptoms was a veterinary surgeon contacted for guidance and support. The delivery of prescription only treatments without veterinary supervision is of global concern; in studies investigating antimicrobial stewardship in animal health, informal service providers with little knowledge, understanding and certainly no training, dispensed antibiotics without veterinary diagnosis or prescription, potentially contributing to antimicrobial resistance (Chauhan *et al.*, 2018; Nye *et al.*, 2020).

The veterinary technicians raised concerns about the harnessing equipment causing integumentary trauma, inhumane handling and the hazards of working mules on

such rough terrain, though their major concerns were around the number of cases of colic, glanders and trypanosomosis they were treating, trypanosomosis was also raised as a concern by owners. Glanders and trypanosomosis are zoonotic infections; although *Trypanosoma evansi* was previously believed non-transmissible to humans but a recent case in Asia has disproven this assertion (Van Vinh Chau *et al.*, 2016).

Clinical signs indicating trypanosomosis was the most commonly recorded sign of illness recorded during assessments, and was a significant issue raised by owners. The protozoan is transmitted via blood sucking vectors such as flies, infections are often acute and fatal in equids (OIE, 2021), there are effective trypanocidal treatments if infection is caught in the early stages but after this the only effective control is the slaughter of infected animals, there are no vaccines. There have been recent outbreaks of trypanosomosis in Europe due to the movement of infected animals into non-endemic areas (Buscher *et al.*, 2019), which is of significance in Nepal where working equids are moved considerable distances through open borders with limited or no checks (AN, 2016).

Although only one mule showed definite signs of glanders, another 13 had eye and nasal discharge. Whilst this discharge could be due to irritation from dust, it could also be an indicator of early-stage infection. The organism responsible for glanders infection, *Burkholderia mallei,* causes acute disease in donkeys and mules; death follows swiftly following infection (Barrandeguy & Carossino, 2018). Discharge from the nares and through the respiratory tract from coughing disperses infectious droplets which facilitate transmission when in close contact with either the mule itself or via something contaminated such as water, food or harness equipment. If people contract the disease in its acute form the mortality rate can be as high as 95% within three weeks if antibiotic treatment is not accessed. Though *B. mallei* is susceptible to desiccation outside a host if exposed to sunlight for 24 hours, the agent can remain infectious and active in water for at least one month (OIE, 2018). This has implications for animal and human health when considering the dependency of the Nepalese mountain dwellers on streams and rivers for their water supplies, as well as the long monsoon season, where the protozoan could potentially remain viable in the environment for some time (OIE, 2018, 2022). The lack of adequate hygiene, and the propensity to house mules in close proximity to people's living quarters, also significantly increases the risk for transmission. The transportation of working equids, if infected, could also introduce glanders into glanders-free areas via the translocation of equids.

Equids that are already stressed from poor nutrition, concurrent diseases, and the demands of excessive work will be more susceptible to infection, which is then compounded by a lack of access to veterinary services. Infected mules may not be effectively dealt with (euthanised or the disease notified) and the carcass safely disposed of, leaving potential sources of infection within the environment. In remote communities with limited access to health services themselves, the health and welfare of the owners is intrinsically linked to the health and welfare of their mules and the environment they all inhabit; an important reminder that to truly create sustainable change a one welfare approach (Pinillos *et al.*, 2016) needs to be adopted.

For non-governmental organisations and service providers these rural communities pose challenges when trying to gain access to and understand the complex needs of these demanding environments and the actors within them. The high prevalence of integumentary trauma, negative behavioural responses and poor dietary provision is of great concern, particularly when there is a lack of access to well trained, suitably supported and adequately provisioned veterinary and harnessing services within these rural communities.

This study gives a detailed understanding of the husbandry and welfare status of mules working the trails in the Gorkha region, Nepal. It supports a call for a more unified approach to tackling equid welfare and supporting the marginalised, resource poor communities they underpin. Facilitating capacity building for owners, supporting improved training for equid service professionals, and the continued lobbying of policy makers to effect political and social change to keep working equids high on their agendas.

STUDY LIMITATIONS

To enable access to sites and provide interpretation during interviews the organisation Animal Nepal assisted. Animal Nepal provided veterinary interventions to some of the villages (Arkhet Bazar and Soti Khola) within the study so acknowledgement is given that this may have influenced interview and survey responses of some participants. Without this assistance, however, language interpretation would have been impossible, and many mules would have had severe colic symptoms left untreated with potentially fatal consequences.

COMPETING INTERESTS STATEMENT

The authors declare that they have no competing interests.

ETHICS STATEMENT

Project code 2018-VOD-NEPAL. The study was conducted in accordance with the Declaration of Helsinki (WMA, 2021); the protocol was approved by the Ethics Committee of The Donkey Sanctuary, UK.

Recruitment of participants was on a voluntary basis, due to literacy levels of participants verbal informed consent was gained from each person and recorded. All participants were anonymised and were given the right to withdraw within a two-week time period by contacting a member of the Animal Nepal team, no participants withdrew. All mules were welfare assessed using non-invasive techniques throughout.

AUTHOR CONTRIBUTIONS

TW, LK, NC: conceptualisation. TW, LK, NC: methodology. TW, LK, ST: investigation and data collection. TW, LK, CN data curation. TW, LK: data analysis. TW: writing of original draft. LK, CN, ST, NC, FB:

revision of original draft. LK, FB: supervision. All authors: manuscript revision and approval of the submitted version.

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