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Welfare assessment of cows in cow shelters (gaushalas) in India

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Abstract

Cow shelters (gaushalas) are unique traditional institutions in India, where aged, infertile, diseased, rescued, and abandoned cows are sheltered for the rest of their life, until they die of natural causes. These institutions owe their existence to the reverence for the cow as a holy mother goddess for Hindus, the majority religion in India. There is a religious and legal prohibition on cow slaughter in most Indian states. A cross-sectional study was conducted to assess the welfare of cows in these shelters, which included the development of a welfare assessment protocol, based on direct animal-based measurements, indirect resource-based assessments, and description of the herd characteristics by the manager. A total of 54 cow shelters in 6 states of India were studied and 1620 animals were clinically examined, based on 37 health, welfare, and behaviour parameters. Thirty resources provided to the cows were also measured. Descriptive statistics and multivariable analysis were used to identify welfare issues in these shelters and risk factors associated with these issues. The major issues found in the shelters were — the low space allowance per cow, poor quality of the floors, lack of bedding, little freedom of movement, and a lack of pasture grazing. Some shelters also had compromised biosecurity and risks of zoonosis. The frictional characteristics of floors was measured by a novel technique that I developed and was least for concrete and greatest for earth floors. The proportion of cows with dirty hind limbs declined with increasing friction of the floor, probably reflecting the fact that they felt more confident to stand rather than lie on high friction floors. The overall lameness prevalence was 4.2% and it was positively correlated with udder dirtiness, the ulceration of the hock joint, carpal joint injuries and claw overgrowth. Lame cows were associated with a low body condition score (BCS). Addressing the principle risk factors identified for lameness in the sheltered cows may help to reduce this serious animal welfare problem. The distance that a cow can be approached by a person before fleeing (the avoidance distance) provided a measure of cows' nervousness of people, which increased with a number of health problems - the proportion of cows with dirty hind limbs, hock joint swellings, and hair loss. There was also evidence of reduced avoidance distances in cows with moving difficulties, those with high levels of body condition score (BCS), dirty flanks, joint ulceration, carpal joint injuries, diarrhoea, hampered respiration, lesions on the body due to traumatic injuries, and body coat condition. Cows aggregated stress levels were measured as hair cortisol concentration, which was increased if there was dung accumulated in the lying area of the cowshed, also if the location was in a cold place and if the cows had little access to yards, dirty flanks, hock joint ulceration, carpal joint injuries, body lesions, dehydration, an empty rumen, or were old aged. Hair cortisol level promises to be an effective biomarker of stress in cows in shelters. A managers' survey revealed adequate vaccination of cows against endemic diseases and paraciticidal treatments. Cows were not screened for brucellosis and tuberculosis and biosecurity measures were very limited; in addition, animal waste disposable was not properly managed in many shelters. Indiscriminate breeding of cows with no separation of the sexes was observed in most shelters. Only one half of the shelters maintained management records. The majority of the managers thought that welfare of cows under their care was important and it was adequate. They also claimed possessing adequate knowledge about cow welfare. Engagement of shelters mangers in decision making is vital for the effective management of the welfare of cows. A survey of the attitudes of 825 members of the public in the vicinity of the shelters revealed general support for the shelter and identified demographic differences. Public donations were the largest source of income to run the shelters. Financial audits were regularly conducted in most shelters. The issues identified in this study will point the way in ensuring the sustainability of these institutions. This welfare assessment protocol has identified the key welfare issues in the shelters, which can be used when providing feedback for improvement to the shelter managers and to government.

<u>Declaration by author</u>

This thesis *is composed of my original work, and contains* no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

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Publications included in this thesis

1. Sharma, A.; Kennedy, U.; Schuetze, C.; Phillips, C.J.C. 2019, ‘The welfare of cows in Indian shelters’, *Animals,* vol**.** 9, no.4,p172.doi: https://doi.org/10.3390/ani9040172
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3) Sharma, Arvind and Phillips, Clive J.C. 2018 Space availability and avoidance distance in cows in shelters (gaushalas) in India. *52nd Congress of the International Society for Applied Ethology (ISAE):* July 30th to August 8th, 2018, University of Prince Edward Island, Charlottetown, Canada.

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Contributions by others to the thesis

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Statement of parts of the thesis submitted to qualify for the award of another degree

Part of the description of the methodology on resource-based measures and data on the resource-based measures in 12 cow shelters in Chapter 3 was used in the thesis of Mrs Uttara Kennedy to obtain her Master's Degree in International Animal Welfare, Ethics and Law from the University of Edinburgh, United Kingdom, 2017. The experimental design for the measurement of resource-based indicators and their results in 12 cow-shelters were included in her thesis, recognising that she helped in this work. Her analysis of the raw data obtained from the 12 cow-shelters was done independently from this work, for presentation in her thesis. The description of methodology, statistical analysis, discussion and conclusion included in this thesis is independent of the work included in her MSc thesis.

Research Involving Human or Animal Subjects

The ethics approval for animals involved in this research was approved by the Production and Companion Animal Ethics Committee of The University of Queensland (SVS/CAWE/314/16/INDIA, dated 4th August 2016, Appendix – 5).

The ethics approval for research on human subjects involved in this research was approved by The University of Queensland Human Research Ethics Committee B (Approval no. 2016001243, dated 7th October, 2016, Appendix – 6).

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assessment, avoidance distance, cow shelters, floor friction, gaushalas, hair cortisol, India, lameness, public survey, welfare

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FoR code: 0707, Veterinary Sciences, 80%

FoR code: 1699, Other Studies in Human Society, 20%

Dedication

To all the animals of the world

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List of Abbreviations used in the thesis

ACA = Adaptive Conjoint Analysis	INR = Indian Rupee
A.D = Anno Domini	IQR = Inter Quartile Range
ANI = Animal Needs Index	KHz = Kilo Hertz
AWBI = Animal Welfare Board of India	Kg = Kilogram
B.C = Before Christ	Km = kilometre
BCS = Body Condition Score	km/h = kilometre per hour
BSA = Bovine Serum Albumin	L = Litre
BQ -= Black Quarter	μL = microlitre
AD = Avoidance Distance	min = minute
ANOVA = Analysis of Variance	m = metre
CCI = Cow Comfort Index	mg = milligram
CI = Confidence Interval	mL = millilitre
°C = degree celsius	m^2 = square metre
cm = centimetre	m/s = metre per second
cm^2 = square centimetre	N = Newton
Coeff = Coefficient	OR = Odds Ratio
CC = Correlation Coefficient	pg/mg = picogram per milligram
CoF = Coefficient of Friction	PCA = Principal Components Analysis
CV = Coefficient of Variation	PBS = Phosphate Buffered Saline
d = Day	Q1 = First Quartile
dB = Decibel	Q3 = Third Quartile
df = Degree of Freedom	QBA = Quality Behaviour Assessment
DMI = Dry Matter Intake	RFS = Rumen Fill Score
e.g. = exempli gratia	RHD = Routine Herd Data
EIA = Enzyme Immunoassay	RIA = Radioimmunoassay
ELISA = Enzyme-Linked Immunosorbent Assay	rpm = revolutions per minute
et al. = et alia	RSPCA = Royal Society for Prevention of Cruelty to Animals
etc. = et cetera	SARA = Sub Acute Ruminal Acidosis
F = Force	SE = Standard Error
FIAPO = Federation of Indian Animal Protection Organisations	sec = second
FMD = Foot and Mouth Disease	SEM = Standard Error of Mean
	SSI = Stall Standing Index

g = gram	TGI = Tiergerechtheitsindex
GLM = General Linear Model	U.K = United Kingdom
HPA = Hypothalamus Pituitary Adrenal	US$ = United States Dollar
HS = Haemorrhagic Septicaemia	VIF = Variance Inflation Factor
h = hour	WQ = Welfare Quality
h/d = hours per day	

Chapter 1

Introduction

Street cattle overpopulation in India is an emerging social and public health problem in India especially in the light of the prohibition of cow slaughter in most of the Indian states (Fox 1999; Ghatak and Singh 2015). Religious and strong inhibitions are carried out in animal husbandry in India and euthanasia is not permitted in the Hindu religion, even to give a mercy killing to a fatally injured cow (Olver 1942; Fox 1999). India has the world's largest cattle population of 190.9 million, out of which nearly 5.3 million are stray (Department of Animal Husbandry Dairying and Fisheries 2014). The large cattle population of India is due to the religious beliefs of the dominant Hindu population of the country and the ancient tradition of gaushalas where cows are sheltered, fed and cared for (Chhangani 2009).This tragic plight of the stray cows is a consequence of modernization and overpopulation. The rural people own cows despite having limited land to graze them; the human population pressure has encroached upon the traditional grazing lands leading to cows roaming freely in the streets, raiding crops, suffering automobile hits and causing traffic problems. In some states it has led to human-animal conflicts due to the crop-raiding by the street cattle in the farmers' fields. In the cities, these street cows survive on roadside city garbage that is contaminated with plastics that leads to health issues causing painful deaths. They are also public health and traffic hazards. There have been reports of many fatal road accidents due to automobile accidents involving cattle in the streets (Bentinck 2000; Fitzharris et al. 2009; Arnold 2012). Recent government reports have revealed an increasing trend in road accidents involving street animals, with 629 human deaths from 1604 accidents in 2016 and 1360 deaths from 3611accidents in 2017 (Government of India 2017, 2018).

In most of the Indian states there are cow shelters or cow sanctuaries called "gaushalas" or "go sadans" where abandoned, unproductive and old cows are housed by philanthropists, animal protection organisations, religious organisations, and temple trusts. These gaushalas have played a significant role in the management of stray cattle in India, by providing shelter for hundreds of cattle (Singh et al. 2013). These cow shelters are traditional and ancient rescue homes for cows with documentary evidence of their existence since the 3rd to 4th century B.C. (Lodrick 1981, 2005b). Presently, the number of gaushalas is variously estimated at somewhere between 3000 to more than 5000 (Alavijeh 2014; Federation of Indian Animal Protection Organisations 2018b; Mandi et al. 2018), so the exact number of gaushalas in India is not known (Singh et al. 2013). According to the latest figures, 1837 gaushalas are funded by the Government of India through a central statutory body, the Animal Welfare Board of India (2016b). The AWBI annually releases funds for the feeding, health care, sheltering and infrastructure according to requests sent by affiliated gaushalas.

The AWBI also sends its Honorary Animal Welfare Officers or Inspectors to see the working of these shelters, which is mandatory for the release of financial grants to the gaushalas. The Animal Welfare Board of India (AWBI) has devised requisite proformas for use by the Honorary Animal Welfare Officers appointed by the Board for inspecting a shelter before release of funds and for auditing the ongoing grant to a gaushala (Animal Welfare Board of India 2016a). However, majority of the gaushalas are funded through donations from the general public, business communities, charitable societies and temple trusts.

These shelters are not able to fully house all cattle due to inadequate space leading to unhygienic conditions (Yadav 2007; Solanki 2010). This leads to overcrowding of shelters which is detrimental to the welfare of the cows. Nevertheless, the gaushalas have played a pivotal role in the cow protection movement for the overall welfare of cows in India. The gaushalas can be a solution to the humane management of the burgeoning stray cattle population of India. To cater to these contemporary societal needs the gaushalas have to reinvent themselves based on modern welfare-based scientific methods of humane cow management.

Some research has been conducted on cattle in gaushalas, assessing the potency of vaccines against paratuberculosis in cattle through the antigen testing on gaushala animals (Kaur et al. 2011; Singh et al. 2015b). Recent studies have been published on the operational constraints and economics of shelters that are restricted to a particular state by gathering information from the shelter management (Bijla et al. 2019; Bijla and Singh 2019; Chandra and Kamboj 2019). However, none of these studies were conducted on the animals that are vital for a valid assessment of the actual welfare of the cows in the shelters. The scientific assessment of the overall welfare of the stray and abandoned cows in these gaushalas based on welfare indicators has not yet been attempted. There has been no study on the development of welfare indicators for abandoned cows in the gaushalas through which the gaushala welfare performance can be audited. The assessment of welfare of dairy and beef cattle is based on the development and validation of specific indicators of animal welfare through an on field-based welfare measurement protocol in the developed world (Johnsen et al. 2001; Welfare Quality® 2009; Kelly et al. 2011; Main et al. 2014). The Welfare Quality® protocol has institutionalized welfare auditing as a routine assessment tool in the western dairy and beef industry. There is a lacuna in the literature and in the wider animal industry about the use of the welfare indicators to improve welfare in gaushala cows. The welfare issues faced by the cows in shelters have not been identified and the risk factors associated with these issues have not been analysed. There is no study on the assessment of long term stress faced by the cows due to the managemental and environmental conditions provided in the shelters. The general public in India due to their veneration for the cows and regular financial support to the shelters are vital stakeholders in the sheltering of the cows. The attitudes of the general public about cow welfare and cow shelters in the contemporary context have not been assessed. Similarly, the constraints faced by the shelter managers in managing the routine working of the shelters have been scarcely documented being isolated to one state (Bijla et al. 2019). The attitudes of the shelter managers' to cow welfare and shelters have not been assessed. The involvement of these stakeholders through the assessment of their attitudes is important for policy formulation and legislation on this societal issue given its contemporary and future ramifications. Welfare based management of cows in shelters hold the promise to deal with street cow overpopulation in the country in order to minimize the conflict between modernity and tradition and ensure sustainability of these institutions.

The present research study seeks to rectify these knowledge gaps about the gaushalas in India. Based on the research gaps identified, the present study envisages the following objectives:

1. Development of welfare indicators that are relevant to cows in gaushalas and their field validation for routine welfare assessment of cows and cow shelters.

2. Assessment of welfare of cows in shelters and identification of key welfare problems.

3. Identification of risk factors associated with the welfare problems in cow shelters.

4. Assessment of long stress in sheltered cows and risk factors associated with it.

5. Assessment of human-animal relationship in the shelters and the risk factors associated with it.

6. Exploration of stakeholder opinion (public and shelter managers) about cow welfare and cow shelters in India.

Chapter 2

Review of literature

2.1 History of Cattle Shelters in India

A “gaushala” literally means a ‘home for cows’, especially housing bovines only, whereas “pinjrapole “refers to the housing of all animals (Singh 1946). The institution of gaushalas is an ancient Indian heritage strongly linked to the Hindu religion where the cow is worshipped as a mother, protection of which is the duty of faith for all Hindus (Simoons 1974). Ancient Hindu texts written by sages are replete with the demonstration of reverence towards the holy cow by the Kings of the Vedic times in India, as a symbol of economic prosperity and humanity (Agoramoorthy and Hsu 2012). The reverence for the cow comes from the intimate connection of the ancient Hindus to life and religion. Thus, under this religious-economic reverence of the people of the Aryan period (1500-500 B.C) the gaushalas and pinjrapoles came into existence (Singh 1946). The Hindu religion espouses the co-existence of humans and animals through the promotion of the belief of incarnations of gods and goddesses in animal forms. The emblems of the Kings and the organisation of various festivals in respect for and to honour animals respectively in the past are a testimony to these beliefs (Agoramoorthy and Hsu 2006). The Vedic hymns of the Hindus written and sung by the sages have references to the cow as the holy mother (Simoons 1974). The sacredness and high ritual status of the cow have led to the use of ‘panchgavyas’ or the five cow products: milk, curd, butter, urine and dung, for the maintenance of a person as free from pollution and for the purification rituals in Hindu religious ceremonies (Simoons 1974).

The presence of the gaushalas in the ancient Rig Vedic period (1500-100 B.C) with the presence of cattle rearing as an economic activity has been documented (Bharadwaj 2012). India is a home to 30% of the cattle population of the world, which was first domesticated approximately 8000-10000 years ago (Loftus et al. 1994). The existence of animal homes about 2000 years ago has been indicated by Evans (2013), though the exact origin of these in the Indian sub-continent is unknown. Lodrick (1981) has documented the existence of these institutions since at least the 3rd century B.C.). Lodrick (1981) further refers to the ‘*Arthashastra*’, a Hindu text written by Chanakya, dating to sometime between the 4th century BCE and 4th century CE, which mentions the presence of gaushalas and describes the maintenance of useless and abandoned cattle herds. These animal homes were classified into six types: the *pinjrapole*, *vania gaushala*, temple *gaushala*, court *gaushala*, Gandhian *gaushala*, and the *Gosadans* (Lourdusamy 1983). The majority of the gaushalas existed in North India (Burgat 2004). *Gaushalas* are typically Hindu institutions encompassing a much wider Northern India than the Jain *pinjrapole*s with more prevalence of these found in Gujarat and surrounding states due to the higher influence of Hindu culture in these regions (Lodrick 1981). The practice of the establishment of the Gaushalas was absent in South India as a culture and the ones which existed were developed by the North Indian migrant merchant communities who had migrated down South (Evans 2013).

2.2 Assessment of Animal Welfare

Animal welfare is an integrative strategy involving farmers, scientists, veterinarians, ethologists and welfare groups to deliver a key output to the animals for their wellbeing (Sejian et al. 2011) .There is a distinction between “conditionally normative “and “inherently normative” issues in risk assessment studies . The values are given importance in the conditionally normative studies as the scientific data collection is not free from bias. In the case of inherently normative studies the application of values to the variables for data collection is not possible (Brunk et al. 1995; Bracke et al. 1999a). The formal scaling systems of the welfare parameters help to collate the variables for measurement but the differing philosophies of scientists will give weight to different variables in assessment protocols. The attachment of weights to different welfare assessment variables as per the goals of assessment and weighing opposite variables are the complications of assessment of farm animal welfare (Scott et al. 2001). This assumption of values for different welfare parameters should be able to find basic differences in parameter values rather than a total focus on the objectivity of the parameters (Fraser 2003). It has been purported that animal welfare indicates the mental states of the animal due to their experiences and hence cannot be measured directly but on an indirect basis (Sandøe and Simonsen 1992). Assessment of animal welfare in dairy farms through the measurement of outcomes on the animals has been advocated to investigate the welfare standards the farms are able to achieve (Main et al. 2012b).

2.3 Epidemiology and animal welfare assessment

An interdisciplinary approach between veterinary epidemiologists and animal welfare researchers has been suggested to identify the interactions of factors of animal health and welfare on actual field situations as the basis for improved decision making on animal welfare and research (Scott et al. 2001; Main et al. 2003; Rushen 2003; Zurbrigg et al. 2005b; Millman et al. 2009). These studies indicate the type of data collection in animal welfare through an interdisciplinary approach, data analysis based on the epidemiological principles, use of data generated for animal welfare assessment and ultimately putting it to use by the stakeholders.

2.4 Purpose of the Assessment of Animal welfare

Welfare is a multidimensional concept (Mason and Mendl 1993; Fraser 1995). Judgements about animal welfare are better carried out when more knowledge about the factors affecting the welfare of a particular species within a management system is there and how these factors are integrated (Sejian et al. 2011). The critical difference between measuring welfare and disease is that in disease a comparatively smaller number of physical measures are assessed by referring to well-established normal parameters. In the case of assessing animal welfare, a wide range of measures are to be considered along with health parameters (Duncan and Dawkins 1983). The quantification of the welfare state of the farm herds is the real purpose of the assessment of the farms for animal welfare on scientific lines. The goals of any animal welfare index system or assessment system could be the certification of individual farms, examination of housing systems, and identification of welfare problems in the farms and to present an advisory to the farmers (Johnsen et al. 2001).

The scientific basis of animal welfare assessment has inherent problems due to the many factors affecting animal welfare, methodologies employed for assessment and the difficulty in weighing the different parameters of the assessment (Waiblinger et al. 2001). There is no comprehensive and completely validated animal welfare assessment system in the world which can be termed as an ideal (Matthews 2008). There is a need to quantify the animal welfare status in the farms through the application of assessment methods (Fraser 2003; Duncan 2006). The assessment of animal welfare has no clear single goal. The goals differ with the method of assessment and the assessment methods may lead to more than one goal. A good animal welfare assessment protocol is a direct feedback to farm owners, managers about of the strengths and weakness of the farm, to the policy makers to arrive at decisions and is also a marketing tool (Spoolder et al. 2003).

2.4.1 Attributes of an animal welfare protocol

The protocols of assessment of animal welfare should be practical and robust in case of involving animals in groups or herds (Webster 2005). It is essential in the development of an animal welfare protocol that there is a minimal amount of subjectivity and personal bias (Whay et al. 2003c). Hence, as per these views, the indicators for measurement of animal welfare will differ. Thus, due to different stakeholders in the animal welfare concept, the requirements for different methodologies for welfare assessment will be different. The farmers require indicators which will give evidence of early warning of poor welfare, the regulatory bodies will need indicators which show enforcement of legal standards of welfare and the civil society and consumers need indicators which reflect the feelings and emotional status of the animals, respectively (Manning et al. 2007). It is necessary for animal welfare science to demonstrate the abilities of the animals to experience positive or negative emotions through an evidence-based approach prior to being included in a welfare assessment protocol (Kjærnes and Miele 2007; Matthews 2008). Some attributes of an ideal animal welfare assessment system outlined are (Matthews 2008):

1) The indicators must have a scientific basis to reflect their validity so that they are relevant to the needs of the stakeholders. These indicators must be outcome based though input based indicators might be sometimes relevant.

2) A system should be there for giving due weight to the indicators based on the area of welfare being assessed.
3) A method of integrating the indicators to develop an overall welfare index must be in place.
4) A method of benchmarking each welfare indicator as per each level of welfare should be there.
5) The indicators must be attributes of feasibility, reliability, repeatability and should serve as early warning systems for poor welfare situations so that preventative measures could be initiated.

There is a lack of explicit guidelines for integration of welfare assessment parameters and scoring scales which lead to an array of welfare assessment indicators despite these representing the concerns of the stakeholders (Fraser 1995).

2.5 Indicators/Parameters of Animal Welfare Assessment

An indicator can be any number, rate, ratio, percentage, index or any other measure that gives a summary of a subject being dealt with (Australian Institute of Health and Welfare 2015) .The indicators, when plotted over a time period, show the change of conditions of the subject under study. As the concept of animal welfare is multi-dimensional, all its aspects have to be assessed by specific welfare indicators (Mason and Mendl 1993; Fraser 2003; Botreau et al. 2007b). The selection of welfare indicators which are of relevance has been done by evaluating them on their individual significance, their marginal welfare value and their applicability for an on-farm welfare assessment (Rousing et al. 2001). There are species differences in being able to live in different conditions and hence it is very important to identify indicators that show the needs and preferences of animals (Dawkins 2006). There have been scientific efforts all over the world for the development of indicators of welfare which signify the quality of life of the animals, are scientifically valid and are practical for use by the stakeholders (Wemelsfelder and Mullen 2014). This means sensitive animal welfare indicators need to be developed which not only identify stress levels but also reflect about the mental states of the animals. Ethological approaches are being developed through close observation of the behavioural indicators of animals, which provide the most authentic information on welfare (Christiansen and Forkman 2007).

There are many animal welfare assessment protocols that have been developed for dairy cows. All these methods of assessment of animal welfare are different to one another as they have different goals of assessment. Animal Welfare assessment at herd level is based on a range of parameters, which are known as indicators. These parameters are principally divided into divided into two categories according to Johnsen et al. (2001):

1) The resource-based parameters/ Environmental parameters

2) The animal-based parameters.

2.5.1 Resource-based parameters for animal welfare assessment

The assessment of provisions or resources is a less direct method of evaluating welfare than the results of a direct observation of the behaviour and physical condition of the animal (Webster 2005).These indirect methods of the evaluation of animal welfare are based on the measurement of the adequacy of inputs provided to the animals in the form of resources and management (Wood et al. 1998). In this method, each resource is given a weight and sum of all the weights to different resources produce a welfare score (Bartussek 1999). It is based on the measurement of the resources provided to the animals. These indicators are variables that are not measured in the animals but in their environment. The resource /environmental parameters include the design and size of the sheds where the animals are housed, the amount and quality of fodder they are provided, the ambient temperature of the shed housing systems, space allowances for each animal, management practices, length of the mangers, water troughs, quantity as well as quality of feed and water, condition of the flooring bedding etc. (Main et al. 2003). These are relatively easy measures to record being observable, less time consuming, objective and highly repeatable. One short visit to a farm is suitable to record these resource-based parameters and hence they are very convenient to assess. The reliability of these parameters, their quick assessment and economy have lead researchers to focus on these parameters for welfare assessment (Sundrum 1997; Bartussek 1999; Bracke et al. 1999b). However, these resource-based parameters are environmental parameters which lead to risk assessment and do not actually measure the welfare state of the animals (Rousing et al. 2001). A good welfare score of these parameters does not guarantee that the animals are fit, healthy and have a high standard of welfare. This may lead to overlooking of the potential risk factors. The real life expressions by the animals can be different (Winckler and Willen 2001). Studies have shown that the animal-based measures may change within the same housing systems and similar management conditions (Whay et al. 2003c; Rousing et al. 2007).

2.5.2 Animal-based parameters for animal welfare assessment

Animal-based parameters such as health and behaviour are considered as the indicators of the feelings as well as state of the animal's body (Waiblinger et al. 2001).These parameters include the health, incidence of disease, injuries, behaviour and physiological parameters. The level of stress hormones, fear, aggression and disease signs are examples of these parameters. These animal-based indicators are direct measures of the state of the animal and are regarded for their high level of validity due to their close linkage with the actual welfare level of the animal (Blokhuis et al. 2010; Dawkins 2012). These give a direct assessment of the animal welfare (Whay et al. 2003a; Barnett and Hemsworth 2009) which is quite valid (Keeling et al. 2013). The animal health parameters are more practical and records of the data can be assessed from the farm records (De Vries et al. 2014a). However, the recording of the animal-based parameters is difficult, time-consuming and requires many resources. This especially holds true in the case of behavioural and physiological parameter recordings (Johnsen et al. 2001).

The measurements have to be robust, quantifiable and subjective to minimise observer bias. Practically the measurements have to be completed within a day (Webster 2005). This leads to the concern on the snapshot assessment of the welfare state of a farm as the long-term welfare picture will not be available. This problem is countered by selecting those animal-based measures which indicate the long-term consequences of management/ husbandry. The animal-based measurements are dependent on the monitoring and recordings of observations by the observer/assessor and hence they rely on subjective assessments (Webster 2005). However, it has been pointed out that this is not a problem if the measurements are repeatable, once the assessors are thoroughly trained and the measures can also be transferable to other animal production systems also (Whay et al. 2003c).

Health and behaviour of the animals are important considerations in the assessment of their welfare. Behaviour is the outcome of the animal's interaction with the environment on account of its perception of its surrounding influences. Behaviour assessments used in farm animals are made by using standardised tests to establish human-animal interactions such as social behaviour, comfort behaviour, rising behaviour and fear tests (Sørensen and Fraser 2010). A typical limitation with the behavioural measurements is that response of the animals differs with an unknown handler than a regular handler (de Passillé et al. 1996). Health assessments from the animal reveal about the acute as well as chronic disease conditions of the animal and provide an idea the short and long term pain and stress the animals are undergoing (Rousing et al. 2001). The direct welfare measures based on animal-based measurements do not alone indicate the causes of poor welfare in a farm as the short time of the visits for assessment and resources do not allow the collection of behaviour and health data of the animals under study (Waiblinger et al. 2001).

There are some other indicators which affect animal welfare such as management practices and human-animal interactions (Rushen and Passillé 1992; Sandøe and Simonsen 1992; Waiblinger 1996) but these are not easy to measure and hence suffer from reliability. There is evidence which shows that physical environments of the farm animals are alone not good indicators of animal welfare but genetic factors and human factors also determine the welfare of the animals in the farms (Sandøe et al. 1999; Hemsworth et al. 2002). The complex interaction of factors in animal welfare warrants a valid assessment of farm animal welfare through on-farm welfare assessment methods (Barnett and Hemsworth 2009). The welfare outcome-based approach for the assessment of animal welfare claims to promote active involvement of the farmers, assessors and the veterinarians in the improvement in the welfare levels of the farms on a daily basis (Main et al. 2012b). This type of assessment is focussed on the improvements based on the performance of the farms in light of the resources provided.

The initial research in animal welfare focussed on the input measures of animal welfare such as management resources and physical resources (Bartussek 1999) but the recent research is on the assessment of output measures or welfare outcomes which means how the resources given to the animals actually affect the animal (Main et al. 2012b). The health and welfare of the animals can be measured in detail through direct observation of the animals in different management systems. Studies now focus on the composite welfare assessment of animals in a management situation through the assimilation of results from an array of indicators into an overall welfare index (Botreau et al. 2009). There is a need to develop smaller groups of indicators which reflect the major health and welfare issues due to the time and cost constraints (Main et al. 2012a). However, for overall validation of the protocols these indicators also need to be validated (Wemelsfelder and Mullen 2014). By conducting experiments or by referring to theoretical works it can be concluded that some indicators depict some kind of experiences of the animals due to their cognitive abilities. The emotional outcome of these experiences in the animal is referred as its welfare state (Mellor 2012). The indicators can also be selected by performing controlled experiments to find out animals' choices in given opportunities (Dawkins 2006). In case they prefer certain activities, the presence or absence of such activities can be used as an indicator of welfare (Forkman et al. 2007).

2.5.3 Validity, reliability and feasibility of welfare indicators

Validity in animal welfare assessment means to what extent we are measuring what we are supposed to measure (Knierim and Winckler 2009). Validation of animal welfare indicators is the selection of appropriate sample sizes within each subgroup so that accurate conclusions can be drawn through the extrapolation for the whole population (Mullan et al. 2009). The resource-based measures suffer in their validity aspect because of their indirect measurement of welfare and the complex interactions with other management conditions (Waiblinger et al. 2001). The reliability of assessors for measuring an indicator is another criterion of validating an indicator. The scoring scales developed for the measurement of indicators in experimental situations need to be validated through on field use to prove their practical applicability. The different assessors should be able to measure a parameter similarly after a basic training. The results should be the same on the same subjects by different evaluators (Knierim and Winckler 2009). It has been found that to ensure reliability between assessors for the development of valid welfare assessment protocols the indicators must have clarity and their scoring must be simple (Channon et al. 2009; Plesch et al. 2010). The assessment of the welfare through the measurement of the indicators must be practically feasible in the given amount of time. This helps to reduce the cost of the assessment in terms of time and resources while at the same time the sample being kept representative (Knierim and Winckler 2009).

2.6. Development of Protocols for animal welfare assessment

It is widely accepted that for a composite and holistic animal welfare assessment of a farm, both resource-based and animal-based parameters are essential to be measured. The process of the development of animal-based protocols and their application for assessment of the welfare of dairy cattle has been deliberated upon (Main et al. 2007). The development of protocols for welfare assessment of the farms is through the evaluation and adoption of measures used in previous studies. The indicators involve examination of individual animals, observation of a group of animals, evaluating the farm records and the recording the observations of the farmers (Main et al. 2007).

The criterion for including a parameter in the study is its relevance to animal welfare (validity), reliability and its feasibility of measurement on the farm visit. A manual has been prepared which shows the pictorial representation of a parameter, its definition, how to measure it and finally its conversion into standard units of measurement (Main et al. 2007).

An on-farm animal welfare assessment tool in cattle and buffaloes has been proposed by dividing the animal-based parameters into three categories. These included the parameters which were reliable, valid and feasible in the first category (viz.lameness, injuries, body condition score, cleanliness, getting up and lying down behaviour, agonistic social behaviour, abnormal oral behaviour, animal-human relationship and stockmanship), the parameters which need more information to be reliable in the second category (viz. indicators of good welfare, housing indicators) and the third category were the parameters which were found to be important but were not reliable and feasible (viz. disease incidence and mortality rates) (Winckler et al. 2003). This was claimed as being the first index for producing a scientifically accepted animal welfare assessment tool and indicated the paucity of literature on reliability of selected indicators, the appropriate sample sizes to be selected to be being representative, procedures for assessing behaviour in a short assessment period and the acceptable level of training of the observer. Thus, a novel idea of incorporation of useful indicators of good welfare in the assessment protocols was advocated. There is a need to develop indicators for nutrition status, thermal and physical comfort and fatigue which could be validated too (Matthews 2008).

The importance of training of the assessors of animal welfare prior to welfare assessment to achieve higher repeatability of the measurement of the indicators has been emphasised. It was further suggested to develop simpler but precise scales of scoring for welfare indicator measurement. This helps in accurate assessments to produce a reliable database through the prevention of observer bias leading to proper analysis of the animal welfare protocols (Gibbons et al. 2012).

2.6.1 The United Kingdom Dairy Farm Protocol

During the development of protocols for UK-based dairy farms, consultations were done with dairy cattle welfare experts and veterinary surgeons and each parameter to be included in the assessment protocol was deliberated upon. This helped in the evaluation of each parameter for its repeatability. Thus, a benchmarking of farm performance on the basis of these parameters was done through the analysis of the performance of each farm on the welfare parameters selected. This helped in the identification of the strengths and weaknesses of the farms in the overall welfare concept (Main et al. 2007). The purpose of this study was to develop a valid, repeatable and feasible protocol for welfare assessment of the farms. This approach has a limitation of being subjective though repeatability is the most important consideration in this approach. The repeatability of a protocol as well as of a parameter is increased by the training of the assessing personnel. A welfare assessment tool must measure parameters which are reliable, valid, easily operated by trained assessors, efficient and must reveal the causes of poor welfare in a farm (Waiblinger et al. 2001).

2.6.2 The "Delphi" technique

The process of assessment of animal welfare and ensuring quality control involves the following steps (Webster 2005):

1. The "Delphi" review process of the opinion of animal welfare experts regarding the weight given to various welfare concerns in order to achieve consensus among the experts. This is done by contact with animal experts to point out their perceived animal welfare issues in dairy cows (Linstone and Turoff 1975; Whay et al. 2003c).
2. Development of animal welfare assessment protocols and their on-farm testing.
3. Selection of a statistically valid sample of farms for the on-farm assessment of the welfare of the animals housed.
4. Identification of the strengths and weaknesses of each tested farm on the basis of analysis of the assessment parameters.
5. Consultation among experts on their views about solutions to the identified and circulated welfare problems which were identified.
6. Advisory report to the farmers to redress specific welfare problems to ensure action is taken by the farm.

The “Delphi” technique allows to elicit opinions of experts on key welfare issues to be used as indicators and for arrival at a consensus. This leads to developing a protocol where the indicators/ measures are given appropriate weight as per the priorities established by the experts. This technique forms the foundation of the development of a welfare assessment protocol as a tool for animal-based welfare measurements on the farms. This technique can further be used to assess the impact of any improvement or addition to assisting the welfare of the animals on a farm. Different studies have included the opinion of experts in welfare assessments and have concluded that it strengthens the welfare assessment system (Bartussek 1999; Main et al. 2003; Rousing et al. 2007).

2.6.3 Exploration of Routine Herd Data (RHD)

A more novel approach for assessing the level of animal welfare in farms is the exploration of the national herd databases in developed countries. The routine herd data of a farm has an ability to measure the welfare of animals if it is combined in multivariate analysis (de Vries et al. 2011; de Vries et al. 2014b). There have been studies on the analysis of the routine herd database on the assessment of nine animal-based indicators and it was concluded that the welfare of a herd was considered to be poor if it scored less than the 10% worst scoring herds on the set indicators of the studies (Sandgren et al. 2009; Nyman et al. 2014). In both of these studies, sensitivity and probability were used for final evaluation of the welfare index of the farms being assessed. The routine herd data can serve as a prerequisite tool for identifying herds with serious welfare problems. This will reduce the numbers of farm visits for welfare assessment and hence be cost effective. This is a useful technique for continuous welfare assessment of the farms but has been found unsuitable for on the spot assessment of animal welfare in a farm (De Vries et al. 2014a).

2.6.4 Criterion based animal welfare assessment protocol

A criterion based assessment of animal welfare has been proposed for the overall measurement of animal welfare on a farm (Botreau et al. 2007b). A total of 12 criteria were initially selected for their applicability on the farm by measuring animal-based parameters as it was maintained that welfare state of animals was related to the mental state of the animal as this is what the animal perceives (Duncan 2005). The requirements were laid down for an assessment criterion to be exhaustive, minimal, independent, consensual and legible. This is a strong support for the animal-based assessment of animal welfare as during its development, the Welfare Quality Project advisors were consulted along with consumer groups in different countries. As a consequence of these consultations, the criteria were reduced to just four for easy understanding and communication with the farmers. A hierarchical level has also been set up between these criteria for bringing out greater transparency in the protocols. However some functional dependency between the indices selected was noticed though each index was independent of interpretation (Botreau et al. 2007a; Botreau et al. 2007b).

2.6.5 The RSPCA's Freedom Food Scheme (RSPCA 2007)

This is one of the longest standing welfare assurance systems. It covers a range of species and has been implemented in many countries. Animal-based measurements and data recorded in farm records were utilised as indicators of the welfare of dairy cows based on the five freedoms (Whay et al. 2003c). The selected parameters were finalised for measurement after consultation with a panel of farm animal welfare experts. The experts were asked to weigh the importance of each measure in the form of the earlier described "Delphi "technique. It was claimed to be the largest animal welfare assessment study carried out in the UK and 15 international experts were consulted in the development of the protocol which was tested on 53 dairy farms. This study was unique as it minimised the subjective bias of the assessors and the results were based on the consensus opinion of the experts.

2.6.6 The Five Domains Model for animal welfare assessment

The model was devised to assess the compromises made on animal welfare in four physical domains and one mental domain that are reflected in terms of an animal's affective experiences (Mellor and Reid 1994). The four physical domains are nutrition, environment, health and behaviour. The affective experiences of the animal reflect the mental domain. This model initially assessed the negative experiences of animals in these domains. The model was developed to assess the compromises made in laboratory animals. Subsequently, it has been broadened to include farm animals, companion animals, captive and free ranging animals (Mellor et al. 2009). This model has been further extended to include the positive welfare states of the animals in the welfare assessments (Mellor and Beausoleil 2015). This helps in the systematic and objective assessment of positive and negative welfare effects, the causes of such effects and the interaction between these two effects. This model is in line with the contextual shift occurring in animal welfare science towards promoting positive and minimising negative welfare states. This model does not take into consideration the human-animal interactions which is an emerging aspect of animal welfare assessment.

2.7. Indices of animal welfare

There is an absence of an animal welfare assessment protocol which can be termed as "Gold Standard" for the objective measurement of the collected welfare parameters and their interpretation (Spoolder et al. 2003). There are various methods of assessments which take into consideration integration of the indicators of animal welfare through parameters of their measurement. In general, five approaches have been developed to club various indicators of welfare into one protocol of measurement of welfare parameters. Each approach has its advantages and disadvantages.

The scoring system approach is the most commonly used (Spoolder et al. 2003) and many welfare assessment schemes are structured based on this approach such as the TGI (Bartussek 1999; Horning 2001), the Animal Welfare Index (DVI) (Bokkers 1996) and Freedom Foods Scheme (Main et al. 2001). The development of an integrated animal welfare assessment system involves many steps which include a selection of the basis of the assessment (e.g. the five freedoms) and the indicators to be measured, according to due weight to each indicator and ultimately the integration of the indicators.

Five different ways of weighting and integrating welfare indicators into an overall assessment index have been proposed (Spoolder et al. 2003) which are the scoring systems (Bartussek 1999); decision support systems (Bracke et al. 2002); multivariate statistical methods (Spoolder et al. 1996), post-hoc experimental analyses and qualitative assessment (Wemelsfelder and Lawrence 2001). For the sake of objectivity of the indicators, it is highly desirable for the indicators to be calibrated independently so that an evidence approach is where animal’s viewpoint is taken into consideration (Matthews 2008). The parameters which depict the linkages between animal behaviour and attributes of physical health and body functioning will be needed for an integrated animal welfare assessment (Dawkins 2004; Febrer et al. 2006). The prerequisites for the selection of parameters are their ranking and qualifications of the experts for assessment to bring about a transparent assessment in all the five methods of welfare parameter integration (Spoolder et al. 2003). However, the inevitability of human judgement in this process leading to subjectivity was also pointed out.

The various index systems developed basically investigated the impact of housing on the welfare of dairy cows. The Animal Needs Index (TGI, TGI 35L, TGI 200) (Sundrum et al. 1994; Bartussek 1999) gave an overall welfare score to the farms on the basis of assigning scores to the various aspects of the animal’s environment in the farms. These indices were ultimately used for farm certification, advisory and farmer support. The management conditions and the environmental parameters formed the major part of these index systems with minimal measurement of animal-based parameters. These systems have been adjudged as being flexible as predefined minimum standards were kept. In a single visit by trained assessor, the overall welfare measurement is done. These index systems have been found to be practical and repeatable (Schatz et al. 1996).

The French Animal Welfare Index emphasised the measurement of animal behaviour and interviewing of the farm owners in addition to the assessment of the farm housing and clinical examination of the animals (Johnsen et al. 2001).The French method of on-farm assessment of dairy cows' welfare utilised the five freedoms or dimensions of animal welfare for the evaluation of 42 animal-based parameters. The overall result of the assessment was listed in terms of five freedoms of animal welfare (Capdeville and Veissier 2001). The attainment of the freedoms of animal welfare cannot be described in a quantitative manner on a common scale but they can be converted into value scales separately. But even if the qualitative values of the indices are converted into quantitative numbers, it can lead to errors as the qualitative categories are different (Scott et al. 2001).

2.7.1 European Welfare Quality project (WQ) Index

The European Welfare Quality Project (WQ) from 2004-2009 is considered the most exhaustive welfare assessment protocol for cattle, pigs and poultry as it comes from a consortium of seven European countries. It was developed to help the owners and managers for identification of the welfare problems on their farms and assess the progress of their farms. Reliable indices of welfare through on-farm monitoring techniques for dairy cows and other domesticated species have been developed (Krug et al. 2015). The WQ assessment protocol for dairy cows measures 30 indices, 12 criteria and four animal welfare freedoms for evaluating a farm. The distinguishing feature of the WQ protocol is that it emphasises the animal-based measures which are indicative of the animal's interaction with its environment (Veissier and Boissy 2007; Botreau et al. 2009). This project interlinked the social values and concerns about animal welfare in the farm production systems with the development of appropriate indicators for measurement thus highlighting the value framework system (Kjærnes and Miele 2007).The previous measures of animal welfare concentrated on indices which were resource-based (Sørensen et al. 2001; Main et al. 2007; Calamari and Bertoni 2009).

The WQ is a system of welfare assessment at herd level in cattle, pigs and poultry based on opinion of experts, who account for the measurement of five freedoms through the measurement of four welfare principles viz. health, feeding, housing and behaviour, which are finally combined into a global welfare scoring (Welfare Quality 2009). In this protocol each principle is based on the measurement of two to four criteria. The WQ fills the gap of having different assessments for different animal welfare schemes by being an overall welfare assessment system which is scientifically valid and widely accepted by all stakeholders (Blokhuis et al. 2010). This welfare project generated considerable amount of data which was later on subjected to analysis to produce an overall evaluation model for the farms being assessed. The WQ has a very dynamic process of construction and development of welfare assessment protocols. It followed a process of development of measures by following four principles 'Good health', 'Good feeding', 'Good housing 'and 'Appropriate behaviour'. The overall assessments of farms as individual units lead to the decision making for welfare improvement by the parties concerned (Botreau et al. 2009).

The feasibility of the WQ protocol has been questioned for its implementation on the farms due to its time consumption and the expenditure involved (Knierim and Winckler 2009). The further criticism of the WQ protocol has been on the excessive importance given to the good feeding and good housing aspects of welfare principles than others which is against the goals of the protocol. Moreover, the usefulness and validity of the single welfare measures in the complete summing up of the welfare score, the bias of interpretation due to different interpreters and the treatment of missing data has also been questioned (Heath et al. 2014a). This protocol has its weaknesses as it relied on a small number of categories and it needed an expert for assessing it on the farm and further advising the farms to address welfare issues in the farms.

An improvised version of the WQ protocol has been devised to answer the feasibility aspect by using the "iceberg indicators" from animals (Heath et al. 2014b). Researchers have advocated a larger sample size of the farms to be assessed with a stronger study design and care towards the validity of the protocols for grading of on farm animal welfare (Krug et al. 2015). A convenience sample should not be used for descriptive studies which aim to represent parameters of a population (Dohoo et al. 2009a). A countrywide attempt to report the overall health of dairy cows in welfare terms, representative of French dairy herds, acknowledged the selection bias in their recruitment method of sample herds (Coignard et al. 2013).

All the contemporary welfare quality based schemes are based on animal husbandry measures i.e. the resources and records. This is due to the ease of objective assessment through records and for the regulation of the farm production methods. The end point of these assurance schemes is the welfare of the animals in the face of the stress of production. An assessment of the reduction in the time for practical application of a reduced protocol of the WQ indicators by replacing some indicators by predictions based on remaining animal and resource-based indicators has been evaluated (de Vries et al. 2013b). The reduction of the indicators of assessment in the WQ protocol does affect the assessment results and hence the use of predictions as replacements for omitted indicators is not recommended. The use of additional data, automated animal monitoring gadgetry like videos recordings, activity sensors which could replace direct measurements on animals, is not recommended as the costs involved will be a limiting factor.

Studies have also been conducted on the replacement of the animal-based indicators with more easily accessible resource-based indicators to save time and costs if a close relationship is observed between these parameters (Waiblinger et al. 2001; Winckler et al. 2003). But it was concluded that there was a wide variation in farms on these parameters and these variations could only be measured by the animal-based parameters which cannot be replaced (Johnsen et al. 2001; Mülleder et al. 2007). Consequently, a welfare assessment method based on welfare indices through the use of secondary sources of animal-based data such as farm register data has been devised (Otten et al. 2016). The researchers tried to find out the correlation of welfare assessments based on primary animal-based measures and those based on secondary data sources. A method of welfare assessment was devised for cutting cost and time of measurements by identifying alternative cheap and easily accessible indicators (de Vries et al. 2011). The lack of association between resource-based measures and animal-based measures warrants a through on form welfare assessment approach rather than the remote assessment of the farm records (Andreasen et al. 2013; Otten et al. 2016).

An assessment of animal welfare based on the animal-based observation methods in loosely housed dairy herds through the listing of welfare indicators and patterns by giving a score to each of the indicators provides a composite animal welfare assessment (Capdeville and Veissier 2001). In this study, the researchers initially consulted six experts for approval of the indices they had selected for measurement on the animals. This protocol thus developed was tested in five farms initially to check the practical possibility of recordings. Then 70 dairy farms were administered this protocol for checking and verification of the index scores. The study concluded that the indices needed to be checked for validity, repeatability and specificity. The weighting of the indices can be done by external validation of the protocol to another expert panel.

2.7.2 Operational Welfare Assessment Tool

This is a collection of risk factors, influencing factors along with the animal welfare indicators. This model takes into account the health, behavioural factors and assigns a norm value for each indicator as an operational welfare tool for assessment on the farm in dairy cows (Waiblinger et al. 2001). The emphasis has been given to the interaction of these influencing factors as a limited knowledge of this interaction has been found in literature such as the interaction between lameness and social behaviour. The examination of relationships and the quantification of the relationship between the parameters has been advocated. Logical regression and path analysis were suitable tools to quantify the interactions in this assessment model. The limitation is on defining the limits between good and bad welfare levels, determination of norm values and the differences in the perceptions of veterinarians and ethologists leading to the loss of information.

2.7.3 The Bottoms up Approach

This is a decision support system to the farmer for improvement through the combination of welfare indicators of animal behaviour and health into an aggregated system which is applicable on a farm (Rousing et al. 2001). The two indicator groups, animal behaviour and animal health are direct measurements. The behaviour measurements depict the adaptability of the animals to the current farm management system and are assessed as per the knowledge about normal behaviour patterns of the animals. The health indicators are depicted by the prevalence and incidence of the diseases in the farm which can be measured by clinical examination of the animals. This is further elaborated by the fact that each animal being measured can provide specific and contextual information to solve a welfare problem. These indicators are applied in addition to other indirect welfare indicators to construct an applicable system which takes into account the risks associated with welfare problems and the causal relations. A process of development of an animal welfare protocol in which selection of quality indicators, their relevance, informational value and suitability to the assessment protocol has been detailed and recommended. This approach is different from the Animal Needs Index (ANI) (Bartussek 1999) which focuses on the husbandry and housing aspects of management to build a protocol of welfare assessment which is a “top-down approach”.

2.7.4 Benchmarking

Benchmarking has been used as a technique for assessment of dairy cow welfare by evaluating the feedback on animal-based and facility based measures (von Keyserlingk et al. 2012). The evaluation of the performance of herds in comparison to the averages from others is done and the deficiencies are highlighted. The causes of welfare outcome assessments of similar parameters can be different. The intention was to provide information about good welfare practices as well bring out changes in the existing practices for sustainable welfare practices.

2.7.5 Adaptive Conjoint Analysis (ACA)

A protocol of selection of indicators for the assessment of welfare in dairy cattle by eliciting the rankings provided by experts about the indicators to be included and assessment methods to be followed has been recently developed (Lievaart and Noordhuizen 2011). The indicators to be measured must be feasible and transparent. An Adaptive Conjoint Analysis (ACA) technique has been followed to rank the observations on indicators provided by experts through an online interview of the experts and to assess the suitability of animal welfare assessment methods used in protocols. 24 experts from 12 nations in Europe were interviewed to rank indicators for animal welfare assessment in dairy cow herds and as per the consistency of these experts, the welfare indicators were ranked for utility in an assessment protocol.

The ACA technique has been claimed to be practical as it achieved consistency among the internationally acclaimed experts as per the selection criterion even for indicators which were not considered widely applicable earlier. It is fast, objective, consistent, having quicker access to the experts and cheaper. Arbitrary values were fixed for indicators measured on a scale which could have influenced their ranking in the protocol. Less commonly followed welfare indicators in worldwide assessment protocols were not included. The other disadvantage of these ACA techniques is that once the questionnaire is sent to the participating experts it cannot be further improved which is in sharp contrast to the Delphi technique (Linstone and Turoff 1975). But Delphi can be run after this analysis and reduce the number of parameters systemically.

2.8 Ethical decision-making regarding animal welfare

Widely accepted indicators should be selected for welfare assessment which encompass the views of farmers, general public and scientists through a process of deliberation. This accommodates the sharing of views with no selfish interests in a legitimate and fair way (Sørensen and Fraser 2010). The goal should be of having a set of mutually agreed indicators. This is possible through the on-farm visits of all stakeholders for experience on the range of welfare conditions. A minimal level of acceptable welfare standards should be set up again through a process of deliberation between the stakeholders through communication and negotiation or through data collection as done in other studies (Grandin 2006). This needs fairness on the part of all parties for credibility of the assessment system. The measurement of the animal welfare indicators should be efficient in terms of time and cost. This is possible through exclusion of indicators which show duplicity and selecting that indicator among many which can be measured in a shorter time. This type of selection ensures scientific as well as social validity to the indicators of animal welfare selected for assessment (Sørensen and Fraser 2010). The ethical accounting model for welfare assessment of the farm provided detailed information of the welfare situation of a farm under study. The one and half hours assessment of a farm was based on environmental, behavioural, management and animal-based parameters measured through inspection, visualization and assessment of farm records. The welfare report was provided to the farmers delineating the various shorting comings along with advice about the improvements to be done (Jensen and Sørensen 1998).

More research is being done through the integration of behavioural and cognitive science, stress physiology, neuroscience and animal physiology to produce evidence of complex emotional intelligence capabilities of animals (Boissy et al. 2007a; Mendl et al. 2009; Green and Mellor 2011).

The monitoring of welfare of a particular given situation over a period of time is the challenge for the assessment agencies as to how the welfare outcomes vary with seasons throughout the year. This requires time and financial costs which most of the times are constraints. There have been suggestions for referring to farm records provided they are accurate and having automated monitoring cum assessment systems (Turner and Dwyer 2007; Vanderhasselt et al. 2014). As a consequence of research in functional cognition in neuroscience (Mendl et al. 2010; Mellor 2012), emphasis is needed on the development of indicators for positive welfare and emotion which indicate the good life of animals (Farm Animal Welfare Council 2009). These include play, exploration, vocalisation, grooming and social behaviour (Boissy et al. 2007b). The problem of including these indicators in a protocol is that these behaviours are displayed too infrequently even when conditions are there to express them but still their monitoring and promotion is a step forward in the promotion of good welfare (Wemelsfelder 2007). The assessment of animal welfare through activity measurements using neck or leg sensor devices (Manson and Leaver 1988; Sprecher et al. 1997) are not useful techniques to measure animal welfare (Lievaart and Noordhuizen 2011).

The development of qualitative behaviour indicators presently suffer from validation and their practical application though they consider the whole animal as a sentient single unit of scientific observation. The rich terminologies for describing these indicators helps in assessment of the dynamic nature of the assessments for which physical indicators are difficult to be found. These qualitative welfare indicators will help in assessing the communication behaviour of the animals and ultimately improve the quality of life of animals (Wemelsfelder and Mullen 2014).

2.9 Parameters as indicators of animal welfare in cows

The selection of appropriate parameters for on-farm welfare assessment in cattle is essential for formulating a scientifically acceptable welfare assessment protocol in a single visit to the farm. As described earlier, the parameters are selected on the basis of their validity, reliability and feasibility (Winckler et al. 2003). There are interactions between indicators in a given farm situation such as the stall dimensions that can have an effect on the cattle welfare as it has associations with lameness, cleanliness and skin injuries (Zurbrigg et al. 2005b). The body condition scores, lesions on the carpal and hock and lameness interact with each other (Burow et al. 2013). However, a lack of interaction between animal-based measures and resource-based measures has been the reason for assessment of management in welfare studies (Andreasen et al. 2013). Many environmental factors are inter-related, for example, feeding regimes and walking surfaces where one may initiate a foot lesion and then a combination of the two set in motion a chain of events that worsen the condition. Improving just one of these inputs could go a long way in stemming the progress of serious foot disease (Cook et al. 2004). The various parameters which are indicators of welfare are

Lameness: It is one of the most serious welfare problems in cattle and it indicates discomfort and a painful state in animals.Lameness affects normal behaviour, locomotion and the movement of the animals to the facilities provided for it and hence affects the welfare of the animal (Phillips 2002). Many lameness scoring scales have been formulated for cattle based on points such as a four-point scale (Breuer et al. 2000a), a nine-point scale (Manson and Leaver 1988), a five-point scale (Winckler and Willen 2001). Locomotion scoring patterns have been developed and a correlation between claw lesions and pattern of locomotion has been found (Winckler and Willen 2001; O Callaghan et al. 2003). Mobility scoring has also been used as a measure of welfare assessment (Main et al. 2012b). This condition may be caused by many factors such as unbalanced nutrition, flooring, social behaviour and time spent standing (Winckler et al. 2003).

Claw overgrowth: The percentage of animals with poor claw confirmation and claw overgrowth should be considered in the welfare assessment (Whay et al. 2003c). A four-point scale has been formulated for assessing the claws of the fore and hind feet separately (Huxley and Whay 2006c). The examination of the claws details the exact pathology of the lameness but is time-consuming and needs expertise (Winckler et al. 2003).

Injuries and swellings: The lesions and swellings on the animal body are indicative of the effects of the animals' surrounding environment on its body (Ekesbo 1984). These injuries and alterations occur due to the contact with hard floors, cubicle walls and feeders (Winckler et al. 2003). There are scoring systems developed to assess the injuries to different body parts, the severity of the injuries or lesions and their sizes (Wechsler et al. 2000; Main et al. 2012b).

Cleanliness : Unclean skin and hair coat lead to itching and make the integument vulnerable to microbial attacks leading to its inflammation (Winckler et al. 2003). Cleanliness indices for dairy cattle have been developed using point scales on different body areas (Faye and Barnouin 1985; Scott and Kelly 1989; Main et al. 2012b). A relationship of cleanliness and mastitis has also been postulated (Valde et al. 1996). The assessment of body cleanliness gives an information about the comfort levels of the animals, the attitude and behaviour of the stockmen (Rosa et al. 2005). Cow cleanliness scoring has been attempted on a four point scale which includes the cleanliness of the hind limbs, udder and the flank. Dirty cows are associated with loose faeces and inadequate bedding and environmental management. Sub acute ruminal acidosis (SARA) can also lead to loose faeces and hence affects cow cleanliness which again indirectly indicates questionable nutritional management in a herd (Hughes 2001; Huxley and Whay 2006c).

Animal –human relationship : The avoidance distance (AD) of a cow towards an known or unknown person in the usual environment (barn, herd) has a more significant correlation with with the behaviour of the milkers (Waiblinger et al. 2002) rather than other indicators like approach test and flight distance (Breuer et al. 2000a; Hemsworth et al. 2002).

Housing factors : These indicators have been well described in the assessment tools based on resources (Bartussek 1999) but their validity and reliability are questionable. The welfare of the animals is not restricted to their normal functioning and performance but they should be able to develop and express themselves in their housing (Rosa et al. 2005).

Disease incidence /mortality : These are quite relevant to welfare but due to their low prevalence their direct assessment is difficult as this will need sophisticated diagnostic instruments and long term data recordings. This becomes difficult as most of the farms have insufficient record keeping and errors in the collected data (Winckler et al. 2003).

Body Condition Scoring (BCS) : It reflects the effects of food and nutrition during the previous weeks or months (Burkholder 2000). This is used to detect any sort of malnutrition or undernutrition in cows which does have a relevance in welfare assessment (Winckler et al. 2003; Rosa et al. 2005). It is an important factor in cattle management as it is the assessment of the proportion of the body fat a cow possesses and its values show the emaciation or obesity levels of the animal, hence a valid indicator of welfare (Roche et al. 2009). It is used as an estimate of the energy balance, body composition and body store in place of live weight change of the animal (Rosa et al. 2005). The effect of nutrition on the cows can be measured by body condition scores and these scores are indicators of the utilization of body energy stores for maintenance, repair and reproduction. It is a subjective method to semi-qualitatively assess the extent of subcutaneous body fat and muscle over the loins, the pelvis and tail head cavity of the cows and other animals (Mulvany 1981; Burkholder 2000; Zaaijer and Noordhuizen 2003). Scores are assigned to each animal on the basis of one or more characteristic which can be seen or palpated. It is a reliable indicator of nutritional and clinical status if performed in accordance with the specific protocols and can be an effective managemental tool for decision making on goals of optimal nutrition and reducing disease incidence . The suitable protocol is the one which assesses a number of regions of the animal and has detailed descriptions. It has been contended that this indicator has been currently underutilized for diagnosis, prognosis and monitoring purposes (Burkholder 2000).

Agonistic social behaviour : The occurrence of skin injuries in horned cows and the frequency of agonistic behaviour occurrences are positively correlated (Menke et al. 1999). In dehorned cows aggressiveness in the herds leads to blunt trauma like haematomas (Winckler et al. 2003). Social licking and other social behaviours involving contact can be recorded for a welfare assessment (Sato et al. 1991; Winckler et al. 2002).

Stockmanship : Human behaviour in the form of herd management and cattle handling as a stockman has influenced animal behaviour, physiology and productivity (Lensink et al. 2001;

Hemsworth et al. 2002; Waiblinger et al. 2002). This indicator can be assessed by direct observation of stockmen behaviour during their interactions with animals or by using questionnaires (Hemsworth et al. 2002; Waiblinger et al. 2002). But these methods of observation can be unreliable as the stockmen can change their behaviour when being observed and even the answers to the questionnaires can be unreliable. So, avoidance distance has been claimed to be a better indicator of the quality of the relationship between the stockmen and the animals. The quality of stockmanship can be assessed by using survey questionnaires for attitude and by direct observation of the stockmen behaviour while interacting with the animals (Hemsworth et al. 2002; Waiblinger et al. 2002). It is a very useful indicator being used in contemporary welfare assessments (Ebinghaus et al. 2016; Lürzel et al. 2018).

Stereotypies : Stereotypies have been shown to develop in dairy cows which are tethered or time spent on such a behaviour is increased (Redbo 1990). In restricted spaces in the farms forced social contact occur amongst the animals as animals have fewer chances to move away from aggressive herd mates especially when animals are not dehorned and are free to show agonistic behaviour (Grasso et al. 2003; Napolitano et al. 2009). Social hierarchy in a herd is based on the age, weight and seniority with first calving cows rank low in the hierarchy, suffer from more skin and udder injuries (Grasso et al. 2003; Rosa et al. 2005; Napolitano et al. 2009).

Positive welfare indicators : Social licking is considered a tension relieving behaviour in cattle which stabilises the social hierarchy in a cattle herd (Winckler et al. 2002; Wasilewski 2003). This behaviour of allogrooming has been found to improve milk yield and weight gain (Wood 1977; Sato 1984). Comfortable lying postures of the cattle in the herds indicates more thermal comfort, less distress and more confidence in the given environment (Grasso et al. 2003). Positive emotional states include playfulness, pleasure, contentment, comfort and curiosity (Mellor 2012).

Rumen fill : Rumen fill is used as a welfare indicator providing information on the nutritional efficiency in a herd as it gives faster information than the body condition score. It is the outcome of the dry matter intake, ration composition, digestion and passage rate of the ingested feed (Zaaijer and Noordhuizen 2003). Digestibility is the outcome of the time interval the feed remains in the rumen and the character of the nutrients in the engulfed feed for digestion (Forbes 1995). Standing at the left hind side of the cow the paralumbar fossa between the last rib, the transverse process and the hip bone is observed and scored (Zaaijer and Noordhuizen 2003). The rumen health can be assessed by this scoring system (Huxley and Whay 2006b).

Faecal consistency : Faeces provide important information about nutritional management and digestion in cows (Ireland-Perry and Stallings 1993). The consistency of the faeces is affected by the proportion of the water to dry matter ingested as the undigested feed makes up the dry matter portion of the faeces. This characteristic of a cow also gives faster information on the nutritional aspect of the herd. The freshly dropped faeces are observed and assessment is done visually as well as application of a boot test (Zaaijer and Noordhuizen 2003). The faecal consistency in cows is also scored for analysis of the nutritional status in the herd and the dry matter intake of the herd can be assessed (Huxley and Whay 2006b).

Coat Condition : This has been used as a welfare indicator in a cow herd though the results could not be interpreted easily. It indicates the long-term health of the herd or the prevalence of sub acute ruminal acidosis (SARA) or the environment in the herd (Huxley and Whay 2006b).

Water resource : Studies have shown a correlation between quantity of milk produced/lactational stage and demand for water. If thermal stress is added to restricted water intake, then apart from milk production, welfare too can be significantly compromised (Costa et al. 2013). Cattle have been shown to consume more water when offered ad libitum rather than intermittently. Conversely, natural sources (ponds) rather than troughs, thoroughfare locations of water source and inadequately sized troughs have all shown to decrease water intake.Since water intake is not easy to measure directly, indirect measures that have been shown to have an association with water intake, such as number of animals per drinker, length of water trough and water flow (de Vries et al. 2011).

Housing: Housing can contribute significantly to welfare of dairy cattle (Bartussek 1999; Bowell et al. 2003; von Keyserlingk et al. 2012). Studies have found that stocking density, housing design, type of bedding, access to grazing and condition/gradient of flooring can all have an impact on lameness, claw lesions as well as cow cleanliness (Cook 2002; Bowell et al. 2003; Cook et al. 2004; Abeni and Bertoni 2009). Concrete floors, due to their unyielding nature have been shown to cause more hock/knee injuries and claw lesions whereas sand, straw or sawdust have proven to be best for foot health, rumination and lying behaviour (Cook et al. 2004; Haskell et al. 2006; Abeni and Bertoni 2009). Optimal flooring conditions include a clean, dry and soft lying area and slip-resistant walking areas (Bartussek 1999; Abeni and Bertoni 2009). Light intensity, noise and air quality/ventilation also have a profound impact on the physiology, fertility and behaviour (Bartussek 1999). Cubicle housing has been associated with more agonistic behaviour and lameness, especially with higher stocking densities (Abeni and Bertoni 2009).

2.10. Conclusions

In the developing countries, as the literacy and awareness levels are improving and due to the greater involvement of animal welfare cum animal protection organisations, animal welfare issues are garnering more attention from the public, consumers as well the governments. The repercussions of certain taboos like the prohibition of cow slaughter in predominant Hindu countries like India has led to the presence of a large number of street cattle which are abandoned due to old age, infertility, non-productivity and inability of the farmer to feed them. This has led to human –animal conflicts. Moreover, the religious sentiments are touted as typical examples of moral hypocrisy. All these issues are the driving factors for the scientific community to take up the challenge of addressing the animal welfare issues in developing countries on the basis of scientific identification, measurement and finally providing methods to improve them. This should be the basis of the ongoing research in the animal welfare field through the assessment of animal welfare in the practical farm situation based on certain indicators of animal welfare.

The welfare of cows in the gaushalas has not been assessed. A general perception is of the adequacy of welfare provisions in light of the traditional sanctity of the cows in the Hindu religion. There is no report in the literature on the welfare assessment of the gaushalas and the development of welfare index for the cows in the gaushalas. There are few studies on gaushalas on outbreaks of acidosis (Kataria and Kataria 2009), incidence of foot disorders in which some gaushalas were screened in addition to commercial dairy farms (Bagate et al. 2012) and evaluation of antigen testing of Johne's disease in gaushala animals (Kaur et al. 2011; Pahangchopi et al. 2014; Singh et al. 2015a). Breeding values of bulls through progeny testing has been attempted in gaushala animals (Singh et al. 2008; Dalal and Khanna 2010). These gaushalas are in fact commercial dairies and are misnomers as gaushalas as breeding trials can be conducted on healthy lactating cows which is not the mandate of the gaushalas. A digitalized inventory of gaushalas and its animals has been prepared for the recording cattle genetic resources in one state of India (Yadav and Vij 2010) but the gaushalas were again commercial dairies rather than housing abandoned, stray, aged and infertile cows. Similarly, a study has been done on the conservation of indigenous livestock breeds in the gaushala system in the same state but in fact it pertains to the dairy animals kept for breed conservation purpose yet again in the commercialised dairies working in the garb of gaushalas (Kumar et al. 2009).

The measurement and assessment of animal welfare at the gaushalas in India through a scientifically based assessment of their sustainability will enhance the sensitivity among the donors, the government and the general public leading to more accountability. The development of an animal welfare assessment protocol will establish guidelines to reassure the stakeholders of the gaushalas that minimum standards have been met. There has been a progressive increase in the number of gaushalas and their size in India parallel to the increase in the number of street cattle. There has been strong public support, materially as well as morally, to these gaushalas and it becomes imperative to regulate the welfare of the animals housed in these institutions. The rapid mushrooming of these institutions could have a negative impact on the lives of the cows being sheltered. There can be a disparity between the general population and the gaushala management regarding their attitudes towards the cows. The gaushala management might have a perception that the public is not knowledgeable about cow management and vice versa.

The animal welfare protocol in general for the gaushalas will serve as a benchmark for the animal welfare requirements at the gaushalas by prescribing the minimum standards of provision of resources and management. This protocol might ensure compliance to the adequate welfare provisions for the gaushala cows. The protocol will in due course provide a coordinated national response to the animal welfare issues in the gaushalas leading to the development of more inclusive, practical and scientifically based animal welfare guidelines for the management of gaushalas. This is a precursor to a welfare audit of the gaushalas on a periodic basis by the identification of welfare and societal concerns gained by inputs from independent experts and the stakeholders. Such a type of welfare auditing should ensure best practices and set goals for improvement.

Publication included in Chapter 3

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Author Contributions to the paper

The conceptualization, design and methodology was done by Arvind Sharma, Clive J.C Phillips and Catherine Schuetze. The data collection and investigation was done by Arvind Sharma and Uttara Kennedy (in two states of the study and in measurement of resource-based parameters). The formal analysis and interpretation was done by Arvind Sharma and Clive J.C Phillips. Original draft of the paper was prepared by Arvind Sharma. The writing review was done by all the authors.

Chapter 3

Overview of the welfare of cows in Indian shelters

3.1 Abstract

Cow shelters (gaushalas) are unique traditional institutions in India, where aged, infertile, diseased, rescued, and abandoned cows are sheltered for the rest of their life, until they die of natural causes. These institutions owe their existence to the reverence for the cow as a holy mother goddess for Hindus, the majority religion in India. There is a religious and legal prohibition on cow slaughter in most Indian states. A cross-sectional study was conducted to assess the welfare of cows in these shelters, which included the development of a welfare assessment protocol, based on direct animal-based measurements, indirect resource-based assessments, and description of the herd characteristics by the manager. A total of 54 cow shelters in 6 states of India were studied and 1620 animals were clinically examined, based on 37 health, welfare, and behavior parameters. Thirty resources provided to the animals, including housing, flooring, feeding, watering, ease of movement, cleanliness of facilities, lighting, temperature, humidity, and noise levels in the sheds were measured. The study showed that the shelters contained mostly non-lactating cows, with a mean age of 11 years. The primary welfare problems appeared to be different to those in Western countries, as the major issues found in the shelters were facility-related—the low space allowance per cow, poor quality of the floors, little freedom of movement, and a lack of pasture grazing. Very few cows were recorded as lame, but about one half had carpal joint hair loss and swelling, and slightly less had lesions from interacting with shelter furniture. Some shelters also had compromised biosecurity and risks of zoonosis. These issues need to be addressed to aid in ensuring the acceptability of these institutions to the public. This welfare assessment protocol aims to address the welfare issues and problems in the shelters, by providing feedback for improvement to the stakeholders.

Keywords: India; cow shelters; gaushala; welfare; assessment

3.2. Introduction

India has the largest cattle population in the world, with more than 190 million cattle (Department of Animal Husbandry 2014), used primarily for dairy and draft purposes. Most rural people own a few cows but have limited land for grazing, especially as the human population has encroached upon their traditional grazing lands, leading to cows roaming freely in the streets and causing traffic problems. In some states, crop raiding by street cattle has led to significant human-animal conflict (Athreya 2006), and there are many fatal road accidents involving cattle on the streets (Bentinck 2000; Fitzharris et al. 2009; Arnold 2012).The majority of the Indian population follow Hinduism, which has strong influences on animal husbandry, in particular, on euthanasia. Euthanasia of species of animals, other than cattle, is considered and carried out by registered veterinarians. However, whilst euthanasia in cows in extreme cases is allowed under the law and is condoned by the Animal Welfare Board of India, it is culturally problematic and, therefore, not often practiced (Fox 1999; Animal Welfare Board of India 2013; Jegatheesan 2015). Street cattle overpopulation is an emerging social and public health problem, especially, in the light of the prohibition of cow confiscation and slaughter in most states (Ghatak and Singh 2015). The large cattle population of India is also partly due to the ancient tradition of sheltering, feeding, and caring for cattle, after they have ceased production (Chhangani 2009). In most Indian states there are cow shelters or sanctuaries, termed '*gaushalas*', or for more recent shelters '*go sadans'* (hereafter, collectively termed 'shelters'), where abandoned, infertile, and chronically ill cows are sheltered by philanthropists, animal protection organizations, religious organizations, and religious temple trusts. Shelters play a significant role in the management of stray cattle in India (Singh et al. 2013), but might have inadequate space, leading to unhygienic conditions (Solanki 2010; Yadav and Vij 2010). Transfer of cattle between shelters is rare, usually only occurring if a single organization manages several shelters. There are, approximately, 3000 care shelters for old and infirm cows (Alavijeh 2014), though the exact number is not known (Singh et al. 2013). There are 1837 gaushalas funded by the Government of India, through a central statutory body—the Animal Welfare Board of India (AWBI) (Animal Welfare Board of India 2016b). The AWBI provides funds for the management and infrastructural needs of cows in affiliated shelters.

No scientific assessment of the welfare of stray and abandoned cows in shelters has yet been attempted, apart from the testing of vaccines against paratuberculosis (Kaur et al. 2011; Singh et al. 2015b). As a result, there are no audits, although protocols for the assessment of the welfare of dairy cattle have been developed and validated, using a field-based protocol that is mainly relevant to Western production systems (Johnsen et al. 2001; Kelly et al. 2011; Main et al. 2014). There is a lacuna in the literature and in the Indian animal industries, generally, about the use of indicators to assess welfare in non-productive shelter cows. It is sometimes assumed that the welfare of the cows in gaushalas is worse than those kept in farms under semi-intensive or intensive conditions, as the cows have outlived their commercial utility (Nair 1986), and they just bear a sentimental value for the Indian society. In this study, the objective was to measure relevant aspects of welfare, using an assessment protocol similar to that used for commercial cattle enterprises.

3.3 Materials and Methods

The animals, resources, and the management-based measures used to assess cattle welfare in different welfare assessment protocols for dairy and beef cattle industries were first reviewed. Potential measures were discussed with a group of experts selected by us (animal welfare scientists (n = 4), veterinarians (n = 4), veterinary epidemiologists (n = 2 and veterinary clinicians (n = 2) in a one-day stakeholder workshop in Delhi in November 2016. Each identified measure was considered for its relevance to a typical Indian sheltered cow scenario. The Welfare Quality® Protocol (Canali and Keeling 2009) objective of good feeding, housing, health, and appropriate behaviour, was used as the guiding directive. As a result of the discussions, 37 animal-based, 31 resource-based, and 35 management-based measures were selected, which were considered relevant, feasible and suitable for an on-field welfare assessment of cow shelters. Most of the animal-based measures selected for this assessment had been tested and validated in previous welfare assessment studies on cows (Johnsen et al. 2001; Canali and Keeling 2009; Napolitano et al. 2009; Rouha-Mulleder et al. 2010; Kelly et al. 2011; de Vries et al. 2013a; de Vries et al. 2013c; Main et al. 2014).

The study was endorsed by the AWBI, which provided the contact details of 34 shelters. The animal assessment component was approved by the Animal Ethics Committee of the University of Queensland (Approval Number: SVS/CAWE/314/16/INDIA). The assessments took place from December 2016 to July 2017. A power analysis (Creative Research Systems, www.surveysystem.com/sscalc.htm) indicated that a sample size of 50 shelters would adequately represent the shelters in the major Indian states. Hence a total of 54 cow shelters were selected from 6 states of India, five of which have the predominant cow shelter population in India (Gujarat, Maharashtra, Rajasthan, Punjab, and Haryana) and one state (Himachal Pradesh), which was at that time establishing many new cow shelters (Anon. 2016). Following discussion with key stakeholders, the criteria for shelter inclusion in the study were—a minimum of 30 cows, that it was not a commercial dairy unit (where commercial indicates that more than 20 L milk per day was being sold), and that the shelter was managed by a philanthropic, temple, government, or public trust. Out of the 54 shelters, 26 shelters were visited on the advice of state veterinary officers, which fell within their administrative jurisdiction and the AWBI, and the remaining shelters were obtained using a snowballing technique, taking recommendations from shelter managers that were visited. There was no significant difference ($p < 0.05$) between shelters obtained by the two methods in any measured parameter, when compared by analysis of variance or a Moods median test (in the case of non-normal residuals in the ANOVA model).

Within each animal shelter, resource and manager-based assessments were conducted. For the animal-based assessment, 30 animals were selected per shelter, as recommended, following a power analysis. Only primiparous and multiparous cows were selected; calves, bulls, steers, or preparturient heifers were not selected. This selection of cows was the same for each shed, within a shelter—every third cow in a line, group, or side of a shed, was selected, irrespective of the distance between them, up to a total of 30. In the case of the different lines of tethered cows or cows being housed in more than one group, an equal number of cows was selected from each line, group, side of a shed (where it was bisected by a passage) or shed (if >1). The assessments for the animal-based measures took place on one day in each gaushala, beginning at 09:00 hours, approximately one hour after the cows were fed.

Pilot trials were also done to validate the chosen measures in the two shelters before the commencement of the actual data collection. If there was more than one shed in a shelter, cows in a maximum of the two sheds were measured.

3.3.1. Interview with the Shelter Manager

The shelter visit started with an interview with the shelter manager, using prepared questions. These included the total number of cattle in the shelter, the types of cattle shed, annual mortality rate, provision of pastures for the cows (dichotomous, present, or absent), mean daily time (hours per day) spent by cows at pasture and yards, and source of water supply (municipal, well, natural, or potable water supply). Shed cleaning method and schedule (Cook 2002; Otten et al. 2016), feeding schedule, fodder type, variety and quantity fed to the cows, were both recorded from the interview, and confirmed by visual inspection of the premises. The shelter manager was asked what the vaccination schedule was for cows in the shelters; whether raw milk or urine was sold (the former to confirm the selection of the shelter according to criterion of this study); and about the deworming protocol, disposal of dung, use of veterinarians' services, disposal of carcasses, biosecurity measures, and disease outbreaks over the last five years.

3.3.2 Animal-Based Measures

A two day low-stress livestock handling course and a three month training was undertaken, in scoring the cows for assessment of body condition, lameness, claw overgrowth avoidance distance, dirtiness, limb lesions (joint hair loss, ulceration and swellings), skin lesions, rumen fill, faecal consistency, and rising behavior, at the School of Veterinary Science, The University of Queensland. The age, breed (classified as indigenous, crossbred with indigenous breeds, crossbred with exotic breeds, such as Holstein Friesian or Jersey, or exotic), lactation status, presence or absence of horns and presence or absence of identification (ear tags, branding marks) were ascertained from a general inspection of each animal, an oral examination, and discussion with the manager. In this study each cow was restrained for the animal-based measurements, restricting the expression of temperament. Therefore, each sampled cow's temperament was assessed during restraint on a simple dichotomized scale (docile or aggressive), which was loosely derived from a five-point scale (Cafe et al. 2011), for loosely restrained cattle in a particular area of the barn. The Cow Comfort Index (CCI) (Krawczel et al. 2008), was modified for shelter cows, by counting the number of cows lying down in the sheds, described as a proportion of the total in the shed. The animal-based measures used in the study have been summarized in Appendix 1.

3.3.3. Measures on Selected Cows

The avoidance distance (AD) was assessed at the beginning of each shelter visit, one hour after morning feeding, as prescribed by the Welfare Quality® protocol (de Vries et al. 2014b). A cow was approached from immediately in front of each animal, at a rate of 1 step per second, starting at 2 m from the manger. The distance between the assessor's hand and the cow's head was estimated at the moment the cow moved away or turned its head, in the following four categories—touched, and hand within 50, 51–100 cm, and >100 cm. For each shelter, the median AD classification and percentage of cows which could be touched on the head were calculated. In the shelters where cows were tethered, they were untied and moved outside the shelter, to assess AD and lameness, and then retied for all remaining animal-based measures. Body Condition Score (BCS) was determined using a 1–5 scale (Edmonson et al. 1989; Thomsen and Baadsgaard 2006), and scored to quarter points. A cow with a score of ≤ 1.25 was considered emaciated, 1.5–2 was labelled 'thin', 2.25–3.75 was labelled 'normal', and 4 or more was labelled 'obese'.

Lameness scores were attributed using a numerical rating scale for walking cows (Flower and Weary 2006): '1'—'not lame' (smooth and fluid movement); '2'—'mildly lame but not easily observable' (an imperfect gait but able to freely move with a mildly arched back); '3'—'moderately lame' (able to move but not freely, with an arched back); '4'—'lame', (unable to move freely with an asymmetrical gait and abnormal head movement); '5'—'severely lame' (severely restricted in movement, requiring considerable encouragement to move, and a severely arched back). Claw overgrowth was assessed by the visual inspection of each sampled cow, using a four-point scale (Huxley and Whay 2006c): '0'—'normal claws'; '1'–'3'—representing 'mild', 'moderate', and 'severe' claw overgrowth, respectively.

Rising behaviour of a sample of 30 cows that were lying down in each shelter was categorized using an existing protocol (Rousing et al. 2004; Chaplin and Munksgaard 2016). All cows lying in the shelter were coaxed to get up with the use of a minimum amount of force. If the presence of the assessor did not evoke rising (as happened with four cows), they were given one or two moderate slaps on the back, followed by more forceful ones if necessary. Rising behaviour was categorized as follows: '1'—'normal' (smooth and a normal sequence of rising behaviour); '2'—'easy, but slightly interrupted' (smooth movement with slight twisting of the head but with normal sequence of rising process); ‘3’—‘uneasy, with effort’ (sudden movement and difficulty in rising with awkward twisting of the head and neck, but following a normal sequential rising process); ‘4’—‘abnormal’ (uncharacteristic sequence of a rising event); ‘5’—‘refused to get up’. Rising restrictions caused by the shelter facilities were scored according to a four-point scale (Huxley and Whay 2006): ‘0’—‘unrestricted’ (cow is able to rise as if it were in a pasture); ‘1’—‘mild restrictions’ (cow is able to modify standing to rise comfortably as it lunges sideways and not forwards); ‘2’—‘cow takes time to rise and hits shed fixtures or fittings while rising’.

Swellings, hair loss, and ulcerations on the hock and carpal joints were scored according to an established scale (Wechsler et al. 2000; Whay et al. 2003a; Whay et al. 2003d): ‘1’–‘3’, representing ‘mild’, ‘medium’, and ‘severely’ swollen joints, respectively. Hock joint hair loss and ulceration were described on a similar scale (Wechsler et al. 2000; Whay et al. 2003a; Whay et al. 2003d): ‘0’—‘no hair loss or ulceration’; ‘1’—‘mild hair loss or ulceration < 2 cm^2’; ‘2’—‘medium hair loss or ulceration, approximately 2.5 cm^2’; ‘3’—‘severe hair loss or ulceration > 2.5 cm^2’. Carpal joint injuries were scored as: ‘0’—‘no skin change’; ‘1’—‘hairless’; ‘2’—‘swollen’; ‘3’—‘wound’ (Wechsler et al. 2000).

Dirtiness of the hind limbs, udder, and flanks was classified by visual inspection of the cows from the left, right side, and from behind (Whay et al. 2003d): ‘1’—‘no dirtiness’; ‘2’—‘mildly dirty’ (small soiled areas of dirtiness with no thick scabs); ‘3’—‘medium dirtiness’ (large soiled areas but with < 1 cm thick scabs of dung), and ‘4’—‘severely dirty’ (large soiled areas with > 1 cm thick dung scabs). The condition of the coats of the sampled cows was assessed on a slightly modified (from the reference scale) 3-point scale (Huxley and Whay 2006b) as: ‘1’—‘dull and short’; ‘2’—‘shiny and short’; ‘3’—‘dull and hairy’. Ectoparasitism was assessed through a modification of the scoring pattern devised by (Popescu et al. 2010): ‘1’—‘absence of ectoparasites’; ‘2’—‘mild infestation’ (no lesions, not easily visible by the naked eye, only on tactile perception in the neck region); ‘3’—‘moderate infestation’ (visually observable ectoparasites or immature forms or eggs in the neck, groin, perirectal, tail root and switch regions); ‘4’—‘severe infestation’ (observable mature ectoparasites over much of the body, especially regions mentioned in score 3).

Lesions were predominantly acquired from shelter furniture as a consequence of interaction with sharp nails/metals protruding from shelter gates, broken mangers, broken edges of shed walls, barbed wire fencing, and manifested in the form of hair and tissue loss. Sharp lacerations and avulsion of the skin were described by using a 3-point scale (Huxley and Whay 2006c): ‘0’—‘normal’ (no lesions present); ‘1’—‘small area of hair loss’; ‘2’—‘moderate area of hair loss or thickening of the skin’; ‘3’—‘severe’ (a large area of hair loss or breakage of the skin). Other skin lesions or integument alterations were recorded as: ‘0’—‘normal’ (no apparent lesions); ‘1’—‘mild hair loss’ (<2 cm^2); ‘2’—‘moderate’ (>2 cm^2 hair loss and inflamed skin); ‘3’—‘severe’ (a large >4 cm^2 area of hair loss with extensive skin inflammation and breakage) (Leeb et al. 2004).

The protocols for teat and udder scoring, skin tenting time, and presence of oral lesions, were designed by the authors, because it was anticipated that emaciation, teat, and udder abnormalities, oral infections, and the presence of very old cows would be more common in the shelters than in dairy cow farms, for which other scales have been developed. The assessment of skin turgor in cattle is a measurement of the time a skin tent takes to return to its original position and is a practical way of assessing dehydration (Constable 2003; Jackson and Cockcroft 2008; Roussel 2014). It was assessed with the following scale: ‘1’—‘≤ 2 seconds’; ‘2’—‘>2 seconds ≤ 6 seconds’; ‘3’—‘>6 seconds’. The scales for other parameters were, oral lesions: ‘0’—‘absent’, ‘1’—‘present’; teat and udder: ‘1’—‘normal teats and udder’; ‘2’—‘dry udder and teats’, ‘3’—‘teat cracks’, ‘4’—‘warts on teats and udder’; ‘5’—‘acute lesions on the teats and udder’; ‘6’—‘chronic lesions on teats and udder’.

Neck lesions were classified as: ‘1’—‘no observable skin change’; ‘2’—‘hair loss’; ‘3’—‘swollen’; ‘4’—‘closed wounds’ (hematomas or closed abscesses); ‘5’—‘open wounds’ (Kielland et al. 2010a). Respiratory problems were measured as the presence or absence of coughing in any of the 30 cows sampled in the sheds, during the total examination period of the sampled cows in each shed. Ocular lesions, nasal discharge, hampered respiration, diarrhoea, and vulvar discharge were assessed on a binary scale, i.e., present or not absent in the sampled cows (Coignard et al. 2013).

Rumen Fill Score is a tool recommended as a key signal for poor health (Aalseth 2005; Hulsen 2005). It indicates the total amount of liquid and dry matter in the rumen, and is a function of dry matter intake, feed composition, digestibility, and rate of passage through the gut (Hartnell and Satter 1979; Aitchison et al. 1986; Llamas-Lamas and Combs 1991). It was visually scored (Zaaijer and Noordhuizen 2003), standing behind the cow on the left side and by observing the left paralumbar fossa between the last rib, the lumbar transverse processes, and the hip bone: ‘1’—‘paralumbar fossa empty, presenting a rectangular cavity that is more than a hand’s width behind the last rib and a hand’s width under the lumbar transversal processes’, ‘2’—‘paralumbar fossa forms a triangular cavity with a width about the size of a hand behind the last rib but less than this under the lumbar transverse processes’, ‘3’—‘the paralumbar fossa forms a cavity less than a hand’s width behind the last rib and about a hand’s width vertically downwards from the lumbar transverse processes and then bulges out’, ‘4’—‘the paralumbar fossa skin covers the area behind the last rib and arches immediately outside below the lumbar transverse processes due to a bloated rumen', '5'—'the rumen is distended and almost fills up the para lumbar fossa, the last rib and the lumbar transverse processes are not visible'.

The consistency of the faeces of the sampled cows was visually inspected and rated on a 5-point scale (Zaaijer and Noordhuizen 2003) '1'—'thin and watery and not truly recognizable as faeces', '2'—'thin custard-like consistency, structurally recognizable as faeces, splashing out wide upon falling on the floor', '3'—'thick custard-like consistency, making a plopping sound while falling on the floor and a well-circumscribed pad which spreads out and is about 2 cm thick', '4'—'stiff with a heavy plopping sound while falling on the floor and a proper circumscribed pad with visible rings and minimal spreading out', '5'—'hard faecal balls like horse faeces'.

3.3.4. Resource-Based Measures

The total number of sheds per shelter and the number of animals per shed in the shelter was assessed by visual inspection (maximum two sheds per shelter). The length, breadth, and height of the sheds were recorded using a laser distance meter (CP-3007 model, Ultrasonic distance meter 40KHz frequency, Chullora, New South Wales, Australia) and confirmed using a traditional measuring tape each time. From these measurements, the area of the shed and area per cow was calculated. The space allowance per cow, in shelters with loose housing, was calculated by dividing the floor area of the shed by the total number of cows within the shed. In shelters with stalls, the area per cow was calculated by calculating the floor area of each stall housing a cow (von Keyserlingk et al. 2012; Otten et al. 2016). In the tethered stalls, the area per cow was calculated by measuring the distance from the end of the rope at the point of attachment, to a peg at the end of the hind limb of the cow, at full extension. This length was used as a radius to calculate the maximum potential area of movement of the tethered cows in the sheds.

Luminosity in the sheds was measured (Bartussek et al. 2000) using a light meter (9V LCD Digital Lux Light Meter Tester LX1010B 0 with 100,000 FC Photo Camera, China), pointed in all six possible directions of the face of a cube, from the centre of the shed. The mean of the six readings was calculated for each shelter. Dry bulb temperature and humidity percentage were recorded using a digital meter (TS-FT0423 Digital Wireless Indoor Outdoor Thermo-Hygrometer Thermometer Humidity Meter, Sydney, Australia) inside the shelters, on both days of the study, before any cows were removed. The gradient of the floors in the sheds and the yards were measured at three different places, using vertical and horizontal measurements at each place, using an inclinometer (Bosch Professional, 600MM, DNM60L Model, Australia).

Noise levels (Bartussek et al. 2000) were measured at three different locations in the sheds and yards, using an Android phone application (Decibel X). The slipperiness of the floors was determined as the coefficient of friction (CoF) (the force required to move an object over a floor divided by the weight of that object (Phillips and Morris 2001; Phillips 2010). This was estimated using a 1 kg/10 N spring balance attached by a hook to a cuboid wooden block (mass 156 g). The block was gently pulled across the floor, at a speed of 0.17 m/s, and the minimal frictional force (F) required to keep it moving was recorded.

The number of sides of the sheds that were open, the type of housing (free stall, tie stall, loose, tethered, or no housing) (Bartussek et al. 2000), type of roofing (portal, flat, sloped, or other), type of shed flooring (brick, stone, earthen, concrete, or other), presence of bedding in the sheds (present or absent), type of bedding if present (hay, straw, rubber mats, or other), presence of any sharp objects protruding from shed walls or shed furniture, presence of yards and number of trees in the shelter yards (Bartussek et al. 2000; Cook 2002; Costa et al. 2013; Otten et al. 2016), watering provisions and the number and types of water points (troughs, bowls, natural water bodies, or other), were recorded in all sheds or yards (von Keyserlingk et al. 2012; Costa et al. 2013). The appearance of water available to the cows (clear, hazy, or opaque), and the presence of any algal growth (Otten et al. 2016) were recorded, during the inspection of the shelter facilities.

The cleanliness of the shelter premises was recorded, by visually assessing the mean percentage of the floor that was covered by dung and urine in the sheds, passages, and the yards, separately (Regula et al. 2004). Mouldiness of each feed offered to the cows in the shelters was assessed by visual inspection and by smelling a sample (recorded as ‘not mouldy’ or ‘mouldy’). Dustiness (‘not dusty’, ‘dusty’ or ‘very dusty’) of the fodder was assessed by dropping the fodder on the floor from the hand of the assessor. The moisture content of the fodder was assessed on a three-point scale of wet, moist, or dry, through the squeeze test (Greub and Cosgrove 2006), in which the fodder was firmly squeezed in the hand of the assessor and any liquid expression, wetting in the inside of the fist, sticking of the fodder particles to the palm, or presence of a dry palm, was observed. The resource-based measures used in the study have been summarized in Appendix 2.

3.4 Data Handling and Statistical Analysis

The recordings and observations obtained from the 54 cow shelters (gaushalas) were collated, cleaned for errors, and entered into spreadsheets. Variables were tested for normal distribution by visual inspection and the Anderson–Darling test (Evans et al. 2017), and data considered to be approximately normally distributed were expressed in terms of a mean value per shelter, standard deviation, and p-value for both continuous and categorical data. For data with skewed distributions, the results were expressed as percentages or proportions, as well as median value per shelter. Interquartile ranges (IQR) for the continuous variables and the maximum and minimum values for the categorical variables have been provided. All the analyses were run at a 5%

level of significance, for assessment of normality of the distribution of the data, using the Minitab 17 Statistical Software (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA).

3.5 Results

The time required to complete the 40 animal-based measures was approximately 15–20 min per cow, or 8–10 h per shelter. The measurement of resource and management-based parameters took 4 h per shelter. The assessment of each cow shelter, therefore, took 12–14 h.

3.5.1 Interview with the Shelter Manager

The managers reported a median number of cattle per shelter of 232 (IQR: 587–126) (Table 3.1). Almost two thirds, 63%, of the cattle in the shelters were cows, the others being bulls, bullocks, calves, and heifers. The median number of cows per shelter was 137 cows (IQR: 272) and the mean age was 11 years. The median mortality incidence rate was 13.6%, with a range of 4% to 76% per year. Only 42% of the cows had identification, in the form of ear tags, and nearly all cows were horned (93.3%). The majority of cows in the shelters were non-lactating (87.9%). Only 26% of the cows examined were classified as aggressive, the remainder being classified as docile. There was a widespread breed distribution, with a predominance of area-specific indigenous Indian breeds including Kankrej, Red Sindhi, Gir, Sahiwal, Dangi, Tharparkar, Deoni, Hariana, Nimari, Khillari, Nagauri, Rathi, Pahari, as well as Holstein Friesian, Jersey, and their cross breeds. The indigenous Indian breed cows comprised 48.6% (787 cows) of the total cows examined, followed by cows that were crossbred with exotic cows 29.1% (472 cows), the cross breeds between indigenous cows 21.5% (349 cows), and the pure-breed exotics 0.7% (12 cows).

Table 3-1: Descriptive statistics for animal-based measures in the cow shelters, measured on ordinal and continuous scales

Parameter	Mean/Median *	Standard Deviation	First Quartile Q_1	Third Quartile Q_3	Interquartile Range IQR *	*p*-Value of Distribution (for Normal Distributed Data)
Total no. cattle in the shelter	232 *	-	126	587	460	
Cows as % of cattle	63.42 *		52.65	73.48	20.84	
No. cows	137 *		77	349	272	
Cow age (years)	11.0	2.02				0. 36
Annual Mortality (%) **	1.14 (13.80)	0.399				0.57
Proportion of cows with identification	0.41 *		0.0	0.82	0.82	
Proportion of horned cows	0.93 *		0.7	1.000	0.3	
Proportion of lactating cows	0.03 *		0.000	0.2	0.2	
Temperament score**	0.41 (2.61)	0.068				0.24
Cow comfort Index (CCI), (no. cows lying / total no. cows)	0.27		0.13	0.34	0.20	
Avoidance Distance (AD) Score (scale 1–4)	1.53 *		1.2	2.13	0.93	
Body Condition Score (BCS) Score (scale 1–5)	2.69	0.366				0.27
Lameness score (scale 1–5)	1.13 *		1.05	1.27	0.22	
Claw overgrowth score (scale 0–3)	0.61 *		0.23	0.90	0.67	
Hock joint swelling score (scale 0–3)	1.64 *		0.233	2.233	0.44	
Hock joint hair loss score (scale 0–3)	1.05	0.298				0.22
Hock joint ulceration score (scale 0–3)	0.59	0.386				0.16
Carpal joint injuries score (scale 0–3)	0.78	0.455				0.17
Dirty hind limbs score ** (scale 0–3)	0.21 ** (1.59)	0.110				0.63
Dirty udder score (scale 0–3)	1.27	0.560				0.90
Dirty flanks score (scale 0–3)	1.24	0.570				0.95
Body hair loss score (scale 0–3)	0.76 *		0.066	2.033	1.04	
Coat condition score (scale 1–3)	1.54	0.298				0.07L
Ectoparasitism score (scale 0–3)	1.51 *		0.966	3.267		
Skin tenting score (scale 0–4)	0.03 *		0.000	0.833		
Lesions from shelter furniture score (scale 0–3)	0.75 *		0.066	1.600	0.67	
Teat condition score (scale 0–5)	1.0 *		0.92	1.00	0.075	
Neck lesions score (scale 1–5)	1.03 *		1.000	1.10	0.1	
Ocular lesions score (scale 0–1)	0.06 *		0.033	0.133	0.1	
Nasal discharge score (scale 0–1)	0.05 *		0.000	0.141	0.141	
Rumen Fill Score (scale 1–5)	3.7 *		3.19	3.90	0.708	
Faecal consistency score (scale 0–5)	3.70 *		3.19	3.93	0.741	
Diarrhoea score (scale 0–1)	0.000 *		0.000	0.033	0.033	

The majority of cows (98.2%) had not been screened for tuberculosis and brucellosis. Raw milk was sold in 37% of the shelters to the general public in the open market. Most (92%, n = 49) of the gaushalas routinely dewormed the cows, but only 33% had a proper veterinary-prescribed deworming protocol.

Most (72.2%) shelters disposed of cow dung as organic manure to farmers or used it for fertilizing their own pastures; 13% utilized it for biogas production, and 27.7% did not utilize it and just collected it in mounds. Some shelters (20.3%) sold urine as a traditional medicine; most (75.9%) were just allowing the urine to flow out of their premises without proper sewerage disposal facilities.

Most (96.3%) cows were vaccinated against foot and mouth disease (FMD), haemorrhagic septicaemia (HS), and black quarter (BQ), with 79.6% of these being vaccinated biannually. Ectoparasiticidal drugs were administered to 88.8% of cows and endoparaciticidal drugs to 92.5%, on a routine basis; 72.2% of shelters utilized the services of visiting veterinarians in emergencies, while 22.2% had their own veterinarians to treat their cows.

Carcasses were usually disposed of by burial within the shelter premises (53.7%) or through municipal contractors (40.7%), while a few shelters (5.5%) discarded carcasses into the open. About half (46.3%) of the shelters had biosecurity measures for the introduction of new animals into the shelter and 70.3% had isolation rooms for diseased cows. Some (11.8%) shelters have had disease outbreaks in the last 5 years, primarily FMD.

3.5.2 Animal-Based Measures

The median CCI was 0.27, i.e., a median of 27% of the cows were lying down. Some 31.5% of the cows had an avoidance distance between 50 cm to 0 cm, and 51.2% of the cows allowed touch by the assessor. The BCS of 53.4% of the cows fell in the range of 2–2.75 and the mean BCS on the 1–5 scale was 2.6.

Lameness was rare; only 4.3% of the cows in all the 54 shelters examined had clinical lameness (lameness score >2), while 84.8% of the cows were not lame at all (score 1). The mean score of lameness on the 5-point scale was found to be between 1 and 2 (1.133) (Table 3.1). More than half (52.47%) of the cows had no claw overgrowth, and 36.3% of the cows had mild claw overgrowth. Severe claw overgrowth (score 3) was observed in just 25 cows (1.5%).

The rising behaviour of cows was mostly normal; 83.6% of the cows rose easily (score 1) and only 10% of the cows had slightly interfered rising behaviour (score 2). Similarly, 96.8% of the cows were able to rise without any restriction (score 0), due to the shelter design or presence of furniture.

Medium swellings of the hock joints were detected in 63.7% of cows and almost one half (49.4%) had mild hair loss (<2 cm) in this joint; only 23% of cows had no loss of hair in the hock joints. One-third of the cows (33.3%) had mild levels (<2 cm) of ulcerated hocks, and more than one half (53.6%) had no hock joint ulceration. Carpal joint injuries were also common; only 45% of cows had no evidence of these (score 0) and 55% had hairless and swollen carpal joints (scores 1 and 2).

The dirtiness of the flanks, udder, and hind limbs of the cows was in the mild to medium range (scores 1 or 2, 74.2%, 76%, and 86% for the three body regions, respectively). The scores for body hair loss of the cows were mostly (53.2% of cows) mild to medium; almost half (45.0%) had no body hair loss. Hair coat condition was almost equally dull and short (47.1% of cows), and shiny and short (52.9%). Ectoparasitism was mostly either absent (53.5%) or mild (34.5%), being mainly lice and ticks in the regions of the tail, croup, udder, groin, and between the elbows and the neck. The skin tenting time was below or equal to two seconds in 92.2% of the cows (score 0). Lesions from the shelter furniture ranged between the absence of lesions (score 0) in 43.8%, mild lesions (score 1) in 37%, and moderate lesions (score 2) in 19% of cows, respectively.

Neck lesions in the form of hairless patches, swellings, and wounds were found in very few cows (4.5%), most being hairless patches (3.8%; score 1 and 2). Similarly, ocular lesions were observed in only 0.6% of cows, comprising mainly ocular discharges and occasional corneal opacities. There were very few oral lesions (0.05%). A vast majority of cows (83%) had dry udders and teats (score 1). Chronic udder and teat conditions, like teat and udder fibrosis, and udder abscess, were found in only 1.5% (24 cows) and 0.43% (7 cows) had teat warts. Vulval discharge was observed in 1.6% cows (score 0), predominantly purulent. The other animal-based health measures, for which a low prevalence was found, were cows with a nasal discharge (9.26%), hampered respiration (0.43%), coughing (proportion of selected cows coughing during the entire cow examination period 0.31%), and diarrhoea (4.26%). The Rumen Fill Score revealed a majority of the cows in the score range of 3 (37%) and 4 (59%). The consistency of faeces was predominantly in the score range of 3 (35.12%) and 4 (58.27%).

3.5.3 Housing

The majority of the cow shelters (74%) had one or two sheds for housing the cows, 15% of shelters had between 3 to 9 sheds, and 11% had more than 10 sheds. Most of the cow shelters had none or just one of the sides open (72%), whereas only five shelters (9.2%) had no walls in any of their sheds. There was a predominance of loose (42.5%) and free stall housing (20.3%). Tethered stalls were found in 20 shelters (37%). Almost half of the shelters had concrete flooring (42 out of 86 shelters), almost a quarter had earthen floors (21 out of 86 shelters), followed by brick floors

(22%, 19 out of 86 shelters) and stone floors (4%, 4 out of 86 shelters), respectively. Most cow shelters (87%) had yards for cows within their premises, with four different types of materials for the floor (earthen—41 shelters, brick—13 shelters, stone—3 shelters, concrete—19 shelters, out of total 76 shelters).

Portal frames were the most common roofing system (46%), with some flat (29%), sloped (26.7%), and domed (2.3%) roofing systems. Most shelters (54%) used galvanized iron sheets as roofing material, followed by re-enforced concrete cement roofs (32%); a few shelters had thatched roofs made of locally available grasses (7%) or corrugated cement sheets (4.6%). The median height of the roof shed was 3.8 m.

Some sheds (26%) had sharp objects protruding from shed walls or shed furniture. There was no bedding provided in most shelters (97%). Regarding shade provision, most shelters (84%) had none in their yards, and 43% of shelters had no trees in the yards (33% had up to 10 trees). Most shelters (60%) did not provide access to pastures for the cows; 23% provided it for up to 6 h/d, 17% provided access for 7–12 h/d. Free 24-h access to a yard was provided in 30% of the shelters, 29% provided access for up to 6 hours and 27.5% for 7–16h/day; 13.5% of the shelters had no yards at all.

The median number of sheds per shelter was 2 and the median number of cows per shelter was 70. The median area of shed per cow was 2.73 m^2 and the yard was 5.9 m^2. The mean area for tethered cows was 4.50 m^2. The median luminosity inside the sheds was 582 lux, and the noise levels inside the sheds and yards were 27.7 and 25.3 decibels, respectively. The CoF of the floor passages of the sheds and yards were 0.43 and 0.64, respectively.

3.5.4 Water Provision

Water points in the sheds were absent in 71% of the shelters; if they were present they were predominantly troughs (98%). Several different water sources were observed —motorized tube wells (37%) and natural water bodies (ponds, rivers, and wells, 23%). A few shelters had a combination of tubewell and municipal tap water (15%), and 4 shelters offered human-potable water to the cows. Just over one-half of the cow shelters provided ad libitum water (52%), the others mostly (64%) provided it twice a day, 32% provided water three times a day, and one shelter provided water four times a day. One-half of the shelters had water with a hazy appearance, and in the other half, it was clear, none having an opaque appearance. Only 10% had algal growth in the water. Eleven shelters (23%) had no water in the yard and 67% had one or two water points in the yards; nearly all (77%) were troughs. There was a clear appearance of water in the yards for 42% of shelters and only one shelter had opaque water.

3.5.5 Cleanliness

A median 20%, 15%, and 10% of the yard, lying area, and passages of sheds, respectively, had dung on the floor (Table 3.2). In the majority of shelters (83%), no urine was found in the lying areas and the passages of sheds; 11% of the shelter yards had floors with urine. The yards, sheds, and passages were cleaned in 71% of the shelters. Shelter sheds and yards were cleaned once a day in 32% of shelters and twice a day in 39%, usually (87%) by manual floor scraping, but 7% of shelters relied on floor scraping by tractors, and 5.5% used both.

Table 3-2: Median, first quartile (Q1), third quartile (Q3), and interquartile range (IQR) values for the non-normally distributed data, and mean, standard deviation (SD), and p-values for the normally distributed data, for resource-based parameters of cows in shelters

Variable	Median/ Mean *	SD	First Quartile Q_1	Third Quartile Q_3	Inter Quartile Range IQR	*p*-Value (Normal Distribution)
Total number of sheds	2.0		2	4	2	
Number of animals /shed	70.0		48.8	137.3	88.5	
Area of the shed (m^2)	173		99	313	214	
Area of the yard (m^2)	756		178	1800	1622	
Shed Area/ cow (m^2/cow)	2.73		1.56	3.63	2.07	
Yard Area/cow (m^2/cow)	5.9		3.6	21.5	17.9	
Area of movement of tethered cows (m^2)	4.50 *	2.752				0.044
Height of eaves in sheds (m)	3.80		2.99	5.34	2.35	
Luminosity in sheds (Lux)	582		89	1036	946	
Noise levels in sheds (Decibels)	27.67		21.33	37.17	15.83	
Noise levels in the yards (Decibels)	25.33		20.33	33.00	12.67	
Dry bulb reading in sheds (◦C)	29.50		27.2	32.8	5.6	
Humidity in sheds (%)	34.00		24.7	45.2	20.5	
Coefficient of friction in shed passage floors	0.43		0.27	0.65	0.37	
Coefficient of friction in yard passage floors	0.64		0.34	0.68	0.34	
Mean gradient of shed lying areas	1.46		0.96	2.2	1.23	
Mean gradient of shed passages	2.36		1.27	3.52	2.24	
Mean gradient of the yard floors	1.51		1.13	2.43	1.30	
Percent dung in lying areas of sheds	15.00		5.00	40.00	35.00	
Percent dung in the passages of sheds	10.00		5.00	42.50	37.50	
Percent dung in yards	20.00		10.00	40.00	30.00	
Quantity of roughages provided to the cows (kg) **	1.25 ** (17.66)	0.168				0.061

3.5.6 Feeding

Cows were either fed thrice (54%) or twice daily (45%). The mean quantity of roughage provided was 17.66 kg/cow/d. Most were (78%) fed dry fodder feed and only 17% were fed moist fodder. mouldiness of the fodder was detected in 2% of the shelters, but 27% were fed dusty fodder. A wide range of feeding practices was noticed in the shelters, all relying on wheat, paddy, or millet straw, and these were classified as follows, into four types (with the number of shelters and percentage of shelters):

Dry straw only (n = 10, 18.52%)

Dry straw + agricultural by-product waste (n = 11, 20.37%)

Dry straw + agricultural by-product waste + hay (n = 25, 46.30%)

Dry straw + agricultural by-product waste + hay + greens (tree leaves, vegetables) (n = 8, 14.81%)

Concentrate feeding was practiced in 85% of shelters, but in 13% of shelters, there was no processing, by rolling, grinding, or making into pellets. The processing of green and dry roughage involved chopping their stems into smaller pieces, either manually or by a chaff cutter. The processing practices were categorized into 6 types:

No processing (12.96%)

1—Chopping only (14.81%)

2—Chopping + ground concentrate (44.44%)

3—Chopping + cakes (11.11%)

4—Chopping + ground concentrate + cakes (3.70%)

5—Chopping + TMR + Cooked concentrates (7.41%)

6—Chopping + TMR + Cooked concentrates + mineral mixture (5.56%)

3.6 Discussion

3.6.1 Assessment Time

The aim was to assess the conditions of cow shelters (gaushalas) in India. Every effort was made to maintain uniform timing of assessment in all shelters, a potential confounding factor, but a mean temperature difference of only 5 °C was observed between the first and second day of assessment in each shelter. The time duration required to complete the assessment of a shelter was more than that taken by other researchers in their assessments, but the latter generally included only animal-based measurements (Main et al. 2007; de Vries et al. 2013c; Viksten et al. 2017). The present study involved shelters with a wide variation in herd size, in contrast to other assessments, which had a narrower range of cows per farm (Krawczel et al. 2008; de Vries et al. 2013c).

3.6.2 Animal-Based Assessment

The mean age of cows was almost 11 years, which is an old age for cattle, compared to the production industries, but it demonstrates that the shelters are being used for their intended purpose, to shelter old cows. Mortality is usually an important indicator of poor animal welfare (Winckler et al. 2003; Sandgren et al. 2009; de Vries et al. 2011). The mortality rate in this study (14%) was greater than that of dairy herds in developed countries, even though there has been an increasing trend there (Thomsen et al. 2004; Miller et al. 2008; United States Department of Agriculture 2008). A mortality rate of 15%–20% has been reported in older beef cows (10 years and above), in Australian herds with an overall range of 2% to 12% (Henderson et al. 2013). However, cows in developed countries are usually sold for slaughter when their productivity declines, or they are diseased. The relatively old age at which abandoned, infirm, and rescued cows enter shelters in India (typically 7–8 years) suggests that mortality is likely to be higher than in dairy farms. Amble and Jain (1967) reported a mortality rate of 2% to 6% in cross bred and pure bred cows, in military farms in India, comparable with dairy herds in developed countries (Thomsen et al. 2004; Miller et al. 2008; United States Department of Agriculture 2008; Alvåsen et al. 2012; Shahid et al. 2015).

Most of the shelter cows were not lactating, so the majority of the cows had dry udders and teats. This parameter has not been assessed in any protocol for dairy cows to date. There are studies on clinical mastitis in Indian cows in peri-urban areas, which report an incidence rate of 1% – 10%; there is a lower incidence in indigenous cows than in cross breeds and exotics (Joshi and Gokhale 2006). The reason for the low incidence of mastitis found in this study could be that the vast majority of cows were local low milk yielding breeds.

The general temperament of the cows examined in the present study was docile, agreeing with other studies of Indian cattle (Banerjee 1991; Sarkar et al. 2007), perhaps because of the regular handling, which is normal in India. The human–animal relationship in most shelters was good, as more than half of the cows did not show fear towards the human approach. Additionally, most of the cows were non-lactating, leading to a reduced level of human–animal contact, so the low avoidance scores reflected good stockpersonship, despite the cows being of no commercial value. The avoidance distance values found in this study were similar to those of European dairy cattle (Mülleder et al. 2003; Popescu et al. 2010).

Lying behaviour might be one welfare concern in the Indian shelters; the Cow Comfort Index (CCI) was low in comparison to the target of 0.85, which is suggested for dairy cows

(Overton et al. 2003; Cook et al. 2005). Reduced lying might be attributed to high stocking density, poor design of the stalls, and the flooring of the sheds. The recommended area per cow is dependent on the size of the animals and the type of shed (Davis et al. 2016). In India, the recommended area per cow is 7m^2 (Manoharan 2013). In the studied shelters, it was much less, 2.5 - 6m^2 per head. This lower area per cow in the shelters suggests a poor welfare, potentially affecting the behaviour and feed access for the cows (Huzzey et al. 2006) .The marginally lower than normal BCS in the shelter cows revealed some inadequacies to cow nutrition, which might be due to reliance on low quality straw.

Lameness has been regarded as one of the most important welfare issues in European dairy cattle, due to economic losses and pain (Whay et al. 2003a; Lievaart and Noordhuizen 2011), and is a key indicator of welfare (Popescu et al. 2010), usually assessed through locomotion scoring (Huxley and Whay 2006c).The low incidence of lameness in shelter cows, as compared to lactating dairy cows could be attributed to the feeding of roughage diets to the shelter cows, rather than the high energy diets fed to dairy cows, for milk production. A lameness prevalence rate of 11% has been reported in the French dairy cows (Coignard et al. 2013), and an incidence of 8.1% to 30.5% has been reported in cross bred Indian dairy cows (Singh et al. 1998; Sood 2005). Claw overgrowth was also low, attributable to the low growth rates, and the reasonable floor abrasion (Platz et al. 2007; Telezhenko et al. 2008).

The movement and socialization of the cows led to an increased incidence of injuries, disease, and subsequently reduced welfare (Busato et al. 2000). Injuries also reflected physical stress from the environment (Webb and Nilsson 1983). Joint injuries occurred due to the restrictions of floor space and lying areas (Blom 1983), and the lack of bedding. In the clinical examinations, joint swellings, hair loss, ulcerations, and injuries of hock and carpal joints were at low to moderate levels, probably reflecting the lack of forced movement. These results were in contrast to the studies on the prevalence of hock lesions in the U.K. dairy cows (Potterton et al. 2011a). Soft tissue injuries were also a consequence of improper construction of barns, and aggression between cows in a loose housing system (Irps 1983; Maton et al. 2012). The mild to moderate levels of soft tissue lesions in half of the cows were due to the presence of sharp objects and improper furniture fittings in some of the shelters, as well as aggression between them. The area per cow in the shelters was small, and this overcrowding increased the chances of sustaining injuries. Likewise, competing for fodder at the manger in the limited space, further increased injuries, for example, due to butting by horns, being pushed against shed walls, and sustaining injuries from shelter furniture. Sustaining injuries in a restricted/confined environment, where cows were allowed to interact with each other in a loose housing system, was an inherent problem in the shelters. Overcrowding revealed the shortcomings of flooring, barn fittings, and narrow passages, which were the main potential sources of getting injured. The location of lesions on the body and their contour/shape (lacerations, bruises) was the best indication that they were sustained from shelter furniture and sharp objects. In some shelters it was observed that almost all the cows had similar lesions at similar body locations, and this study was able to locate their origin, in the form of protruding nails, galvanized sheets, and exposed concrete reinforcement, as well as old mangers protruding from the wall and old gates.

The overall cleanliness levels of the cows in the shelters were much better than that has been observed for dairy cow cleanliness in the U.K (Whay et al. 2003b) and Eastern Europe (Popescu et al. 2010). The cleanliness levels of hind limbs, udder, and flanks, were measured as the scoring of these reflected the sources of contamination—dirty legs indicate faecal soiling from waste passage, a dirty tail indicates loose faeces, or more time spent in waste passage, and dirty flanks indicate dirtiness of bedding or the tail (Hughes 2001). Therefore, the cleanliness of the cows in this study reflected that of the shelters, which probably derived from the relatively high labour input into cleaning. The hair coat was also assessed to find out whether the cows were able to maintain their own cleanliness (Thomsen and Baadsgaard 2006). A lack of self-grooming was indicative of illness, poor general health, and movement restrictions (Popescu et al. 2010). The dull coat condition of nearly half of the cows (47.1%) of the cows in the shelters reflected their sub-optimal health status. This finding was further strengthened by the marginal BCS found in some shelter cows.

Dairy cows with tick lesions have been shown to express more kicking behaviour and a higher avoidance distance (Rousing et al. 2004). The prevalence of ectoparasites (46.3%) in the form of ticks, flies, and lice in this survey was lower than that found by Chavhan et al. (2013) (77.2% - 84.8% prevalence in one of the states that we recorded). The negligible presence of neck lesions (4.6%) in this study was probably due to the absence of feed barriers in cow shelters. This is in contrast to the findings in Norwegian dairy cows where neck lesions were observed in 20% to 40% of cows, depending upon the type of feed barriers being used (Kielland et al. 2010a). The proportion of cows showing ocular discharge/lesions, hampered respiration, coughing, and vulvar discharge was higher than in a study on French dairy cows (Coignard et al. 2013). However, the proportion of cows suffering from diarrhoea and showing nasal discharge was less than that in the French study. The incidence of nasal discharge and diarrhoea was much less than the threshold limits (to trigger a need for veterinary aid) of Welfare Quality® assessments in Europe. A low frequency of nasal and ocular discharge was also found in the welfare assessment of Danish dairy herds and this was influenced by season (Otten et al. 2016). Seasonal influence in the cows assessed in this study cannot be ruled out, but it could not be determined.

3.6.3 Assessment of Disease Status and Carcass Disposal Risks

Regarding the presence of diseases in the cattle, although brucellosis, leptospirosis, and tuberculosis have been reported to be prevalent in cattle in India (Bharadwaj et al. 2002; Singh et al. 2004a; Kumar et al. 2005), most of the cow shelters did not have any testing protocols for the diagnosis of these diseases. Most shelters followed deworming and vaccination practices, routinely, according to the standards laid down by the National Code of Practices for the management of dairy animals in India (Kamboj et al. 2014). Outbreaks of foot and mouth disease (FMD) were the only disease outbreaks, reported by 22 shelters (12%), in the last five years.

There was no proper provision for disposal of carcasses, dung, and urine, in the majority of the shelters. Carcass disposal by contractors was questionable, as deskinned carcasses were left in the open in some shelters; this is relevant to animal welfare because diseases, such as botulism, could be transferred to other cattle, if they are not disposed off, appropriately, usually by burying. Disease risks associated with improper disposal of urine, faeces, and carcasses of livestock, have been emphasized by many workers in Indian conditions (Panda and Kumar 2006; Park 2011), as they contaminate the groundwater supply, due to the presence of inorganic pollutants and coliform bacteria (Chantalakhana et al. 1999).

3.6.4 Housing and Flooring

The five freedoms for good animal welfare must be achieved through the adequate design of housing and other structures, as well as good management practices (Farm Animal Welfare Council 1993b). Traditionally, there has been a predominance of tethered/tie stalls in Asia (Moran 2012), but author’s experience is that these are slowly moving towards loose housing or free stalls, due to the benefits of allowing animals the freedom to move about. Tethered stalls decrease the labour efficiency (Phillips 2010), which is a critical aspect of shelter management in a time when commercial aspects of cow keeping are paramount. The predominance of loose housing in this study indicated a good welfare, as cows were free to move about, but overcrowding might thwart this.

The floor is the primary point of contact of a cow with its environment and is very important for the cow’s movement. It affects wearing of the hooves and conducts heat from the body, when the cow is lying down (Phillips 2010). Slippery floors affect the behaviour and can lead to injuries due to falls (Rushen and De Passillé 2006). Earthen flooring is a typical feature of Indian cattle housing. The coefficient of friction values of the yard and shed flooring in the present study were higher than those of Telezhenko et al. (2017), who reported decreased values in floors made of concrete, asphalt, and rubber, in dairy farms. Appropriate friction levels of the flooring are important to facilitate a comfortable movement of the cows, without slipping, as they provide an adequate grip for the cows' hooves. Based on the comparisons of the coefficient of friction found in this study, it was concluded that the floors were less slippery than in dairy farms (Telezhenko et al. 2017). This might be due to lesser movement of the cows, in and out of the sheds, compared with dairy farms, in which the cows are usually moved in and out twice daily. Moreover, access to yards in most shelters reduced the wear of the shed floors. The absence of bedding for cows in the shelters is a significant welfare issue, as it reduces their comfort levels - few cows like to lie down on a non-bedded floor (Tucker and Weary 2004). The body hair loss observed in the cows could be due to the lack of bedding in most of the shelters. The scarcity of fodder straw and its exorbitant cost could be attributed as a factor for the lack of bedding.

The minimum recommended eave height of cattle sheds is 3.5 m (Davis et al. 2016) and the median height of the sheds in this study (3.8 m) was just above this recommendation, enabling machines to achieve a proper clearance, and work inside sheds. The gradient of lying areas and yards in the shelter sheds was within the recommendations (covered areas 0.5%–1.5%; uncovered areas 1%–2%), whereas the gradient of passages, which were predominantly in uncovered areas, was similar (1.5%) to the recommendations (Davis et al. 2016). A minimum slope of 0.5% (1:200) was recommended, to prevent water pooling, though the floor slope depended on the natural slope of the site and the method of cleaning the floor (Moran 2012). A proper gradient was very important for adequate drainage of urine. Most of the shelters in the present study had an adequate gradient of the floors, which allowed proper drainage, as the majority of the shelters did not have urine pooling in the lying areas and passages.

3.6.5 Access to Pastures and Yards

Access to pastures is a very important welfare provision for cattle, and deprivation of grazing leads to behavioral and health problems, such as stereotypies, aggression, and lameness (Phillips 2010). An 8–12 h per day grazing period is considered adequate for cows (Phillips 2010). In the present study, very few shelters had a provision of pasturing for the cows, probably because of lack of resources for this. The yard access provided to the cows in more than half of the shelters would provide some relief to the discomfort experienced in the sheds and reduce the aggressive interactions between the cows. The cow's heel and heel bulb were weakened by constant hoof contact with the wet flooring, contaminated by the acidic dung where there was no access to pastures or yards. This caused necrosis, digital dermatitis, and laminitis, due to the proteolytic action of the acidic excreta (Aalseth 2005). The comparatively low incidence of lameness and claw overgrowth in the shelter cows testified to the significance of access to the yards and the relative absence of slurry in the lying areas and passages.

3.6.6 Noise and Luminosity Levels

Cows are able to hear higher frequency sounds than humans (Heffner and Heffner 1992). This might disturb them and as they lack the capacity to know the direction of the sound as accurately as humans, they might be stressed by being unable to avoid it (Phillips 2010). The noise levels in shelter sheds and yards recorded in this study were a maximum of 37.7 dB, well below the permissible limits of 90–100 dB (Phillips 2010). Most shelters in rural areas were located in quiet areas away from the population and the automobile traffic. Cleaning operations were mostly manual, leading to more settled cows than in the commercial dairy sector.

Light is another important factor regulating animal health and welfare (Patbandha et al. 2016). Light intensity should be between 161 and 215 Lux, during the day (Buyserie et al. 2001). The luminosity levels for the cows in the shelter shed, during the day, were much higher than these levels and stood in contrast to very low levels of light intensity (52–53 Lux) in a study conducted in Eastern European dairy farms (Furnaris et al. 2016).

3.6.7 Feeding and Watering Provisions

A dry matter intake of 3% of body weight for dry cows in Indian conditions has been recommended (Ranjhan 1997), usually achieved by feeding roughages (green and dry) and concentrates (grains, oilcakes, and agricultural by-products) (Kamboj et al. 2014). Birthal (2010) in a field survey of dry cows kept in households in rural India, found that the mean daily consumption rates of dry roughage, green roughage, and concentrates were 4.0, 3.4, and 0.4 kg per cow per day, respectively. The dry roughages and greens fed to the gaushala cows in this study appeared to be better than that fed to the dry cows of rural farmers in India. The proportion of cows with a normal rumen fill score in this study, suggests an adequate dry matter intake (DMI), and is comparatively greater than that recorded for dairy cows in England (Whay et al. 2003b). Fecal consistency indicates the ratio of water intake to dry matter and indirectly provides information about the nutritional and digestive states of cows (Ireland-Perry and Stallings 1993; Zaaijer and Noordhuizen 2003). A score of 3 is an ideal score and indicates a well-digested fodder, a score of 4 is acceptable for dry cows; these were the predominant scores in the sheltered cows in the present study. However, the absence of water points inside the sheds, availability of clean drinking water in only 42% of the shelters, and the absence of ad-lib water availability in 48% of the shelters, is a welfare concern. Nevertheless, the majority of the cows assessed in the shelters (92.2%) showed adequate hydration levels, according to the reference scale (Roussel 2014). It could be due to a better water conservation capacity, which enables the local Indian cattle breeds to withstand dehydration and thermal stress (Upadhyay et al. 2013).

3.7 Conclusions

Assessing animal welfare using animal-based, resource-based, and management-based assessment tools provided a holistic view of the welfare state of facilities. In this study of welfare assessment of cows in shelters in India, the three types of assessments provided an overview of the welfare conditions and management practices in the shelters, facilitating a diagnosis of conditions for the cows in these shelters. In all shelters, there were several concerns that needed improvement or rectification. These included the small space allowance per cow, non-uniform type of floors, some cows with poor body conditions, little freedom of movement, lack of pasture grazing, lack of bedding, the absence of ad libitum access to water, and compromised biosecurity. The high mortality rate, when compared to commercial dairy farms, is not considered a welfare problem, because many cows enter in poor condition, at an old age.

This study is a scientific assessment of animal welfare and animal management in a specific socio-religious setting. It helped us identify problems directly concerning the cows, which could be used in the future to provide feedback to the shelter managers, for rectification and improvement of their institutions. The purpose of the shelters is to house unwanted cows to the highest standards of animal welfare, despite their commercial redundancy. This is in keeping with the tradition and religious sentiments of India, which espouses the holiness of the cows. The results of the present study revealed varying levels of welfare of cows in Indian shelters, which partly contradicts the original hypothesis that these unproductive, old, infirm, and abandoned cows would suffer from poor welfare practices and conditions. Continuous efforts are required by stakeholders to develop new, sustainable management practices, and optimize the existing ones, to improve the welfare outcomes in the shelter cows. Further research is needed to investigate the interplay of the various welfare parameters and to identify their association with the risk factors that were identified. An ongoing work is recommended on the repeatability and validity of the assessments. The results of this study can be dovetailed into a restructuring of the gaushalas on scientific lines, based on global animal welfare practices, to ensure the sustainability of these unique institutions.

Publication included in Chapter 4

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Author Contributions to the paper

The conceptualization, design and methodology was done by Arvind Sharma, Uttara Kennedy and Clive J.C Phillips. The data collection and investigation was done by Arvind Sharma and Uttara Kennedy (in two states of the study and in measurement of resource-based parameters). The formal analysis and interpretation was done by Arvind Sharma and Clive J.C Phillips. Original draft of the paper was prepared by Arvind Sharma. The writing review was done by all the authors.

Chapter 4

Assessment of floor friction in cowsheds and its association with cow health

4.1 Abstract

Measurement of friction of cowshed floors to determine slipperiness potential is important for cow comfort. Existing methods require elaborate equipment and procedures. A quick method for assessment of friction characteristics is proposed. Friction was measured in 54 cattle housing and yard facilities with earth, brick, concrete, and stone floors, and its association with cattle health parameters was investigated through assessment of 30 animals per facility. A 156 g cuboidal wooden block attached to a spring balance was pulled over 3 m, and the coefficient of friction was recorded as the force required to move the block at a constant speed. The coefficient of friction ranged from 0.3 to 0.7 and was lowest for concrete and highest for earth floors. A multivariate analysis found that cows were standing more and could be more easily approached when they were on floors with high friction levels. The proportion of cows with dirty hind limbs declined with increasing friction of the floor, probably reflecting the fact that they felt more confident to stand rather than lie on high friction floors. This simple measure of frictional characteristics of cattle floors offers promise to be included in welfare measures as an indicator of cow welfare.

Keywords: coefficient of friction; floor; cows; housing; welfare; assessment

4.2. Introduction

India has an ancient tradition (from the 2nd century B.C.) of sheltering cows in shelters. These cow shelters (gaushalas) house abandoned, infertile, and non-productive cows. The size of these shelters ranges from fifty to ten thousand cows. The shelters play a significant role in the management of stray cattle in India where cow slaughter is not permitted by law in most of the states. The cows are sheltered until they die from natural causes. These shelters are managed by philanthropists, trusts, temples, government municipalities, and animal welfare groups. Cow shelters are usually simple traditional structures with a variety of floor types and little attention to, or routine maintenance of, the floor (Divekar and Saiyed 2010). The quality of floors of cow sheds is important for cow comfort. Long term wear of the floors renders them smooth and more slippery (Lorentzon 2005), which may affect getting up, lying down, and walking behaviour. Improper flooring will lead to deprivation or alteration of these behaviours (Phillips et al. 2013). Contemporary cow welfare assessment studies have assessed types of flooring and bedding (Mülleder et al. 2007; Potterton et al. 2011a; de Vries et al. 2015), but none of them, to the best of knowledge, have measured floor slipperiness. The floor surface should be clean and dry for comfortable resting and avoidance of slipping (Phillips et al. 2013). Floors should allow cows to lie down, rise up, and walk without slipping (Bickert 2000). Measurable changes in the gait of cows, slipping, falls, and injuries occur due to the absence of adequate friction, usually as a result of poor design or the presence of a slurry of urine and faeces on the floor (Albutt et al. 1990; Phillips and Morris 2000, 2001; van der Tol et al. 2005). Slippery floors restrict the natural locomotion of cows as they are forced to adapt to an unnatural walking environment (Metz and Bracke 2003). Increasing the friction of floors also increases abrasiveness and wear of the hooves of cows, but insufficient abrasiveness leads to overgrowth of their hooves or claws (Bonser et al. 2003). A judicious trade-off between the two is required so as to design floors which are neither too abrasive to cause excessive wear of the hooves and joint lesions nor insufficiently abrasive to cause slipping.

Slipperiness has been assessed by measuring friction levels of floors (Chang et al. 2001). Floor frictional forces and the reaction of hooves and claws of cows to floor abrasiveness have been studied under laboratory conditions using cow-simulating machines and biological materials in the form of cattle hooves (Phillips et al. 1998; Phillips et al. 2000; Chang et al. 2001; Bonser et al. 2003). A coefficient of friction (CoF, the force required to move an object/object mass) is usually measured, which varies inversely with slipperiness of flooring. CoF depends on the hoof, flooring, contact surface between the hoof and the floor, and presence of slurry or other liquids on the floor (van der Tol et al. 2005). Literature has not revealed an easy, on the spot method of assessment that welfare assessors can use to rapidly measure the slipperiness of floors in cowsheds. Floor slipperiness has not been incorporated into welfare assessment protocols for cattle to the best of our knowledge. This could be due to a time-consuming and cumbersome methodology which is difficult to be carried out in routine welfare assessments. Welfare assessments are increasingly common in farms to meet the growing need by members of the public for improved conditions for dairy cows (Knierim and Winckler 2009). The objective of this paper was to test a simple method of measuring friction levels of different types of floors found in cow sheds and yards of the cow shelters and validate it with measurements of the characteristics of the buildings and cattle within, in particular, their behaviour and lesions on their limbs.

There is a lacuna in the scientific literature about the welfare assessment of cows in such shelters in general and assessment of the friction of various types of flooring in these shelters in particular. In this study, it was attempted to formulate a novel method of assessing the friction of the floors in cow shelters and then correlate these frictional characteristics with cow health, behaviour, and other relevant measures of welfare, in order to determine if this measure could usefully be added to existing protocols.

4.3 Materials and Methods

Fifty-four cow shelters (gaushalas) in six states of India were assessed for animal welfare conditions in the form of 31 resource-based measurements and 28 animal-based measurements

(Appendix 1, Appendix 2 and Table 4-1). A typical cow shelter is an institution in which one or more sheds house the cows. In the cow sheds, there may or may not be an open loafing area present, referred to as the yard, where the cows are able to freely move about, sit, or stand. In case of shelters having multiple sheds and yards (more than two), two representative sheds and adjoining yards were assessed. A total of 86 sheds and 76 yards were assessed in the 54 cow shelters as a part of a welfare assessment protocol.

A combination of assessment methods (behaviour observations, evaluation of skin alterations indicative of poor comfort levels, and clinical examination) was used to describe the health and welfare status of the cows. For each of these methods, specific indicators that were considered relevant for health and welfare were identified. Indicators which had been described and validated in previous welfare assessment studies conducted in Europe and other western countries in dairy cattle, especially the Welfare Quality® Project protocol, were selected. The 31 resource-based measurements were divided into six main criteria: Housing, specific shed measurements and features, bedding, flooring, watering, and feeding characteristics. The characteristics of the flooring was one of the parameters for assessment. A total of 1620 cows in 54 cow shelters were randomly selected for animal-based measurements, 30/shelter, as recommended following a statistical power analysis. In each cow shelter, 30 cows were sampled as recommended by the power calculation performed for the number of shelters to be sampled and the number of cows to be sampled in each cow shelter. The study was designed to detect an odds ratio of 4 with a power of 0.8 and $\alpha = 0.05$. A sample size of 30 cows is sufficient to estimate within-herd prevalence with an accepted error of 10% at a 95% level of confidence. Cows were selected randomly by choosing every 3rd cow in the shed or the yard. There was only one observer who carried out the measurements.

Friction levels of the floors of sheds and yards (where present) were assessed using a spring balance measuring 1 kg/10 N (RS Pro Spring Balance). The hook of the balance was attached to a cuboidal wooden block weighing 156 g and being 12.5 × 5.5 × 3.5 cm in length, breadth and height, respectively. The block was gently pulled across the floor, and the minimal frictional force (F) required to move it at a speed of 0.3 m/s over a distance of 3 m was recorded from the scale of the spring balance. The block was pulled at three randomly selected places on each shed and yard floor. The coefficient of friction (CoF) was calculated by the formula:

CoF = weight required to move block ÷ weight of the cuboidal wooden block (CoF = WSB/WB) *(1)*

where WSB is the spring balance weight recorded and WB is the block weight.

Twenty-one sheds had earthen, 19 had brick, four had rock slabs/stones and 42 had concrete based as flooring material (Table 4.2). Forty-one yards had earthen, 13 had brick, three had stone and 19 had concrete-based floors. The methodology of assessment of the animal- and resource-based measures followed in this study has been elaborated upon in Appendices 1 and 2.

Table 4-1: Shelter housing parameters for assessment of floor characteristics

Criterion	Parameter	Measurement Description
Flooring	Type of flooring	Earth, Brick, Concrete, Stone/Rock
Bedding	Type and thickness of bedding	Type, thickness of bedding (in cm) (if any)
Cleanliness	Presence of faeces in the lying areas and passages separately	Visual estimation of % of faeces in the passages and lying areas *
	Presence of urine in the lying areas and passages	Visual estimation of % of urine in the passages and lying areas
	Water pooling in the lying areas	Present/absent
Space allowance	Area/cow (m^2)	Area of the shed ÷ Number of cows in the shed
Floor gradient	Floor gradient of the lying areas and passages	Ratio of incline to length (as measured by inclinometer)

***** For estimation of cleanliness levels, each shed floor was divided into four quadrants; % of dung in each quadrant was estimated visually and an average was taken for the entire floor. Pilot trials were conducted initially to standardize each resource- and animal-based parameter.

Table 4-2: Shed coefficients of flooring for four types of flooring in cow shelters (n = 86)

Type of Shed Flooring	Number	Median Coefficient of Friction	IQR
Earth	21	0.67	0.075
Brick	19	0.57	0.171
Rock/stone	4	0.39	0.246
Concrete based	42	0.29	0.163

Interquartile range (IQR)

4.4 Statistical Analysis

All the analyses were run at 5% assumed level of significance using a computerized statistics software Minitab 17 (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA). Each set of observations in a facility was assumed to be independent of all others. The differences between the coefficients of friction of different types of floors were calculated by the Mood’s Median test because residuals after a general linear model were not normally distributed. The 54 shelters were considered as a fixed factor. The coefficients were taken as a continuous response variable.

Overlap in factors associated with the coefficients of friction was initially identified by a Principal Components Analysis (PCA) of the animal-based as well as the resource-based parameters. As a result, values for % of dung in the passageways and lying areas were combined. The variables were then subjected to a univariate analysis with the coefficient of friction of the flooring, using Spearman’s Rank Correlations because several variables were not normally distributed. The variables having a correlation with the coefficient of friction at a *p*-value of less than or equal to 0.05 were retained and subjected to multivariate analysis using a general linear model employing a backward elimination stepwise process to identify the association of risk factors with the coefficient of flooring. Alpha to remove variables was set at 0.25. There were only four shelters that had stone/rock floors, and hence they were not included in the model. The CoF of the flooring of sheds and yards was determined in this study, in the multivariate analysis, only the shed CoF was used because many shelters did not have yards. Variance inflation factors were inspected to ensure low levels of collinearity between variables. Residuals were tested for normality by the Anderson–Darling test.

4.5 Results

The overall median floor CoF was 0.43 ± 0.194 SD. The potential range of CoF in the present study was from 0 to 1, and the actual range was 0.61, from 0.11 minimum value to 0.72 maximum value. The median CoF was higher for earth and brick floors than stone and concrete (Table 4.2) (chi-square value = 52.78, df = 3, p-value < 0.001).

The descriptive statistics of the animal-based and resource-based parameters used in the linear model are presented in Tables 4-3 and 4-4, respectively. Spearman’s rank order correlation between the coefficient of friction of the shelter floors (continuous variable) and ordinal and continuous variables of the resource- and animal-based measures demonstrated significant correlations in both categories of variables (Table 4-5). CoF was positively related to the % of faeces in the lying areas and passages, and it was increased in sheds that were not cleaned. In sheds that were cleaned, it was negatively correlated with the frequency of scraping. It was also positively correlated with the gradient of the passages. In terms of animal-based measures, a negative correlation with the stall standing index indicated that floors with a high CoF had fewer cows standing. Floors with a high CoF had cows with more body hair loss and body lesions, but fewer swellings and ulceration of the hock joints and injuries to the carpal joints.

Table 4-3: Descriptive Statistics for animal-based measures in the cow shelters measured on ordinal as well as continuous scales

Parameter	Mean/Median*	Standard Deviation	First Quartile Q*$_1$	Third Quartile Q*$_3$	Interquartile Range IQR *	*p* Value (>0.05 = Normally Distributed Data)
Cow age (years)	11.0	2.022				0.37
Lactating cow %	0.03 *		0	0.2	0.2	
Temperament, log_{10} of values	0.41 (2.61)	0.068				0.24
Stall Standing Index (SSI)	0.77 *	0.25	0.59	1.0	0.31	
Avoidance Distance (AD) score (Scale 1–4)	1.53 *		1.20	2.13	0.93	
Body condition score (Scale 1–5)	2.69	0.37				0.27
Lameness score (Scale 1–5)	1.13 *		1.05	1.27	0.22	
Claw overgrowth score (Scale 0–3)	0.61 *		0.23	0.90	0.67	
Hock joint swelling score (Scale 0–3)	1.64 *		0.23	2.23	0.44	
Hock joint hair loss score (Scale 0–3)	1.05	0.30				0.22
Hock joint ulceration score (Scale 0–3)	0.59	0.39				0.16
Lateral hock joint swelling score (Scale 0–3)	0.87	0.41				0.88
Lateral joint hair loss score (Scale 0–3)	0.27 *		0	1.30	0.26	
Lateral joint ulceration score (Scale 0–3)	0.11 *		0	1.13	0.20	
Carpal joint injuries score (Scale 0–3)	0.78	0.45				0.18
Dirty hind limbs score ** (Scale 0–3)	0.21 ** (1.59)	0.11				0.64
Dirty udder score (Scale 0–3)	1.27	0.56				0.90
Dirty flanks score (Scale 0–3)	1.24	0.57				0.95
Body hair loss score (Scale 0–3)	0.76 *		0.066	2.03	1.04	

Coat condition score (Scale 1–3)	1.54	0.298				0.08
Ectoparasitism score (Scale 0–3)	1.51 *		0.97	3.27		
Skin tenting time score (Scale 0–4)	0.03 *		0	0.83		
Teat condition score (Scale 0–5)	1.0 *		0.92	1.00	0.075	
Neck lesions score (Scale 1–5)	1.03 *		1.0	1.10	0.1	
Ocular lesions score (Scale 0–1)	0.06 *		0.033	0.13	0.1	
Nasal discharge score (Scale 0–1)	0.05 *		0.000	0.14	0.14	
Rumen fill score (Scale 1–5)	3.68 *		3.19	3.90	0.71	
Diarrhoea score (Scale 0–1)	0 *		0	0.033	0.033	

***** Data not normally distributed; ****** Log_{10} transformed

Table 4-4: Median, first quartile (Q1), third quartile (Q3), and interquartile range (IQR) values for not normally distributed and mean, standard deviation (SD), and p-values for normally distributed data, for resource-based parameters for cows in shelters

Variable	Median/Mean*	SD	First Quartile Q_1	Third Quartile Q_3	Interquartile Range (IQR)	* *p*-Value (>0.05 = Normal Distribution)
Area/loose housed cow (m^2)	2.73		1.56	3.63	2.07	
Area/tethered cow (m^2)	4.50 *	2.75				0.04
Shed eave height (m)	3.80		2.99	5.34	2.35	
Shed luminosity (lux)	582		89	1036	946	
Shed noise level (dB)	27.7		21.3	37.2	15.8	
Yard noise level (dB)	25.3		20.33	33.00	12.7	
Shed dry bulb temperature (°C)	29.5		27.2	32.8	5.6	
Shed humidity (%)	34.0		24.7	45.2	20.5	
CoF of shed passage floors	0.43		0.27	0.65	0.37	
CoF of yard passage floors	0.64		0.34	0.68	0.34	
Gradient of shed lying areas	1.46		0.96	2.2	1.23	
Gradient of shed passages	2.36		1.27	3.52	2.24	
Gradient of yard floors	1.51		1.13	2.43	1.30	
Dung on shed lying areas (% of area)	15		5	40	35.	
Dung on shed passages (% of area)	10		5	42.5	37.5	
Dung on yards (% of area)	20		10	40	30	
Roughage/cow (kg fresh)	1.25 ** (17.66 *)	0.168				0.06

***** Mean; ****** Log_{10} transformed.

Table 4-5: Spearman's rank correlations between coefficient of friction of shelter flooring and resource- and animal-based variables with p-values ≤ 0.05

Variables	Correlation Co-Efficient	*p* Value
Resource-based		
Shed flooring type	−0.75	<0.001
Shed % of faeces in lying area	0.37	0.005
Shed % of faeces in passages	0.320	0.02
Shed cleaning (absence 0, presence 1)	−0.29	0.03
Scraping frequency of sheds	−0.42	0.001
Shed average gradient of passages	0.29	0.03
Animal-based		
Stall Standing Index (SSI)	−0.33	0.01
Body hair loss	0.31	0.02
Hock joint swellings	−0.32	0.02
Hock joint ulceration	−0.27	0.05
Carpal joint injuries	−0.31	0.02
Lesions on the body	0.30	0.02

In the multivariate analysis of CoF with animal and shed variables, there were four variables significantly related to the coefficient of friction (r^2 adjusted = 82.8; residuals of the model were normally distributed): Stall standing index ($p = 0.01$), avoidance distance ($p = 0.04$), dirty hind limbs ($p = 0.03$), and shed flooring ($p < 0.001$). For the stall standing index, more cattle were standing as CoF decreased (Figure 4-1). Avoidance distance decreased as CoF increased (Figure 4-2), and the proportion of cows with dirty hind limbs decreased with CoF (Figure 4-3). The relationship was described by the equation:

$$\textit{Shed flooring CoF} = c - 0.157\ \textit{Stall Standing Index}\ (\pm 0.0577,\ p = 0.01) - 0.0649\ \textit{Avoidance Distance Score}\ (\pm 0.0299,\ p = 0.04) + 0.0861\ \textit{Dirty Hind Limbs Score}\ (\pm 0.0377,\ p = 0.03), \tag{2}$$

where c is the intercept, which for earthen floors was 0.812 and for brick floors was 0.736, relative to concrete floors which was 0.442; $p < 0.001$ and $p = 0.002$, respectively.

Other variables that were not significant ($p > 0.05$) but were initially included in the regression equation were floor scraping frequency (coefficient —0.020 (±0.0147), $p = 0.18$), body hair loss (coefficient —0.043 (±0.0272), *p* value 0.13) and nasal discharge (coefficient + 0.213 (±0.124), $p = 0.09$).

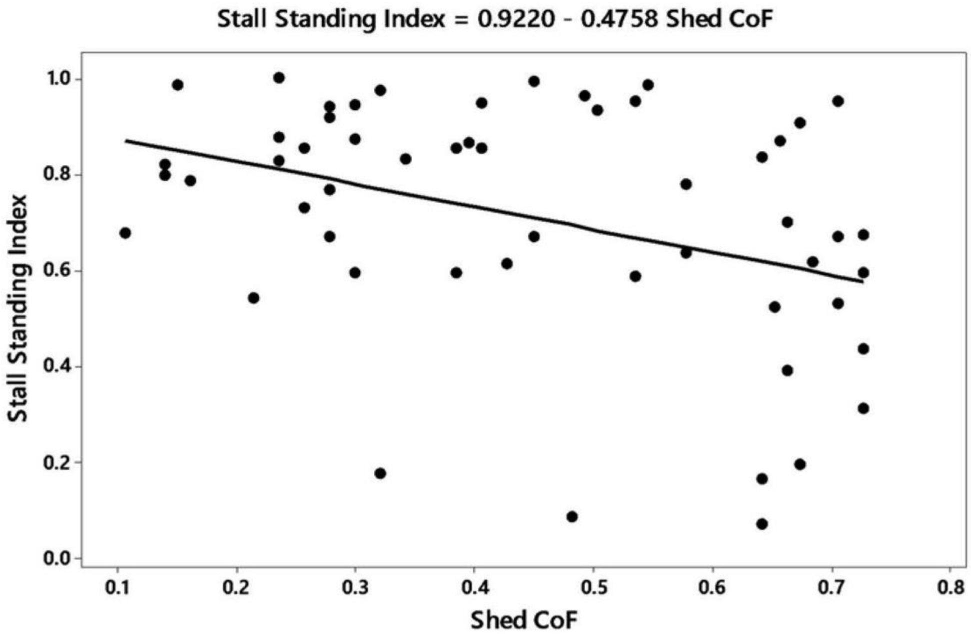

Figure 4-1: Relationship between the proportion of cows standing (stall standing index) and coefficient of friction (CoF) of shed floor

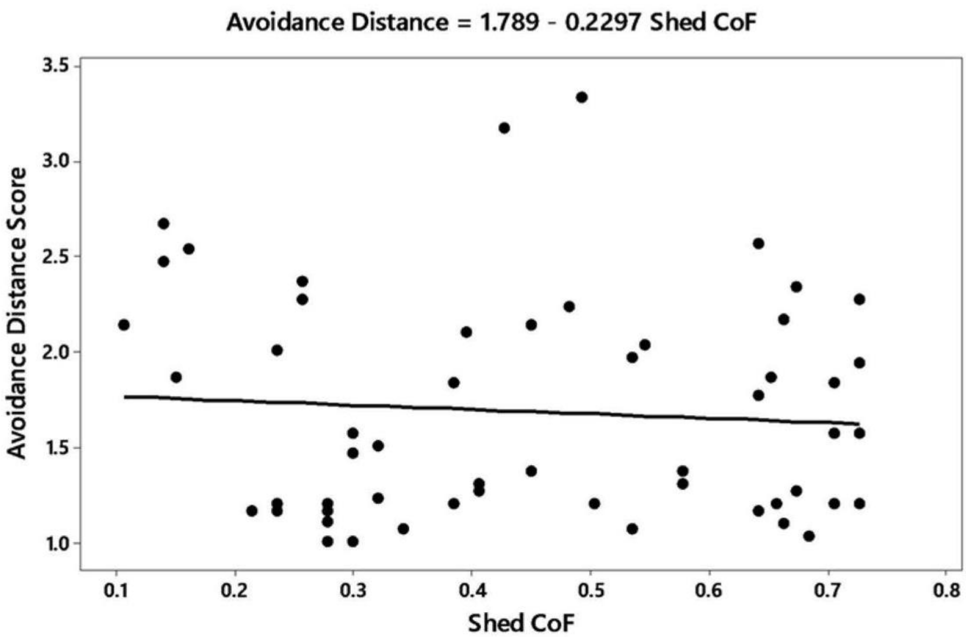

Figure 4-2: Relationship between the avoidance distance score and coefficient of friction (CoF) of shed floor

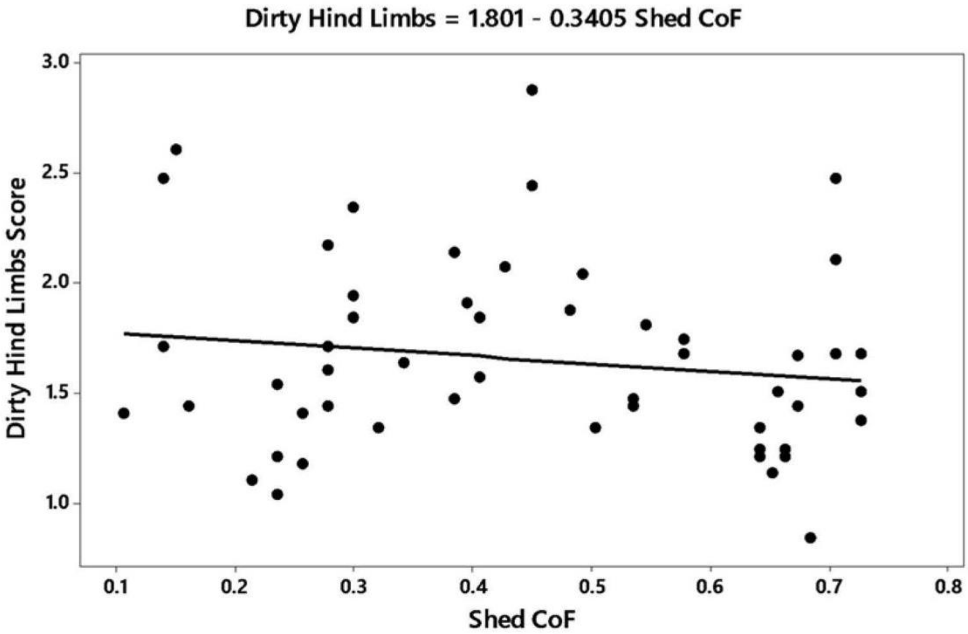

Figure 4-3: Scatter plot showing relationship between dirty hind limbs score and coefficient of friction (CoF) of shed floor

4.6 Discussion

The objective of developing a method of measuring CoF that related to resource- and animal-based characteristics in different types of cattle accommodation was achieved. Through the measurements of CoF, the results indicated an interactive relationship between the environment in cow shelters and the reaction of cows to that environment, quantified through the measurement of various cow- and resource-based measures. The coefficient of friction of flooring in this study ranged from 0.3 to 0.7 across four types of shelter flooring (earthen, brick, stone, and concrete), which is a broader range than that calculated by Penev et al. (2013). The higher the value of the coefficient of friction of a floor is, the lower the probability of slipping is (Phillips and Morris 2001). The lower end of the range calculated in the present study was below the critical point of 0.4 to avoid slipping, as suggested by Phillips and Morris (2001) and van der Tol et al. (2005). However, this is not surprising as the van der Tol et al. (2005) study evaluated only two types of floors: Concrete and rubber matting floors. There is a tendency of cows to walk quickly in short steps on floors with lower friction, while they walk slowly with longer steps on floors with higher friction (Phillips and Morris 2001).

CoF was highest for earthen floors, intermediate for brick floors, and much reduced for concrete floors. The small number of stone floors appeared to be most similar to concrete floors in frictional characteristics. Concrete floors wear smooth over time, and even if they are grooved with a diamond cutter (Steiner et al. 2008), they still wear down with constant traffic of cows on the floor.

The negative association of the frequency of scraping the shelter floors with CoF was demonstrated by the finding that CoF was higher in floors that had faeces in lying areas as well as passages. This is similar to the increase in frictional characteristics of the floor that was previously found for floors with an aggregate embedded (Phillips and Morris 2001), for which it was suggested that the greater CoF on floors with aggregate presented a vertical impediment to the motion of the block.

The method used in this study attempted to mimic the sliding frictional aspect of the cow's movement on floors, as this movement truly reflects the risk of slipping. The presence of only urine on the floors of the sheds and passages did not significantly affect the CoF. This partially corroborates the studies of Phillips and Morris (2000) who found no changes in the gait of cows when the floor was wet, though the limb movement angles, as well as patterns, were affected. However, the presence of faeces increased the CoF of the floors in this study, as has been previously reported (Phillips and Morris 2001).

The stall standing index (SSI), devised by Cook et al. (2005), is one of the indices for the assessment of comfort levels of cows in a stall, or in shelters in the present case. The negative correlation between the CoF and SSI in this study suggests that with an increase in CoF, the cows were less likely to be standing and more likely to be lying down, reflecting greater comfort levels on floors with higher friction. Slipping whilst standing is more likely at low friction levels (Albutt et al. 1990; Leonard et al. 1994; Haley et al. 2000). Floor bedding may work in a similar way to faeces on the floor, providing resistance to horizontal motion.

The avoidance distance (AD) measure is used to quantify the human–animal relationship and to assess an animal's fear of humans (Mazurek et al. 2011). The model revealed a negative relationship between AD and CoF, thus high friction floors had cows that would permit a very close approach by a researcher. Cows will potentially be less nervous and more comfortable on floors that permit safe movement, and there is an absence of slipping. Flooring with a low CoF and increased slipperiness impedes the natural behaviour of cows (Cook et al. 2016). A reassessment of the design of free stalls for cows has been recommended if SSI is more than 0.2 (Zeeb 1983). There is a dilemma that cows need to be active and walk, which can only be done when the cow is standing, but after being active they need to rest. A simple measure of the proportion of cows standing is not sufficient to understand the complexities of cows' needs and further work is needed in this area to develop simple measures that measure the cows' needs better.

A possible negative correlation between the CoF and body hair loss was suggested (p = 0.13) but was not significant. If confirmed, it can be explained by the frequent slipping of the cows causing injuries and hair coats getting contaminated with dung. These might lead to loss of hair on the body. It has been suggested that lesions and swellings in the body of dairy cows are influenced by the quality of flooring in the passages and stalls and the presence or absence of bedding on it (DeVries et al. 2012; de Vries et al. 2015). Norberg (2012) further proved that floor surface influences the cleanliness of cows and stalls. The presence of dung on various body parts might lead to skin irritation and subsequent hair loss (Elmore et al. 2015).

The correlation of CoF with dirty hind limbs may be because some cows were lying in passageways with excreta. Often, it is only a minority of cows that engage in this behaviour if suitable free stalls/cubicles are provided (Kara et al. 2011). For high friction floors, the proportion of dirty hind limbs declined with the CoF, which would be expected if cows felt confident to stand more on these floors. This finding could also reflect the lack of cleaning of sheds with high CoF, which was found in the univariate analysis. The relationships confirm that hygiene levels and lesions on the body of cows reflect the design of the facility, which includes flooring (Zurbrigg et al. 2005b; Cook et al. 2016).

The possible correlation between the CoF and nasal discharge in the cows, although only a trend ($p = 0.09$), if confirmed in other studies could be due to high CoF floors having more faeces, which produces ammonia. This leads to irritation of the nasal mucous membranes. A correlation between floor slipperiness and ammonia emissions in cow housing has previously been demonstrated (Swierstra et al. 2001). The results of the multivariate analysis revealed that lower CoF friction renders the flooring slippery due to which the cows prefer to stand instead of slipping and falling down as shown by the increase in the SSI. Moreover, the majority of the shelter floors were concrete ones and studies have shown that cows prefer to remain standing for longer on such floors (Haufe et al. 2009), which supports the higher SSI in the present study. The cows might have felt more comfortable standing and walking on floors having higher CoF as their feet have a better grip with the floor and thus their AD was lower than cows on lower CoF floors. Cows have a natural predisposition to walk for about an hour a day, at 3–4 km/h, hence many cows in shelters are likely to have an unfulfilled urge for activity (Phillips 2002). Asymmetry in the gait of dairy cows has been found to be less in floors that have low levels of slipperiness (Telezhenko et al. 2017). The reduced gait asymmetry results in an absence of nervousness and walking discomfort (Telezhenko et al. 2017).

The dirtiness of the hind limbs decreased with increasing CoF probably because the cows slipped less, and even because the cows were more confident in their walking and less likely to knock into objects or other cows. These suppositions would need to be confirmed experimentally.

The inclusion of animal-based health indicators in this study has been validated by their significant correlations with the floor coefficient of friction. Other studies have demonstrated correlations between floor characteristics and animal health; for example, it has been revealed that cows have reduced immunity on concrete floors compared to rubber floors, which the authors attributed to increased stress (O'Driscoll et al. 2009).

No effects of the coefficient of friction on other animal-based welfare indicators were observed. The reason could be the variability in flooring in the cow shelters. The fact that the majority of the animal-based indicators were not normally distributed supports this observation.

Future studies could include animal behaviour in more detail, e.g., confidence in walking, knocking into objects or cows, and even the ability of cows to balance on three legs to scratch themselves which would be expected to increase at high friction levels. Subtle indicators of cow comfort on floors of different textures and friction levels are therefore warranted. It would also be interesting to correlate block performance with hooves obtained from an abattoir, as used previously (Phillips et al. 1998). Uneven hooves may enmesh with the floor better, leading to increased CoF. Theoretically, the size of the block will not alter friction, but different sizes may enmesh with the floor surface, depending on its variability in surface smoothness, to a variable degree, leading to differences in CoF.

4.7 Conclusions

Flooring is a vital component of welfare for a cow facility and has been included in most cow welfare assessments in different parts of the world. The purpose of developing this method of measurement of friction of various floors was to provide an easy, affordable, and quick method of assessment. Univariate analysis yielded a correlation of the CoF with shed flooring, bedding, cleanliness of the cow sheds, frequency of cleaning of the floors, gradient of the floors, lesions on the hock joints of the cows, lesions on carpal joints, and on the body. The multivariate analysis led to the identification of confirmed correlates with the friction of floors, which were the type of flooring, the proportion of cows standing, the avoidance distance of the cows, and the presence of dirty hind limbs. This analysis has validated the hypothesis of the present study that CoF does affect the welfare of cows in shelters. The results of this study suggest that this simple measure of floor coefficient of friction could be a useful measure in cow welfare assessments. Further work on the validity, repeatability, and reproducibility of this method for the measurement of slipperiness of flooring of cowsheds is recommended.

Publication included in Chapter 5

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Author Contributions to the paper

The conceptualization, design and methodology was done by Arvind Sharma, Clive J.C Phillips and G. Umapathy. The data collection was done by Arvind Sharma. The laboratory analysis was done by Arvind Sharma, G Umapathy and Vinod Kumar. The formal statistical analysis and interpretation was done by Arvind Sharma, Clive J.C Phillips and G. Umapathy. Original draft of the paper was prepared by Arvind Sharma and G Umapathy. The writing review and editing was done by Clive J.C Phillips and Arvind Sharma.

Chapter 5

Hair Cortisol in sheltered cows and its association with other welfare indicators

5.1 Abstract

India, the country with the largest population of dairy cows in the world, has a policy of retiring abandoned and non-lactating cows in shelters, but the level of provision for their welfare in these shelters is unclear. Cows in 54 shelters across India were assessed for historic evidence of physiological stress, through determination of hair cortisol in 540 samples from 10 cows in each shelter by enzyme immunoassay. Animal-based and shelter resource-based welfare measures were recorded and correlations with the hair cortisol investigated by multivariable analysis. High hair cortisol concentrations were associated with dung in the lying area of the cowshed, a low dry bulb temperature there and little cow access to yards, as shelter-based variables. At a cow level, high hair cortisol concentrations were associated with dirty flanks, hock joint ulceration, carpal joint injuries, body lesions, dehydration, an empty rumen, old age, and low levels of body hair loss. Hair cortisol level promises to be an effective biomarker of stress in cows when conducting studies under field conditions.

Keywords: hair cortisol; cows; shelters; welfare; measures; resources; indicators

5.2 Introduction

Hair cortisol is a biomarker of chronic stress in animals and its analysis provides an objective assessment of hypothalamic pituitary adrenal (HPA) axis activity over a long time period (Heimbürge et al. 2019). As a welfare measure, it is non-invasive, valuable for longitudinal studies, has a long-time lag for changes and is especially useful for field studies (Yang et al. 1998; Koren et al. 2002; Touma and Palme 2005; Davenport et al. 2006; Sheriff et al. 2010; D'Anna-Hernandez et al. 2011; Macbeth et al. 2012; Russell et al. 2012; Stalder and Kirschbaum 2012; Hernandez et al. 2014). The other matrices for detection of cortisol, principally urine, blood, saliva and faeces, cannot provide long term retrospective evaluations of cortisol (Bévalot et al. 2000; Probst et al. 2014; Tallo-Parra et al. 2015). Hair cortisol analysis is also more reliable to assess long term stress than blood, saliva, urine and faeces because the sebum of hair has lipophilic properties, which facilitate the effective binding and aggregation of the circulating cortisol in the shafts (Koren et al. 2002; D'Anna-Hernandez et al. 2011; Comin et al. 2013; Tallo-Parra et al. 2015; Heimbürge et al. 2019). Hair analysis is now being used to detect long-term retrospective levels of cortisol in farm animals, principally cattle (Comin et al. 2011; del Rosario et al. 2011; Cerri et al. 2012; Comin et al. 2013; Burnett et al. 2014; Hernandez et al. 2014; Tallo-Parra et al. 2015). It has also been analysed in humans (Bévalot et al. 2000), dogs (Bennett and Hayssen 2010), horses (Duran et al. 2017), pigs (Casal et al. 2017) and wild animals, such as rhesus macaques (Davenport et al. 2006), polar bears

(Macbeth et al. 2012), rats (Scorrano et al. 2014), coyotes (Schell et al. 2017), and kangaroos (Sotohira et al. 2017) for studying reproductive and adrenal endocrinology.

Studies have demonstrated the sensitivity of hair cortisol in cattle to the stresses of changes from winter indoor housing to summer pasture grazing and changes in nutrition (Comin et al. 2011; Comin et al. 2013). Enzyme Immunoassay (EIA), Enzyme-Linked Immunosorbent Assay (ELISA), and Radioimmunoassay (RIA) techniques have been deployed to detect and validate milk, plasma and hair cortisol concentrations in cows (Rigalma et al. 2010; Comin et al. 2011; del Rosario et al. 2011; Cerri et al. 2012; Moya et al. 2013; Burnett et al. 2014). However, there is a paucity of information relating to hair cortisol with other welfare indicators for cattle. The purpose of this study was, therefore, to assess hair cortisol concentrations in a range of old, retired and unproductive cows housed in traditional cow shelters or retirement homes (gaushalas) in India and explore its association with other indicators of welfare, measured both on the cows and in their housing conditions. This study was a part of a larger study of the welfare assessment of cows in the cow shelters.

5.3 Materials and Methods

This research study was conducted with animal ethics and human ethics approval from the University of Queensland Animal Ethics Committee (approval number SVS/CAWE/314/16/INDIA). A sample size of 54 shelters was selected based on a power analysis (Creative Research Systems, www.surveysystem.com/sscalc.htm) which indicated that a sample size of 50 shelters would be an adequate representation of shelters in major Indian states. Hence a total of 54 cow shelters were selected in six states of India (Gujarat, Maharashtra, Rajasthan, Punjab, Haryana and Himachal Pradesh. The study was conducted from December 2016 to July 2017. The criteria for selecting a shelter were: a minimum of 30 cows, that it was not a commercial dairy unit (defined as a shelter not selling more than 20 litres milk/day), and that the shelter was managed by a government, temple, public or a philanthropic trust. Power calculations were then performed based on a review of published hair cortisol studies (Comin et al. 2011; del Rosario et al. 2011; Cerri et al. 2012; Moya et al. 2013; Peric et al. 2013; Burnett et al. 2014; Tallo-Parra et al. 2015) that suggested a mean hair cortisol concentration with standard error estimates of 4.99 pg/mg and standard deviation of ±3.65 pg/mg. To detect a 10% difference between the samples in the present study and a reference sample added to the study samples at a p-value of 0.05 and a power of 0.8, a sample size should be 419 cows was determined (Creative Research Systems, www.surveysystem.com/sscalc.htm). In each shelter, 10 cows that were confirmed by the manager and shelter records had been in the shelter at least 6 months were selected randomly by choosing every third cow in the shed or the yard until the sample size was attained.

5.3.1 Welfare Measurement

These cows were further assessed for their welfare in the shelters by the measurement of both cow and shelter-based parameters. A two-day course on low stress livestock handling and a three-month training was underwent in scoring the cows for assessment of body condition, lameness, claw overgrowth avoidance distance, dirtiness, limb lesions (joint hair loss, ulceration and swellings), skin lesions, rumen fill, faecal consistency and rising behaviour, at the School of Veterinary Science, The University of Queensland. Pilot trials were also conducted to validate the selected welfare measures in two shelters before the commencement of the actual data collection. The cow-based welfare parameters (Appendix 1) assessed were as follows: lactation status (lactating or non-lactating), Body Condition Score (BCS) on a scale of 1 to 5 (Edmonson et al. 1989; Thomsen and Baadsgaard 2006); in increments of 0.25, with score ≤1.25 indicating emaciation, 1.5–2 indicating thin, 2.25–3.75 normal and 4 or more obese. General demeanour was assessed by modifying a five-point scale formulated by Cafe et al. (2011) into a dichotomized scale, docile or aggressive.

5.3.1.1 Cleanliness, Lesions and Disease Measures

Details of individual scoring systems are presented in Appendix 1. Dirtiness of the hind limbs, udder and flank and body hair loss were scored as described by Whay et al. (2003b); swellings, hair loss and ulceration of the hock joints and carpal joint injuries using the four-point scales of Wechsler et al. (2000) and Whay et al. (2003b). Lesions were presumed to be predominantly acquired from shelter furniture as a consequence of interaction with sharp nails/metals protruding from shelter gates and/or barbed wire fencing, and manifested in the form of hair and tissue loss. Sharp lacerations and avulsion of the skin were described using the method of Huxley and Whay (2006c), neck lesions by the method of Kielland et al. (2010a) and ocular lesions, nasal discharge, hampered respiration, diarrhoea and vulvar discharge by the method of Coignard et al. (2013). Rumen fill score and the consistency of faeces was evaluated according to the method of (Zaaijer and Noordhuizen 2003) and lameness was assessed using the locomotion scores referred to by Flower and Weary (2006). Claw overgrowth was visually assessed using the scale devised by Huxley and Whay (2006c). Skin lesions or integument alterations were evaluated using the method of Leeb et al. (2004).

Protocols for teat and udder scoring, skin tenting time, to assess dehydration, and the presence of oral lesions were formulated in this study only, because it was anticipated that emaciation, teat and udder abnormalities and the presence of very old cows would be more common in the shelters than in dairy cow farms, for which other scales had been developed. Ectoparasitism was scored using a modification of the method devised by Popescu et al. (2010).

5.3.1.2 Cow Behaviour Measures

The avoidance distance (AD) of the sampled cows in each shelter was used as recommended in the Welfare Quality® protocol (Welfare Quality® 2009). A cow was approached from immediately in front at a rate of one step per second, starting at 2 m from the manger. The distance between the assessor's hand and the cow's head was estimated at the moment the cow moved away and turned its head, using the following four categories (Appendix 1). Rising difficulty of a sample of 10 cows that were lying down in each shelter was categorized using an existing protocol (Rousing et al. 2004; Chaplin and Munksgaard 2016). All the cows lying in the shelter were coaxed to get up with the use of a minimum amount of force. If the presence of the assessor did not evoke rising they were given one or two moderate slaps on the back, followed by more forceful ones if necessary (for four cows only).

5.3.1.3 Shelter-Based Measures

Shelter-based resource assessments were based on housing features, including cleanliness, bedding, flooring, and water and feed provisions in the shelter. First, the total number of sheds per shelter and the number of animals per shed in the shelter was assessed, then two representative sheds were selected if more than two were present. Then the length, breadth and height of the sheds were recorded using a laser distance meter (CP-3007 model, Ultrasonic distance meter 40 KHz frequency, Chullora, New South Wales, Australia) and confirmed for each one using a measuring tape. From these measurements, the area of the shed and area per cow were calculated. The space allowance per cow in shelters having loose housing was calculated by dividing the floor area of the stall by the total number of cows within. In shelters with stalls, the area/cow was calculated from the floor area of each stall housing a cow (von Keyserlingk et al. 2012; Otten et al. 2016). In tethered stalls, the area per cow was calculated by measuring the distance from the end of the rope at the point of attachment to a peg to the end of the hind limb of the cow at full extension. This length was used as a radius to calculate the maximum potential area of movement of the tethered cows in the sheds.

Luminosity in the sheds was measured using a light meter (LCD Digital Lux Light Meter 9V Tester LX1010B 0 with 100,000 FC Photo Camera, Shenzhen Yongxiang Science and Technology Co., Ltd., Shenzhen, China) pointed in all six possible directions of the face of a cube at the centre of the shed. The mean of the six readings was calculated for each shelter. Dry and wet bulb temperatures were recorded using a digital meter (TS-FT0423 Digital Wireless Indoor Outdoor Thermo-Hygrometer Thermometer Humidity Meter, Sydney, Australia) inside the shelters before any cows were removed. The gradient of the floors in the sheds and the yards were measured at three different places as vertical and horizontal measurements with an inclinometer (Bosch

Professional, 600MM, DNM60L Model, Bairnsdale Electrics, Victoria, Australia). Noise levels in the cow shelters were measured at three different locations in the sheds and yards within the herd using an android phone application (Decibel X). Friction levels of the shelter floors were determined as the Coefficient of Friction (CoF), the force required to move an object over a floor divided by the weight of that object (Phillips and Morris 2001; Phillips 2018). This was estimated using a 1 kg/10 N spring balance attached by a hook to a cuboid wooden block (mass 156 g). The block was gently pulled across the floor at a speed of 0.17 m/s and the minimal frictional force (F) required to keep it moving was recorded (Sharma et al. 2019a).

The type of housing (free stall, tie stall, loose, tethered or no housing); roofing (portal, flat, sloped or other); and shed flooring (brick, stone, earthen, concrete or other); presence of bedding in the sheds (present or absent); type of bedding if present (hay, straw, rubber mats or other) and the presence of yards (present or absent) and number of trees in the shelter yards (Bartussek et al. 2000; Cook 2002; Costa et al. 2013; Otten et al. 2016), watering provisions and the number and types of water points (troughs, bowls, natural water bodies or other), were recorded in all the selected sheds and/or yards (von Keyserlingk et al. 2012; Costa et al. 2013). The cleanliness of the shelter premises was recorded by visually assessing the mean percentage of the floor that was covered by dung and urine in the sheds, passages and the yards separately (Regula et al. 2004). The information about the duration of cows' access to these yards (in h/day); access to pasture grazing (present or absent) and duration of access to the pastures (in h/day) was obtained from the interview of the shelter manager.

5.3.2 Hair Cortisol

5.3.2.1 Sampling

Hair samples of approximately 5 g were taken in triplicate from the switch of the tail only, cutting from the base at skin level using scissors disinfected with 70% alcohol between cows, a site recommended in a previous study (Moya et al. 2013) for hair cortisol analysis, and stored in individual plastic zip lock bags at room temperature (approximately 20 °C) in the dark before processing. Hairs present at the switch of the tail were collected irrespective of their colour.

5.3.2.2 Extraction of Cortisol from Hair

Cortisol was extracted from hair samples using a protocol described by Davenport et al. (2006) and modified by Tallo-Parra et al. (2015). Approximately, 250 mg of hair was weighed and washed with 5 mL of isopropanol to remove the external steroid sources. The hair samples were washed twice with water and twice with isopropanol for 3 min each wash to remove the external steroids and dirt. Approximately 250 mg of hair sample was placed in a 15 mL falcon tube before adding 5 mL of water and vortexed for 3 min at room temperature. The samples were then dried, adding 5 mL of Isopropanol and vortexing for 3 min at room temperature to remove the excessive dirt, urine and faecal contamination. The hair sample was then allowed to dry for 3–4 days in a hot air oven at 40 °C, after which it was minced into 2 mm lengths and pulverized manually into a fine powder using a pestle and mortar. Then 50 mg of hair powder was weighed into 2 mL micro centrifuge tubes, 1.5 mL of absolute methanol was added and shaken at 100 rpm for 18 h at 30 °C for extraction of steroids. After incubation, tubes were centrifuged at 7000× *g* for 2 min. Following centrifugation, 0.75 mL of supernatant was transferred into a fresh vial and kept in an oven at 38 °C for drying the supernatant for 24 h. Dried extracts were reconstituted with 300 µL of EIA assay buffer (0.1 M PBS, pH 7, containing 0.1% BSA), vortexed for 30 s and stored at −20 °C until analysis.

5.3.2.3 Cortisol Enzyme Immunoassay (EIA) for Determination of Hair Cortisol Concentration

Hair cortisol samples were analysed at the Centre for Cellular and Molecular Biology in the Laboratory for the Conservation of Endangered Species, an internationally recognized endocrinology laboratory. The hair cortisol concentrations were measured using a polyclonal cortisol antibody (R4866, provided by Dr. Coralie Munro, University of California, Davis, CA, USA), diluted to 1:9000 in the assay. Cross-reactivity of polyclonal cortisol antibody approximated 100% with cortisol, prednisolone 9.9%, prednisone 6.3%, cortisone 5% and <1% with corticosterone, desoxycorticosterone, 21-deoxycortisol, testosterone, androstenedione, androsterone and 11-deoxycortisol (Kumar et al. 2014; Umapathy et al. 2015; Budithi et al. 2016). The cortisol antibody sensitivity was calculated at 90% binding and found to be 1.95 ng/well. The inter- and intra-assay coefficients of variation (CV) of the assays were 7.19% (n = 10) and 2.68% (n = 10), respectively. Hair extracts were pooled and serially diluted (1:2, 1:4, 1:8, 1:16, 1:32) in triplicates (three repetitions i.e., each dilution was made in triplicates) to determine the parallel displacement curves between the pooled hair extract and respective standard of cortisol. Parallelism is the way to determine the immunological activity of antigen (cortisol in hair extract) and antibody (cortisol antibody) using serial dilutions at 50% binding. Parallel displacement curves were drawn to determine the relationship between the pooled serial dilution of hair extracts and their respective standards (Kumar et al. 2014) (Figure 5-1). The enzyme immunoassay (EIA) was performed using the previously described procedure (Kumar et al. 2014; Umapathy et al. 2015; Budithi et al. 2016).

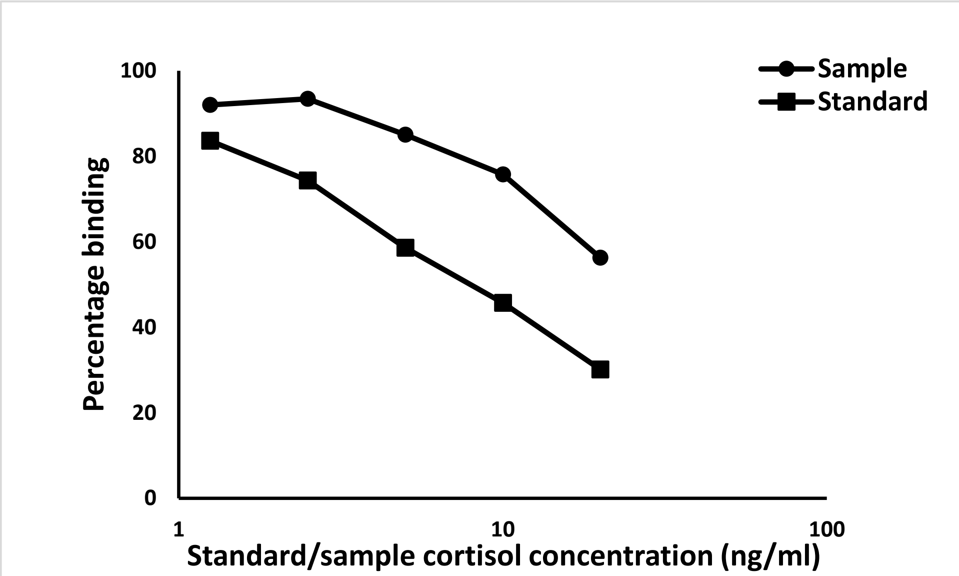

Figure 5-1: The parallelism between the serial dilution of pooled hair extracts of cow samples and cortisol standards.

5.4 Statistical Analyses

Statistical analyses were performed using the Minitab 17 Statistical Software (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA), following removal of outliers. Prior to statistical analysis, all data were tested for normal distribution by means of Anderson–Darling test and visualisation of probability distribution curves. Descriptive statistics were calculated and expressed as median, first quartile (Q_1), third quartile (Q_3) and interquartile range (IQR), as the data were not normally distributed. A univariate analysis was done to evaluate the relationships between various analysed parameters by performing the Spearman's Rank Correlations for cow-based welfare parameters and shelter-based parameters separately. The statistical significance was set at $p \leq 0.05$. Then a multivariable analysis was undertaken to reveal associations between the cow hair cortisol (response variable) and other cow-based parameters at the individual cow level as well as with the shelter-based welfare parameters. A principal component analysis was performed in both cases to reduce the data and avoid multicollinearity in order to explain the maximum variance with least number of principal components. The variables which were omitted were lesions from shelter furniture, vulval discharge, neck lesions and hampered respiration. The principal components with eigenvalues of more than one were considered for entry into a stepwise General Linear Model with alpha to remove variables of 0.05. The final models were evaluated for validity by taking into account adjusted r^2 and *p*-values of the factors and the independency of factor variables assessed by variance inflation factor (VIF) statistics. Factors with VIF < 10 were considered to show the absence of multicollinearity between factors. The assumptions of homoscedasticity and normal distribution of the residuals were tested graphically. Stability of the modelling process was evaluated by comparing the models from forward and backward selection methods.

5.5 Results

5.5.1 Animal and Shelter Based Measures

The median hair cortisol concentration was 1.43 pg/mg (IQR = 1.02 pg/mg). Descriptive statistics for animal-based and shelter-based parameters are shown in Tables 5-1 and 5-2. None of the parameters, animal- or shelter-based were normally distributed. Out of the 540 sampled cows, median age was 11 years; most were non-lactating, docile, of intermediate body condition and had mild to moderate dirtiness of the hind limbs, udder and flanks. Most had no or only a mild hair loss, mild to moderate hock joint swelling and hair loss on their hock joints, but no, or only mild carpal joint injuries (swelling, hair loss and ulceration). Few cows had lesions on their necks or bodies. There was some evidence of nasal discharge, lameness, claw overgrowth, teat, udder and ocular lesions but little evidence of diarrhoea. Rumen fill was usually intermediate. Mild to moderate levels of ectoparasitism were recorded, mainly in the form of lice and tick infestation, but there was little evidence of clinical dehydration, as evidenced by a skin tenting time. The avoidance distance scores indicated an ability to approach the cows to close range and mostly had had a normal sequence of rising.

The median number of cows per shed was 70, and the shed area per cow was 2.73 m^2. The median percentage of dung in the lying areas and passages of the sheds was 15% and 10%, respectively. In 83.3% of the sheds (45 sheds) and 88.8% of the yards (48 yards), there was no accumulation of urine in the lying areas and passages. There was no provision of bedding in 96.3% (52 shelters) of the shelters; only two shelters had paddy straw bedding, 0.03 and 0.05 cm thick. There was no water run-off in the lying areas in 72.2% of the shelters (39 shelters). The median height of the eaves of the shed roofing was 3.80 m. The median gradients of the shed flooring in the lying areas and passages was 1.46 and 2.36, respectively, and median CoF of shed floors 0.43. The median luminosity and noise levels in the shed were 582 lux and 27.7 decibels, respectively. The median dry and wet bulb readings in sheds were 29.5 °C and 34%, respectively. There was only one water point in 48% of the shelters, which was mostly located in the yards. Water points were absent in the sheds in 71% shelters. Twenty-three per cent of the shelters had no water points in the yards, 48% had one water point, 18.5% had two water points and only 10.5% shelters had three or more (up to six) water points in their yards. A median 20% of the floor was covered with dung in the shelter yards, but most shelters (88.8%, n = 48) had no urine on the yard floors.

A median of 8 h of access to the yards was provided to the cows in the shelters. The median yard area per cow was 5.9 m^2 and the median CoF and gradient of yard flooring were 0.64 and 1.51. The median noise level in the yards was 25.3 decibels, and the median number of trees in the yards was 2. There was no access to pastures for the cows in 59.2% of the shelters (32 shelters), and 26% of the shelters (14 shelters) provided access to pastures for up to 6 h/day. The median frequency of feeding the cows was three times a day, with the median quantity of fodder fed on a daily basis being 17.5 kg. Dry straw was fed in 18.3% shelters (n = 10), dry straw with agricultural by product waste in 20.4% (n = 11), dry straw with agricultural by product waste and hay in 46.4% (n = 25) and all the three along with greens and vegetable waste in 14.9% shelters (n = 8). Though 86% of the shelters provided concentrates in the form of rice or wheat husk and grains, the quantity received by each cow was less than 0.5 kg/day.

Table 5-1: Descriptive statistics of the resource-based welfare parameters in shelters (n = 54)

Parameter	Median	First Quartile (Q_1)	Third Quartile (Q_3)	Interquartile Range (IQR)
Cows/shed	70	47.8	137.3	89.5
Shed area/cow (m^2)	2.73	1.56	3.62	2.06
% dung in the lying area of the shed	15.0	5.0	40.0	35.0
% dung in the passages of shed	10.0	5.0	42.5	37.5
Height of shed eaves (m)	3.80	2.99	5.34	2.35
Gradient of shed lying area	1.46	0.96	2.2	1.23
Gradient of shed passages	2.36	1.27	3.52	2.24
Coefficient of friction of shed flooring (CoF)	0.43	0.27	0.65	0.37
Shed Luminosity level (lux)	582	89	1036	946
Shed noise level (decibels)	27.7	21.3	37.2	15.83
Shed dry bulb reading (°C)	29.5	27.2	32.8	5.6
Shed wet bulb reading (%)	34.0	24.7	45.2	20.50
Number of water points in the shelter	1.0	1.0	2.0	1.0
Percent dung in the yard	20	10	40	30
Yard area/cow (m^2)	5.9	3.6	21.5	17.9
Coefficient of friction of yard flooring (COF_{yards})	0.64	0.34	0.68	0.34
Gradient of the yard flooring (degrees)	1.51	1.13	2.43	1.30
Nose levels in the yard (decibel)	25.3	20.3	33.0	12.7
Number of trees in the yard	2.0	0.0	6.0	6.0
Provision of ad lib water in the yard	10	0.0	1.0	1.0
Availability of access to yards (h)	8.0	4.0	24.0	20.0
Frequency of feeding to the cows (times/day)	3.0	2.0	3.0	1.0
Quantity of fodder provided (kg)	17.5	13.0	20.0	7.0

Table 5-2: Distribution of different animal-based welfare parameters in 54 cow shelters (n = 540 cows)

Parameter	% Score					
	0	**1**	**2**	**3**	**4**	**5**
Dirty hind limbs score (Scale 0–3)	2.41	43.3	41.8	12.4	-	-
Dirty udder score (Scale 0–3)	21.6	42.7	28.3	7.2	-	-
Dirty flanks score (Scale 0–3)	22.2	39.6	31.8	6.3	-	-
Body hair loss score (Scale 0–3)	46.6	27.5	23.1	2.5	-	-
Hock joint swelling score (Scale 0–3)	38.3	33.5	26.7	1.5	-	-
Hock joint hair loss score (Scale 0–3)	71.8	22.4	5.1	0.5	-	-
Hock joint ulceration score (Scale 0–3)	83.7	13.1	2.9	0.1	-	-
Carpal joint injuries score (Scale 0–3)	44.0	32.7	22.5	0.5	-	-
Neck lesions score (Scale 1–4)	-	93.5	5	0.5	0.9	
Ocular lesions score (Scale 0–1)	90	10	-	-	-	-
Lesions on the body score (Scale 0–3)	41.2	32.2	24.2	2.3	-	-
Nasal discharge score (Scale 0–1)	88.1	11.8	-	-	-	-
Diarrhoea score (Scale 0–1)	96.3	3.7	-	-	-	-
Faecal consistency score (Scale 1–5)	-	0.5	4.63	35.9	57.4	1.4
Rumen Fill Score (Scale 1–5)	-	0.0	4.4	38.5	56.8	0.1
Lameness score (Scale 1–5)	-	85.7	9.0	3.3	1.8	-
Claw overgrowth score (Scale 0–3)	54.0	34.6	9.2	2.0	-	-
Teat score (Scale 0–5)	14.6	82.4	0.9	0.3	0.0	1.6
Ectoparasitism score (Scale 0–4)	0.1	56.3	29.8	13.5	0.1	-
Skin tenting time score (Scale 0–4)	90.9	5.7	2.5	0.7	-	-
Rising up difficulty score (Scale 1–5)	-	93.3	3.8	2.9	-	-
Avoidance Distance score (Scale 0–3)	72.0	20.3	5.8	1.9	-	-

5.5.2 Correlations between Hair Cortisol and Animal and Shelter Based Measures

Several animal-based measures showed weak but significant correlations with hair cortisol (Table 5-3). At the shelter level, the Spearman's Rank Correlations detected a significant positive correlation (CC = −0.298, $p = 0.028$) between hair cortisol concentration and the presence of runoff water in the shed lying areas. A significant negative correlation (CC = −0.370, $p = 0.006$) indicated that the hair cortisol concentration decreased with increasing duration of access of the cows into the yards and with the cleaning of areas other than sheds and yards (CC = −0.317, $p = 0.019$). Significant correlations were observed between variables in both animal and shelter based measures (Tables 5-5 and 5-6).

Table 5-3: Spearman's Rank Correlation coefficients for hair cortisol concentration (pg/mg) with other animal-based parameters, together with a p-value for each correlation

Animal-Based Parameter	Correlation Coefficient	*p*-Value
Dirty hind limbs score	0.232	<0.001
Dirty udder score	0.270	<0.001
Dirty flanks score	0.297	<0.001
Hock joint hair loss score	0.086	0.046
Hock joint ulceration score	0.213	<0.001
Carpal joint injuries score	0.276	<0.001
Diarrhoea score	0.152	<0.001
Rumen fill score	−0.224	<0.001
Claw overgrowth score	0.157	<0.001
Lameness score	0.177	<0.001
Lesions on the body score	0.176	<0.001
Avoidance distance score	0.222	<0.001
Age	0.111	0.012
Rising up difficulty score	0.270	<0.001
Lactation	−0.090	0.041
Body Condition Score (BCS)	−0.173	<0.001
Ocular lesions score	0.100	0.023
Nasal discharge score	0.149	0.001
Teat and udder score	0.169	<0.001

The multivariable analysis of the animal-based measures with hair cortisol revealed positive correlations with: dirty flanks, hock joint ulceration, carpal joint injuries, lesions on the body skin tenting time, age of the cows and lactation status and a negative correlation with body hair loss and rumen fill score (Table 5-4). The total r^2 adjusted was 20.98% and residuals were normally distributed.

Table 5-4: Regression analysis of animal-based parameters significantly related (p < 0.05) to hair cortisol concentration in $\log_{10}$pg/mg

Parameter	Coefficient	SE of Coefficient	*p*-Value	VIF
Constant	0.20	0.084	0.017	
Dirty flanks	0.07	0.014	≤0.001	1.46
Body hair loss	−0.06	0.018	0.001	2.47
Hock joint ulceration	0.03	0.015	0.04	1.12
Carpal joint injuries	0.04	0.013	0.002	1.21
Rumen fill score	−0.06	0.019	0.002	1.17
Lesions on the body	0.03	0.018	0.04	2.39
Skin tenting time (s)	0.08	0.025	≤0.001	1.15
Age of cows (years)	0.005	0.002	0.03	1.09

VIF = Variance Inflation factor; SE = Standard Error

The relationship was described by the equation:

$$\text{Hair Cortisol Concentration } (\log_{10}\text{pg/mg}) = c + 0.20\ (\pm 0.084, p = 0.017) + 0.07\ \text{Dirty flanks score } (\pm 0.0142, p < 0.001) - 0.06\ \text{Body hair loss score } (\pm 0.0180, p = 0.001) + 0.03\ \text{Hock joint ulceration score } (\pm 0.0150, p = 0.04) + 0.04\ \text{Carpal joint injuries score } (\pm 0.0139, p = 0.002) - 0.06\ \text{Rumen fill score } (\pm 0.0195, p = 0.002) + 0.036\ \text{Lesions on the body score } (\pm 0.0182, p = 0.04) + 0.08\ \text{Skin tenting time score } (\pm 0.0252, p < 0.001) + 0.0058\ \text{Age of the cows } (\pm 0.0028, p = 0.03), \quad (1)$$

where c is the intercept, which was 0.236 for non-lactating cows and 0.165 for lactating cows (p = 0.02); r^2 adjusted = 20.98%; residuals were normally distributed.

The multivariable analysis of the shelter-based measures with the mean hair cortisol concentration in cows at the shelter level produced a positive correlation between hair cortisol concentration and % dung in the lying area of the cowshed, and negative correlations with dry bulb temperature reading in the shed and the duration of access of the cows to the yards (Table 5-7). The relationship is described by the equation:

$$\textit{Hair cortisol concentration} = c + 0.016\ \textit{Percentage of dung in the lying area of the cowshed}\ (\pm 0.00597, p = 0.02) - 0.15\ \textit{Dry bulb reading in the shed}\ (\pm 0.0298, p = 0.001) - 0.070\ \textit{Duration of access to the yard}\ (\pm 0.0241, p = 0.01), \quad (2)$$

where c is the intercept, which is 6.15 ($p < 0.001$); r^2 adjusted = 65.69%; residuals of the model were normally distributed following visual inspection of their graphical representation.

Table 5-5: Spearman's Rank Correlation coefficients with p-values for hair cortisol concentration (pg/mg) with resource-based parameters

Resource-Based Parameter	Correlation Coefficient	*p*-Value
Shed runoff in the lying area	0.298	0.028
Availability of access to yards	−0.370	0.006
Cleaning of the areas in addition to sheds and yards	−0.317	0.019

Table 5-6: Spearman's Rank Correlation coefficients with p-values for hair cortisol concentration (pg/mg) with animal-based and resource-based parameters which were not significant (p > 0.05)

Parameter	Correlation Coefficient	*p*-Value
Temperament score	−0.029	0.511
Hock joint swelling score	0.066	0.137
Neck lesions score	0.012	0.788
Hampered respiration score	−0.066	0.136
Diarrhoea score	0.040	0.366
Vulvar discharge score	0.056	0.209
Faecal consistency score	−0.042	0.344
Ectoparasitism score	0.021	0.635
Shed flooring	−0.007	0.879
Shed bedding type	0.044	0.319
% dung in the lying area	−0.082	0.062
% dung in the passages	0.003	0.947
Presence of urine in shed passages	0.059	0.182
Thickness of bedding	0.044	0.316
Type of yard flooring	0.061	0.166
% dung in the yard	0.076	0.109
Area/cow in the shed	−0.056	0.207
Area/cow in the yard	−0.035	0.466
Frequency of scrapping the floors	−0.014	0.757
Method of floor scrapping	−0.024	0.594

Table 5-7: Regression analysis of resource-based parameters significantly ($p < 0.05$) related to hair cortisol concentration ($\log_{10}$pg/mg)

Parameter	Coefficient	SE of Coefficient	*p*-Value	VIF
Constant	6.15	0.881	≤0.001	
Dung in the lying area of shed (%)	0.01	0.005	0.02	1.83
Dry bulb temperature in the shed (°C)	-0.15	0.029	0.001	2.00
Duration of access to yards (h/day)	-0.07	0.024	0.015	1.16

VIF = Variance Inflation factor; SE = Standard Error.

5.6 Discussion

5.6.1 Hair Cortisol Concentrations

The hair cortisol concentration in the present study was in the similar range to that recorded in some studies in dairy and beef cattle (Comin et al. 2011; del Rosario et al. 2011; Comin et al. 2013; Moya et al. 2013; Peric et al. 2013; Burnett et al. 2014; Tallo-Parra et al. 2015). Though the median hair cortisol concentration was lower in this study, it was still within the similar range reported in previous studies (Table 5-8). The hair samples were cut into 2 mm pieces and pulverised manually, as recommended to maximise extraction of hair cortisol (Burnett et al. 2014; Tallo-Parra et al. 2015). A major difference between this study cows and those cited above was that this study had a much larger number of cows, over a wider geographical area with different agro-climatic conditions and management practices. The different analysis protocols, extraction procedures, climatic and breed variabilities are important factors affecting the results of hair cortisol estimation. There is interplate and intraplate variation in the estimation process, which was below 6% in this study. This is acceptable, and each plate sample was mixed for the required period of time.

Table 5-8: Comparative results of studies on the analysis of hair cortisol concentration in cattle

Reference	Hair Cortisol Concentration (pg/mg)	Sample Size
Burnett et al. (2014)	5.7 ± 1.7	18
del Rosario et al. (2011)	12.15 ± 1.85	5
Moya et al. (2013)	2.35 ± 0.176	12
Comin et al. (2013)	2.1 ± 0.10–2.9 ± 0.17	83
Comin et al. (2011)	3.29 (0.76–20.41) 5.12 (1.62–28.95)	257 218
Peric et al. (2013)	Holsteins: 5.38 (1.91–27.95) Crossbreds: 4.40 (2.11–41.74)	142 148
Tallo-Parra et al. (2015)	White hair: 2.1 ± 1.10 Black hair: 3.9 ± 1.44	17

5.6.2 Hair Cortisol and Animal-Based Measures

The low hair cortisol concentration in the cows with hair loss is in contrast to the findings of Novak et al. (2014), who observed a positive correlation between hair loss and hair cortisol concentration in Rhesus Macaques. However, this study was inconclusive on whether the relationship between hair loss and hair cortisol concentration was causal or just an association. Moreover, one of the sub groups of macaques showed no relationship between hair loss and elevated hair cortisol concentrations. There is a “wash out effect,” in which there is a decline in the hair cortisol concentration from the proximal segments to the distal ones (Kirschbaum et al. (2009) due to the ultraviolet radiation (Wester et al. 2016) or due to the effect of grooming and licking in animals (Acker et al. 2018). The most plausible reason for the result in the present study is adrenal gland fatigue due to extended periods of overactive cortisol production. The overworked adrenal gland works less efficiently and might lead to less cortisol production and other glucocorticoids, which may lead to hair loss. Studies in humans have shown that subjects with hair loss express reduced levels of glucocorticoids due to a weak response to stress (Ito 2010, 2013). However, the adrenal gland fatigue theory has been rejected in a systemic review by endocrinologists (Cadegiani and Kater 2016) citing the absence of substantive proof of this condition due to the methodological and confounding errors in various studies on the relationship between HPA axis activation and adrenal gland fatigue. The cows in the shelters suffer chronic stress due to the health and managemental issues such as old age, low quality feeding practices, less area/cow, improper flooring and cleanliness, highlighted in this study which could activate the HPA axis leading to elevated hair cortisol concentrations.

This is a cross sectional study at a point of time which might not fully explain the causality of the elevated hair cortisol concentrations in shelter cows. A prospective study is recommended to further explore this relation between the HPA axis activation and adrenal gland fatigue. The positive association between the dirtiness of the flanks and hair cortisol in the shelter cows may derive from an indirect effect of dirtiness on stress levels in the body, as dirtiness predisposes animals to diseases and injuries (Busato et al. 2000). Dirtiness reduces hygiene of the cows and exposes the risk of pathogens leading to disease which causes stress (Schreiner and Ruegg 2003; Munoz et al. 2008). The dirtiness of the animals could be due to improper management and high stocking density in the housing facilities (Schubach et al. 2017). The matting of the hair caused by dirtiness might cause minor haemorrhages, putting tension on the epithelial tissue of the skin when strained leading to pain and stress (Jackson and Cockcroft 2008). Faecal contamination of the cows’ hair coat causes discomfort, reduces thermoregulation and increases the incidence of disease (Broom and Fraser 2015). The area per cow in the current study was much lower than the recommended for comfort (Leaver 1999; Phillips and Morris 2001) which might have led to dirtiness and stress, thus accounting for the positive correlation between dirtiness of flanks and elevated hair cortisol concentrations. Significant univariable positive correlations were observed between dirty flanks and body hair loss (CC = 0.42, $p \leq 0.001$), carpal joint injuries (CC = 0.33, $p \leq 0.001$), lesions on the body (CC = 0.33, $p \leq 0.001$), ectoparasitism (CC = 0.22, $p \leq 0.001$), diarrhoea

(CC = 0.14, $p = 0.002$) and skin tenting time (CC = 0.25, $p \leq 0.001$). A negative correlation was observed between dirty flanks and rumen fill score (CC = −0.22, $p \leq 0.001$). The positive univariate relationships reveal that the interplay of these animal health indicators is correlated with changes in the hair cortisol concentration in the shelter cows. The effect of dirtiness on the health of cows has been documented in previous studies, underlying the importance of cleanliness in reducing health risks (Schreiner and Ruegg 2003; Ellis et al. 2007). The associations between cleanliness and lesions on the joints and integument alterations have also been reported (Norring et al. 2010).

Hock joint ulceration at the tuber calcis, carpal joint injuries and lesions on the body are painful traumatic lesions which lead to inflammation. The positive correlation between the hair cortisol concentration and the carpal joint injury score and body lesions' score is probably attributable to the activation of the HPA axis due to the stress response of the body to these injuries, at least in dairy cattle (Burnett et al. 2014). However, in the present study, the hair cortisol concentration was found to be elevated in sub clinical health problems (joint and skin injuries and swellings) in contrast to the findings of Burnett et al. (2014), who found no elevation in sub clinical endometritis. This could be because of greater stress caused by the injuries in the limbs and joints than in the case of endometritis.

The negative correlation between rumen fill score and hair cortisol concentration, though weak, may justify its inclusion in the welfare assessment protocol as a cow health signal (Aalseth 2005), being indicative of dry matter intake, fluid intake, the composition of feed, digestibility and the passage rate of the ingested feed (Hartnell and Satter 1979; Aitchison et al. 1986; Llamas-Lamas and Combs 1991; Zaaijer and Noordhuizen 2003). Almost 60% of the cows in this study had a score of 4 which shows low fluid intake and more dry matter, as is common for dry cows. Rumen fill score also indirectly provides an indication of underlying sub clinical disease due to changes in feed intake or dry matter intake (Oetzel 2004). Rumen fill score indirectly provided information about the feeding management, and the latter could be a potential stressor in the shelter cows. Rumen fill score has been used as an indicator of poor health and nutritional stress in cows (Olmos et al. 2009). In this study rumen fill score provides information about the lack of balanced nutrition and health of the cows due to its significant negative univariable association with diarrhoea (CC = −0.12, $p = 0.006$), ocular lesions (CC = 0.18, $p \leq 0.001$), hock joint ulceration (CC = −0.15, $p \leq 0.001$), carpal joint injuries (CC = −0.14, $p = 0.001$), lesions on the body (CC = −0.32, $p \leq 0.001$), lameness (CC = −0.12, $p = 0.006$) and claw overgrowth (CC = −0.18, $p \leq 0.001$) (Sharma et al. 2019a). Most of these lesions induce chronic pain and could potentiate stress in the cows depicted by elevated hair cortisol levels. The association of rumen fill score with these other health parameters in this study should be interpreted with caution as these scores change over a 24 h period and in a cross-sectional study at a point of time does not indicate a causal relationship. A routine measurement of this parameter in a cow herd has been suggested to interpret its relevance to predict the cows at risk of developing disorders (Burfeind et al. 2010).

Age and lactation showed a positive association with hair cortisol concentration and are in agreement with Burnett et al. (2014). Lactating cows are challenged physically, metabolically and immunologically as a result of production stress, clinical and sub clinical diseases and immune suppression (Esposito et al. 2014). Aged cows are normally multiparous and harbour subclinical health disorders like metritis that might activate the HPA axis through inflammatory conditions (Dobson and Esslemont 2002), even though Burnett et al. (2014) did not find that sub clinical conditions of endometritis increased hair cortisol. Lactation had significant positive correlations with BCS (CC = 0.15, $p = 0.001$) and coat condition (CC = 0.12, $p = 0.004$) in the present study. Contrarily, significant negative relationships between lactation and teat and udder score (CC = −0.59, $p \leq 0.001$), ectoparasitism (CC = −0.14, $p = 0.001$), faecal consistency (CC = −0.13, $p = 0.002$) and age (CC = −0.13, $p = 0.003$) were observed. Age was significantly but weakly correlated with lactation (CC = −0.13, $p = -0.003$), BCS (CC = −0.11, $p = 0.008$), coat condition (CC = −0.09, $p = 0.03$), lesions on the body (CC = 0.11, $p = 0.007$), faecal consistency (CC = 0.08, $p = 0.04$), teat and udder score (CC = 0.11, $p = 0.007$), ocular lesions (CC = 0.10, $p = 0.02$), hock joint swelling (CC = 0.13, $p = 0.002$), hock joint hairloss (CC = 0.15, $p = 0.001$) and hock joint ulceration (CC = 0.11, $p = 0.01$). In a study on dairy cows (Peric et al. 2013) greater hair cortisol concentrations were reported in heifers than two-year-old cows. This was explained because of the diffusion of circulating cortisol concentrations in blood into the hair follicles following the stimulation of the adrenal gland of the cows by the foetal pituitary adrenal axis. However, the pregnancy of these cows could be the confounding factor in this elevation of hair cortisol levels. Similar correlations between lameness and dirtiness, hock lesions and lactations have been observed in previous studies (Relun et al. 2013; Bergsten et al. 2015; Nash et al. 2016).

All of the locations reflecting dirtiness of the cows i.e., flanks, udder and/or hind limbs, had significant positive relationships with carpal joint injuries (CC = 0.32, $p \leq 0.001$), claw overgrowth (CC = 0.27, $p \leq 0.001$), lameness (CC = 0.27, $p \leq 0.001$), nasal discharge (CC = 0.11,$p = 0.01$), diarrhoea (CC = 0.12, $p = 0.004$), lesions on the body (CC = 0.33, $p \leq 0.001$) and skin tenting time (CC = 0.24, $p \leq 0.001$). The interrelationships between these parameters of cleanliness and cow health suggest a cumulative stress on the cows which could have been revealed by the elevated hair cortisol concentrations. Similar univariable relationships have been observed between different health and resource-based welfare parameters in welfare assessment in dairy cows (Regula et al. 2004).

Many of these welfare parameters were weakly correlated with each other and associations are not strong. However, these were not ignored because they represented different aspects of welfare. For this reason, they were analysed separately with each other though it had the disadvantage that spurious associations might appear significant as multiple analysis were performed. So, caution against the over-interpretation of single statistically significant variables is advised, as concluded by Regula et al. (2004).

5.6.3 Hair Cortisol and Shelter-Based Measures

The positive relationship of the hair cortisol concentration and the percentage of dung in the lying area of the cows in the shelters is almost certainly linked to the effect observed on the dirtiness of the cows. Dung in the lying areas makes the cows dirtier and hence susceptible to diseases and infection, leading to stress (Schreiner and Ruegg 2003; Munoz et al. 2008).

The negative relationship between hair cortisol concentration and dry bulb temperature in the shelters in the present study is hard to explain. The thermal comfort zone for cattle is between 5 and 25°C (McDowell 1972) and in the current study, the median dry bulb temperature recorded in the shelters was 29.5°C, above the thermoneutral zone. Examination of the data suggests that there was elevated hair cortisol when the ambient temperature was higher or lower than this range. Plasma cortisol concentrations have been found to be inconsistently related to higher temperatures, with studies showing an increase (Satterlee et al. 1977; Wise et al. 1988b; Elvinger et al. 1992), decrease (Collier et al. 1982; Correa-Calderon et al. 2004) or no changes (El-Nouty et al. 1980; Wise et al. 1988a; Johnson et al. 1991).

The negative association of the hair cortisol concentration and the access to the yards of the shelters (CC = −0.32, p = 0.01) suggests benefits of greater ease of movement. There were significant relationships between hair cortisol concentrations and hock lesions, cleanliness levels of cows, claw overgrowth and lameness in the univariable analysis in this study (Table 5-3). Reviews on studies about the benefits of loose housing with yards have shown that there is a low incidence of lameness, hoof pathologies, hock injuries, uterine affections and cleanliness in cows with such facilities, leading to less stress and better welfare (Arnott et al. 2017). Cattle like spending time on concrete pads rather than the muddy wet soil of the yards where poor hygiene prevails and might lead to immunosuppression (Chen et al. 2017). One study (Olmos et al. 2009) found no changes in the circulating plasma cortisol levels in pasture-grazed cows and totally housed cows. Another study (Comin et al. 2011) found elevation in hair cortisol levels when cows were moved from housing to summer pastures, though the freedom from confinement and better nutrition could be confounders. The lower hair cortisol concentrations in the present study in cows having access to yards and pastures point to long term effects on the welfare of the cows.

5.7 Limitations of the Study

The parameters measured in this study were assumed to be accurate reflections of what it was needed to measure, which may not always have been the case. For example, it was not known whether cortisol concentration in hair is linearly related to the welfare of the cattle. Measurement techniques were, it is believed, the best available and informed by a full literature review, but again these might have inherent inaccuracies. For example, this study assumed that hair cortisol was best measured from tail hairs, as suggested previously (Moya et al. 2013), and did not compare cortisol between or within sites. The repeatability and reliability of many of the measures used is not yet known and should be the subject of further study.

In terms of the number of animals sampled, to author's knowledge, this is the largest study so far on the assessment of hair cortisol concentrations in cows. There are conflicting reports on other studies conducted on the hair cortisol concentration of cattle, a topic which needs further assessment, for example, cows of different hair colours (Tallo-Parra et al. 2015; Ghassemi Nejad et al. 2017), to produce guidelines that can be built into future studies. However, the relationships observed suggest that hair cortisol is a good matrix to assess stress levels and hence the welfare status of cattle in facilities from a historical perspective.

5.8 Conclusions

Hair cortisol concentrations in shelters cows were elevated by the dirtiness of the cows, swellings and injuries of the limbs and body, age lactation and dehydration in the cows in the shelters. A negative association was found in the hair cortisol concentration and hock joint swelling, rumen fill and body hair loss. Evidence of a weak relationship was found between the hair cortisol concentration of the cows and the dry bulb temperature depicting the low levels in zones of thermoneutrality. Shelters providing access to the yards and having clean lying areas had cows with lower hair cortisol levels. This study was an analysis of welfare issues in the cow shelters at only one point in time, but a longitudinal study of cows from the time at which they enter the shelter could add further information on stress responses.

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Author Contributions to the paper

The conceptualization, design and methodology was done by Arvind Sharma and Clive J.C Phillips and Catherine Schuetze. The field data collection and investigation was done by Arvind Sharma. The formal analysis and interpretation was done by Arvind Sharma and Clive J.C Phillips. Original draft of the paper was prepared by Arvind Sharma. The writing review and editing was done by Clive J.C Phillips and Arvind Sharma.

Chapter 6

Lameness in sheltered cows and its association with cow and shelter attributes

6.1 Abstract

The sheltering of old, unproductive and abandoned cows in traditional cow shelters, known as gaushalas, has been practiced in India since ancient times. Cows are kept in these shelters until they die of natural causes. The welfare of the cows in these shelters was assessed through a cross-sectional study of 54 cow shelters in six states of India. A total of 1620 cows were examined to assess the prevalence of lameness in these cows, and the associated risk factors for lameness were identified through the measurement of animal-based and resource-based welfare indicators. The overall lameness prevalence was 4.2%. The majority (86%) had mild to moderate hock joint swellings but no or only mild carpal joint injuries. Approximately one-half had mild to moderate hock joint hair loss and most were free of hock joint ulcerations. Claw overgrowth was present in almost one half of the cows. Lameness prevalence was positively correlated with coat dirtiness, hock and carpal joint lesions, diarrhoea and claw overgrowth scores. In a multivariate analysis, lameness prevalence increased as the Body Condition Score (BCS) decreased and was associated with increased udder dirtiness, the ulceration of the hock joint, carpal joint injuries and claw overgrowth. Resource-based indicators measured at the shelter level suggested that an absence of bedding in the sheds and an increase in the gradient of the shed flooring increased lameness. Addressing the principle risk factors identified for lameness in the sheltered cows (low body condition, dirty udders, lesions on the hock and carpal joints, overgrown claws, and a steep floor gradient) may help to reduce this serious animal welfare problem.

Keywords: cow shelters; lameness; risk factors; welfare assessment; indicators

6.2 Introduction

The sheltering of old, abandoned, unproductive and stray cows in traditional cow shelters, or Gaushalas, is a five-thousand-year-old tradition in India (Yadav 2007). The cows are housed in shelters until they die of natural causes. The management of these shelters is organized by temples and public trusts, with the financial support of the public, philanthropists, non-governmental organizations and the Indian Government (Mandi et al. 2018). Animal health care management is a major challenge faced by shelter managers due to the paucity of funds and lack of trained manpower (Yadav 2007; Kachhawaha et al. 2015).

Determining the relationships between husbandry practices and cow health is important to develop protocols for husbandry that will improve welfare (Farm Animal Welfare Council 1993a). Lameness is a health problem in cows that has significant welfare implications due to the pain induced, the effects on mobility, the long duration of the illness (Phillips 1990) and its greater prevalence in herds all over the world (Cook 2003; Bicalho et al. 2007; Vermunt 2007). Most welfare assessments of cattle herds have lameness as one of the most important animal-based measures in their protocol (Whay et al. 2003d; Napolitano et al. 2005; Mülleder et al. 2007; Botreau et al. 2009; Knierim and Winckler 2009). Prevalence rates of lameness in dairy herds range from 17 to 35% in most parts of the world where it has been measured, including the United Kingdom, Canada, Italy, United States, and Malaysia (Cook 2003; Espejo et al. 2006; Bicalho et al. 2009; Barker et al. 2010; Solano et al. 2015; Sadiq et al. 2017). The reported incidence of lameness in dairy cows in India ranges from 8.1 to 30.5% (Singh 1998; Sood and Nanda 2006; Chakrabarti and Kumar 2016). Intensively managed systems are particularly associated with lameness in cattle (Cook and Nordlund 2009). Known risk factors include lying behavior, hock lesions, limb hygiene, inadequate stall dimensions, insufficient or low-quality bedding, slippery walking surfaces, and exposure of the feet to slurry (Faull et al. 1996; Borderas et al. 2004; Dembele et al. 2006; Barker et al. 2007; Fregonesi et al. 2007a; Sadiq et al. 2017). The prevalence of lameness in cow shelters has been reported in the descriptive study (Chapter 3) and the same data set has been used in this study for further analysis of the association of lameness with other animal- and shelter-based welfare parameters. There is a possibility of such association if the shelters have conditions, such as poor flooring that predispose the cows to lameness. Therefore, the objective of this study was to determine the associated risk factors with lameness in a cross-sectional study of the welfare of cows in shelters.

6.3 Materials and Methods

Cows in 54 shelters (gaushalas) located in the six states of India (Gujarat, Maharashtra, Rajasthan, Punjab, Haryana and Himachal Pradesh) were assessed for their welfare. These six states are located in the northern and western part of India, have the most shelters, and have a tradition of sheltering cows, except one (Himachal Pradesh), which is establishing new shelters to manage the street cow problem. Of the 54 shelters, 26 were visited on the advice of state veterinary officers or the Animal Welfare Board of India (AWBI), and the remaining shelters were chosen using a snowballing technique, taking recommendations from shelter managers. There was no significant difference ($p < 0.05$) between shelters obtained by the two methods in any measured parameter when compared by analysis of variance or a Moods median test (in the case of non-normal residuals). A single 2 day visit was made to each shelter between December 2016 and July 2017. In each shelter, 30 cows were sampled, following a power calculation to determine the required numbers of cows and shelters (Hsieh et al. 1998), to detect an odds ratio of 4 with a power of 0.8 and $\alpha = 0.05$. The sample size of 30 cows was sufficient to estimate within-herd prevalence with an error of 10% at a 95% level of confidence. Cows were selected by choosing every third cow in the shed or the yard, and 1620 cows were sampled in total.

Data collection included the recording of direct observations of the cows and measurements, as well as the recording of the various housing parameters (resource-based parameters). Management data (feeding time and regime, frequency of water provision to the cows if not available ad libitum, duration of pasture grazing and access to yards, frequency of scraping the floors) were collected in a 30-minute interview of the shelter manager, based on a predesigned questionnaire(Appendix 4). Twelve animal-based parameters were chosen based on a literature search and author's experience of welfare issues in shelters: lameness score, lactation status, cow age, Body Condition Score (BCS), dirtiness of the hind limbs, dirtiness of the udder, dirtiness of the flanks, hock joint swellings, hock joint hair loss, hock joint ulceration, carpal joint injuries and claw overgrowth.

6.3.1 Animal-Based Welfare Parameters

Lameness scoring was undertaken by scoring the locomotion of each sampled cow according to a 5-point scale (Table 6-1) developed by Sprecher et al. (1997). The lactation status (lactating or non-lactating) of the cows was recorded, and the age of each cow was approximated from the shelter's records, an interview with the shelter managers and from the cows' teeth. The BCS was assessed by visual inspection of the cows from the side and back of the cows, with units ranging from 1 (lean) to 5 (fat), scored to quarter points as described by Edmonson et al. (1989) and modified by Thomsen and Baadsgaard (2006). Cows with a score of $\leq$ 1.25 were considered emaciated, 1.5–2 thin, 2.25–3.75 normal and 4 or more obese.

Table 6-1: Lameness Scoring System used in the study to determine the prevalence of lameness

Locomotion Score	Interpretation	Description of Locomotion
1	Normal	Normal walk with a flat back
2	Mild lameness	Normal walk but with an arched back
3	Moderate lameness	Slight abnormal walk, short stride with one or more legs
4	Lameness	Visibly lame, but able to bear some weight on all legs
5	Severe lameness	Almost complete transfer of weight from an affected leg

[a] Adopted from Sprecher et al. (1997)

The dirtiness of the hind limbs, udder, flanks and body hair loss was assessed by visual inspection on both sides of the cow and from behind, as described by Whay et al. (2003b): 1—no dirtiness; 2—mildly dirty (small soiled areas of dirtiness with no thick scabs); 3—medium dirtiness (large soiled areas but with < 1-cm thick scabs of dung) and 4—severely dirty (large soiled areas with > 1-cm thick dung scabs). The body hair loss score was assessed as: 1—no hair loss, 2—mild hair loss, 3—moderate hair loss, and 4—severe hair loss (Whay et al. 2003b).

The hock region was defined as the lateral tarsus, medial tarsus and the lateral, medial and dorsal calcaneus. Both of the hind limbs of each cow were visually inspected and examined. Hock lesions included hair loss, ulcerations and swellings in a modification of the method of Wechsler et al. (2000) and Whay et al. (2003b). Hair loss and ulceration on the joints were scored as: 0—no hair loss or ulceration, 1—mild hair loss or ulceration < 2 cm^2, 2—medium hair loss or ulceration (approximately 2.5 cm^2), 3—severe hair loss or ulceration > 2.5 cm^2. Hock joint swellings were scored as: 1—mild swollen joint, 2—medium swollen joint, and 3—severely swollen joint. Carpal joint injuries were scored as: 0—no skin change, 1—hairless, 2—swollen, and 3—with wound (Wechsler et al. 2000). Claw overgrowth was visually inspected on each sampled cow and scored according to the scale devised by Huxley and Whay (2006c): 0—normal claw, 1—mild claw overgrowth, 2—moderate claw overgrowth, and 3—severe claw overgrowth.

6.3.2 Resource-Based Welfare Parameters

The area of each shelter shed was calculated after measuring the length and breadth of shed using a laser distance meter (CP-3007 model, ultrasonic distance meter 40KHz frequency, Chullora, New South Wales, Australia), confirmed by measurement with a measuring tape. The space allowance per cow in the shed was calculated by dividing the area of the shed by the total number of cows housed within that shed. In shelters with cows in tie-stalls, the space allowance was calculated by finding the area covered by a cow in each such stall (Otten et al. 2016). In shelters where the cows were tethered but not in stalls, the space allowance was calculated by measuring the length of tether rope from where it was tied to a peg to the hind limb of the cow when fully extended. This allowed calculation of the diameter of a semicircular area in which the cows was able to move. Using the formula for calculating the area of a semi-circle ($\pi r^2/2$), the area per cow was calculated for each tethered cow.

The types of flooring of the sheds and yards were recorded. The Coefficient of Friction (CoF) of the flooring of the shed was determined as the force required to move an object on a floor, divided by the weight of the object (Phillips and Morris 2001), using a 1-kg/10N spring balance attached by a hook to a cuboid wooden block weighing 156 g. This block was gently pulled across the floor at a speed of 0.17 m/second and the minimal frictional force (F) required to keep it moving was recorded (Sharma et al. 2019a). The CoF in the lying areas and passages of the shelter sheds was calculated using the above-mentioned formula. The presence or absence of bedding in the shelter sheds and type of bedding of the sheds was recorded by visual inspection.

The cleanliness levels of the shelters were assessed by estimation of the percentage of floor covered by dung in the lying areas and passages of sheds and yards (Regula et al. 2004). Similarly, the proportion of the floor covered with urine in lying areas and the passages of the sheds was visually determined. The average gradient of the flooring in the shed lying areas, passages and yards was recorded at three different places using vertical and horizontal measurements with an inclinometer (Bosch Professional, 600MM, DNM60L Model, Clayton, Australia).

6.4 Statistical Analysis

Descriptive and other statistical analyses were conducted using statistical software Minitab 17 Statistical Software (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA). Variables were tested for normality by the Anderson–Darling test (Evans et al. 2017). The univariate analysis of cow-based variables for each shelter was conducted using Spearman's rank correlations, because not all of the variables were found normally distributed by the Anderson–Darling test. This investigated correlations between mean shelter values for lameness and the other cow-based variables, which were continuously distributed.

Two sub-models were then generated for the data analysis. In the first, cow-based risk factors for lameness were examined in a multivariate analysis. An ordinal regression modeling using all five lameness scores as outcome variables, but the models did not show a biologically plausible association between lameness and predictors. This was because there were very few cows with scores of 4 or 5. Hence lameness scores were transformed into binary values, cows that were clinically not lame (0), and scores of 3, 4 and 5 as clinically lame cows (1). A binary logistic regression analysis with the logit procedure and the modeled outcome lameness (present or not), based on the locomotion score of the sampled cows, was undertaken. Predictor variables (dirty hind limbs, udder, flanks, body hair loss, hock joint swellings, hock joint hair loss, hock joint ulceration, carpal joint injuries, diarrhea and claw overgrowth) were also dichotomized by classifying them as the absence of a lesion/change (scores 0 and 1) or the presence of a lesion (scores 2, 3 and 4, as prescribed by the scoring system of the variable). Thus, these dichotomous variables were defined as 0 or 1, with 1 representing the expected increased risk. Observations within shelters were accounted for by including shelter as a clustering effect in the model. The residuals were analyzed to explore the basic assumptions of logistic regression and model fit, according to (Dohoo et al. 2009b). The graphical examination of the residuals showed them to be normally distributed. Levels of significance were set as $p \leq 0.05$ for all analyses.

In the second sub-model, resource-based and management parameters were analyzed at the shelter level. Lameness prevalence estimates at the shelter level were used as the outcome in analyzing risk factors. The multivariate analysis of the effects of lameness on resource-based parameters was performed by a Stepwise General Linear Model (GLM) with α to enter at 0.15. The residuals were normally distributed ($p = 0.27$) but were also examined graphically.

6.5 Results

6.5.1 Animal-Based Welfare Parameters

Categorical animal-based parameters are enumerated in Table 6-2. The overall prevalence of lameness in the cow shelters was 4.2%. Out of the 1620 cows examined, only 69 cows were clinically lame (locomotion scores 3 to 5; 3—3.2%, n = 53, 4—0.9%, n = 15, and 5—0.06%, n = 1). Most (n = 1373, 84.7%) of the cows were not lame (score 1), and 11% (n = 178) of the cows had mild/subclinical lameness (score 2).

Table 6-2: Percentage of cows in each category (number) of animal-based welfare parameters in 54 shelters (n = 1620 cows), see text for details of scoring systems

Parameter	Score 0	Score 1	Score 2	Score 3	Score 4	Score 5
Lameness score (scale 1–5)	-	84.7 (1373)	10.9 (178)	3.2 (53)	0.9 (15)	0.06 (1)
Lactation status (scale 0, non-lactating, 1, lactating)	87.9 (1425)	12.04 (195)	-	-	-	-
Dirty hind limbs score (scale 0–3)	2.3 (38)	42.5 (690)	43.02 (697)	12.04 (195)	-	-
Dirty udder score (scale 0–3)	17.4 (283)	44.5 (722)	31.4 (509)	6.5 (106)	-	-
Dirty flanks score (scale 0–3)	19.5 (316)	42.2 (684)	32.0 (519)	6.2 (101)	-	-
Body hair loss score (scale 0–3)	44.9 (728)	30.3 (492)	22.9 (371)	1.7 (29)	-	-
Body Condition Score (BCS) (scale 1–5) 1(≤ 1.25) 2(1.5–2) 3(2.25–3.75) 4(4 and above)	-	0.1 (2)	22.8 (371)	75.4 (1223)	1.4 (24)	
Hock joint swelling score (scale 0–3)	11.7 (191)	22.3 (262)	63.7 (1032)	2.1 (35)	-	-
Hock joint hair loss score (scale 0–3)	22.9 (372)	49.3 (800)	27.3 (443)	0.3 (5)	-	-
Hock joint ulceration score (scale 0–3)	53.6 (869)	33.2 (539)	12.9 (210)	0.1 (2)	-	-
Carpal joint injuries score (scale 0–3)	44.8 (726)	31.8 (516)	23.0 (373)	0.3 (5)	-	-
Claw overgrowth score (scale 0–3)	52.4 (850)	36.3 (589)	9.6 (156)	1.5 (25)		
Diarrhea (scale 0–1)	95.7 (1551)	4.3 (69)	-	-	-	-

The median age of the cows in the shelters was 11 years (Q_1 = 8, Q_3 = 14 years; Inter Quartile Range (IQR) = 6 years) and the majority were non-lactating (87.9%, n = 1425). The median BCS was 2.75 (Q_1 = 2.25 and Q_3 = 3.25; IQR = 1.0), most cows being in the normal range for the BCS, i.e., 2.25 to 3.75 (75.4%, n = 1233). Some were thin (BCS range of 1.5 to 2, 22.8%, n = 371) and very few were obese (BCS 4 and above, 1.4%, n = 24).

Most cows had mild to moderately dirty (scores 2 and 3) hind limbs (85.6%, n = 1387), udder (75.9%, n = 1231) and flanks (74.2%, n = 1203). Almost half of the cows had no body hair loss (score 1, 45%, n = 728) and the rest had just mild to moderate hair loss (scores 2 and 3) (53.2%, n = 863). Hock joint swellings and hair loss were mostly mild or moderate (swellings 86%, n = 1394; hair loss 76.6%, n = 1243). Hock joint ulceration was mostly absent (score 0, 53.6%, n = 869), but mild ulceration (score 1, 33.2%, n = 539) was common and moderate ulceration occasional (score 2, 12.9%, n = 210). Carpal joint injuries were mostly either absent (score 0) or mild (score 1) (total 86.6%, n = 124). Claw overgrowth was absent (score 0) in 52.4% of the cows (n = 850), but mild overgrowth was common (36.3%, n = 589) and moderate or severe claw overgrowth levels (scores 2 and 3) occasionally observed (11%, n = 181). Diarrhea was observed (score 1) in 4.2% of the cows (n = 69).

6.5.1.1 Relationship between Lameness and Animal-Based Measures

The univariate analysis of the animal-based welfare measures by Spearman's rank correlation found significant ($p < 0.05$) positive correlations of lameness with dirtiness of hind limbs, udder, and flanks, and also with body hair loss, carpal joint injuries, diarrhea, claw overgrowth, cow age and hock joint swelling, hair loss and ulceration (Table 6-3).

Table 6-3: Significant (p < 0.05) Spearman's rank correlations between lameness (scores from 1 (not lame) to 5 (severely lame) and other animal-based variables

Variables	Correlation Coefficient	*p*-Value
Age (years)	0.099	≤0.001
Dirty hind limbs score (scale 0–3)	0.147	≤0.001
Dirty udder score (scale 0–3)	0.160	≤0.001
Dirty flanks score (scale 0–3)	0.188	≤0.001
Body hair loss score (scale 0–3)	0.060	0.015
Hock joint swelling score (scale 0–3)	0.064	0.010
Hock joint hair loss score (scale 0–3)	0.051	0.040
Hock joint ulceration score (scale 0–3)	0.092	≤0.001
Carpal joint injuries score (scale 0–3)	0.223	≤0.001
Diarrhea score (scale 0–1)	0.112	≤0.001
Claw overgrowth score (scale 0–3)	0.360	≤0.001

In the multivariate analysis, lameness, as a binary outcome variable, was related with the BCS of the cows, udder dirtiness, hock joint ulceration, carpal joint injuries and claw overgrowth (Table 6-4). Lame cows were associated with a low BCS (OR = 0.64, CI = 0.42–0.97), but lameness was increased in cows with dirty udders (OR = 2.13, CI = 1.25–3.61), hock joint ulcerations (OR = 2.54, CI = 1.10–5.84), carpal joint injuries (OR = 3.75, CI = 1.81–7.75) or overgrown claws (OR = 2.67, CI = 1.50–4.73).

Table 6-4: Binary logistic regression of lameness with other animal-based welfare parameters in shelter cows (n = 1620)

Parameter/Variable	Coefficient	Odds Ratio (OR)	Confidence Interval (CI)	*p*-Value
Constant	−3.974	-	-	≤0.001
Body Condition Score (BCS)	−0.444	0.64	0.42–0.97	0.03
Dirty udder	0.758	2.13	1.25–3.61	0.004
Hock joint ulceration	0.934	2.54	1.10–5.84	0.04
Carpal joint injuries	1.322	3.75	1.81–7.75	<0.001
Claw overgrowth	0.983	2.67	1.50–4.73	<0.001

6.5.2 Shelter and Resource-Based Welfare Parameters at the Shelter Level

The median space availabilities provided for the cows in the sheds and yards were 2.73 and 5.90 m^2/cow, respectively. Four types of floors were found in the shelters—earth, brick, stone and concrete. Concrete floors were the most predominant (42 sheds), followed by earth (21 sheds), brick (19 sheds) and stone (4 sheds). The floors of the yards were predominantly earth (41 yards), followed by concrete (19 yards), brick (13 yards) and stone (3 yards). The median CoF of the shed flooring was 0.43. In 96% of the shelters, no bedding was provided. The median percentages of dung present in the lying areas and passages of the shed were 15 and 10%, respectively. The median percentage of dung in the yards was 20%. The average floor gradient in the shed lying area, shed passage and shelter yard was 1.46, 2.36 and 1.51, respectively (Table 6-5). In 83.3% (45 shelters) of the lying areas and passages of the sheds, urine was not found accumulated on any part of the floors. In 89% of the yards (48 shelters), there was no accumulation of urine on the floors. The median values of duration of access to yards and pastures were 8 hours/d and zero. Shelter yards were usually cleaned twice in a day.

Table 6-5: Descriptive statistics of resource-based welfare parameters of cow shelters (n = 54)

Parameter	1st Quartile (Q_1)	Median	Third Quartile (Q_3)	Inter Quartile Range (IQR)
Shed area per cow (m^2/cow)	1.56	2.73	3.62	2.06
Yard area per cow (m^2/cow)	3.60	5.90	21.50	17.90
Coefficient of friction of shed flooring (CoF)	0.27	0.43	0.65	0.37
Percentage of dung present in lying areas of the shed	5.00	15.00	40.00	35.00
Percentage of dung present in passages of the shed	5.00	10.00	42.50	37.50
Percentage of dung present in the yards	10.0	20.0	40.0	30.0
Average gradient of the flooring of lying areas of the shed (%)	0.96	1.46	2.20	1.23
Average gradient of the flooring of passages of the shed (%)	1.27	2.36	3.52	2.24
Average floor gradient in yards (%)	1.13	1.51	2.43	1.30
Duration of access to pasture (h/d)	0.0	0.0	6.0	6.0
Duration of access to yard (h/d)	4.0	8.0	24.0	20.0
Frequency of cleaning of yards (number of times/d)	1.0	2.0	2.0	1.0

The cows in all shelters were offered a basal feed of straw (mean 17.6 kg/cow/day), either thrice or twice daily, from locally available crops (paddy, wheat or millet). Ten shelters (18.5%) fed only straw, but most fed supplements (11 shelters, 20.3%, agricultural byproducts; 25 shelters, 46.3%, agricultural by-products and hay, and 8 shelters, 14.8%, fresh green fodder, typically lucerne, clover, or vegetable waste). In addition, concentrate feeding (grains, flour and rice or wheat husks) were offered at 0.1–0.5 kg/cow in most shelters (43, 85%).

6.5.2.1 Relationship between Lameness and Resource-Based Measures

The univariate analysis of the resource-based welfare measures at the shelter level using Spearman's rank correlation revealed no relationship ($p > 0.05$) with lameness. In the multivariate analysis model (r^2 adjusted = 34.1%; residuals were normally distributed, $p = 0.10$), lameness had a significant positive association with the presence of bedding ($F = 12.4$; $p = 0.001$) and a positive association with the gradient of the shed passages ($F = 5.5$; $p = 0.02$). The relationship was described by the equation:

$$Lameness = c + 1.26\ (\pm\ 0.072) + 0.028\ (\pm\ 0.012)\ \text{gradient of shed passages} \qquad (3)$$

where the intercept, c, was 1.06 for no bedding and 1.46 for bedding.

Further exploration of relevant correlations revealed that the hock lesions were negatively correlated with the % dung in the passages (correlation coefficient = −0.283, $p = 0.04$).

6.6 Discussion

The prevalence of lameness in the present study was 4.2% in the cow shelters, less than reported in dairy herds in the US and North America (Espejo et al. 2006; von Keyserlingk et al. 2012), Finland (Sarjokari et al. 2013), Germany (Rouha-Mülleder et al. 2009) and Norway (Fjeldaas et al. 2011). Studies on the prevalence of lameness in dairy cows in India are scant and restricted to individual farms, with prevalence levels of 10 and 33% clinical lameness reported in two cross bred herds of 110 and 251 cows, respectively (Cook and Nordlund 2009). The low prevalence of lameness in sheltered Indian cows could be attributed to the absence of production stress which would arise from the commercial use of the cows for milk and the very limited energy-rich concentrate feeding (Sharma et al. 2019b). In 85% of the shelters recorded in this study, a very insufficient quantity of concentrate diet (<0.5 kg/cow) was fed to the cows.

Differences in lameness prevalence rates could also be due to housing and management conditions, lameness scoring methods and threshold scores used, as well as breed differences in lameness susceptibility (Sarjokari et al. 2013).

The median age of the cows in the shelters was 11 years, which demonstrates that it was an older age group than commercial herds, and some lameness may be explained by the long exposure of some cows to the shelter housing and flooring. However, although age has been reported as a risk factor for lameness in dairy cows (Espejo et al. 2006; Haskell et al. 2006; Sarjokari et al. 2013), it was not a significant factor in the multivariable model for lameness prevalence at the shelter level in this study.

The strong association between a low BCS and lameness in this study corroborates the findings of previous authors (Wells et al. 1993; Espejo et al. 2006; Kielland et al. 2009; Randall et al. 2015; Solano et al. 2015). A low BCS in cows is both phenotypically and genetically positively associated with susceptibility to lameness (Van Dorp et al. 1998; Bicalho et al. 2009). Lameness leads to reduced movement (including potentially to feed and water supply), a slower feeding rate and decreased feed intake, all of which potentially reduce the body condition of the cows (Hassall et al. 1993; Juarez et al. 2003; Espejo et al. 2006). The lack of movement is partly due to a reduced digital cushion (a fatty pad located in the claw capsule), which serves as a shock absorber to the third phalanx when it bears the weight of the cow during the interaction of the hoof with the flooring (Räber et al. 2004). However, this digital cushion is much reduced in cows with a low BCS, increasing susceptibility to lameness (Lischer et al. 2002), indicating a bidirectional relationship. Lame cows in the shelters may arrive late at the feed bunks, where the leftover feed is restricted in quantity and quality. This effect of lameness on the BCS in the sheltered cows may be more profound than for dairy cows, as the shelter feed, being for subsistence only, is of low quality.

Cows with a low BCS are also more susceptible to lameness due to non-infectious lesions of the feet (Green et al. 2014). Furthermore, a low BCS may predispose cows to body lesions; higher BCS cows have fewer protruding bones which has a protective effect against hock lesions (Kielland et al. 2009; Potterton et al. 2011a).

The dirtiness of the udder in the shelter cows was another risk factor for lameness. This could be attributed to the associated dirtiness of the floor, mainly with slurry which soils the udder and limbs while a cow is lying, standing and walking. Dirty conditions are known to predispose cows to lameness (Cook 2003). Poor hygiene in terms of the accumulation of dung and urine in the lying areas and passages predisposes the hooves to various lesions leading to lameness (Rodríguez-Lainz et al. 1996; Greenough et al. 1997). The median of 15, 10 and 20% of the floors of the lying areas, passages and yards of the shelters, respectively, covered with dung (Table 6-5) signifies an increased level of dirtiness in these areas. A previous study (Regula et al. 2004) investigated three husbandry systems (tie stalls with seasonal outdoor access, tie stalls with daily outdoor access and loose housing with daily outdoor access) for floor dirtiness, using the % of dung in lying areas as the main measure. Their findings of 11–17% dung in the three different housing systems are similar to results of the present study (median 15% dung in the lying area), which was probably because there were tie stalls and loose housing with variable outdoor access also.

The presence of hock joint ulcerations and carpal joint injuries as risk factors for lameness could be due to the type of flooring surfaces of the shelter premises. Hock joint lesions arise from (1) the abrasiveness of the floor (Haskell et al. 2006); (2) the continuous increased pressure on the limbs and body from the body weight of the cows and the inelastic flooring surface affecting the blood circulation to these areas (Zerzawy 1989); and (3) the collision with the flooring surface when getting up and lying down. In the present study, the median CoF of the flooring in the shelters was 0.43, which shows that the floors were not very abrasive and there was a vulnerability of the cows to slipping. This CoF value is close to the critical value of 0.4, below which there is an exponential increase in the risk of slipping (Webb and Nilsson 1983; Phillips and Morris 2001). This indicates the floor surface lacked adequate friction, perhaps because of the old age of some shelters, with repeated wear. Hock and knee joint lesions are also attributed to the type and condition of the flooring surface of the housing (Regula et al. 2004; Sogstad et al. 2005; Zurbrigg et al. 2005a; Huxley and Whay 2006a). Lesions on the hock joints have been implicated in the causation of lameness in cows (Whay et al. 2003b; Kielland et al. 2009). Lame cows experience difficulties in lying down or getting up, leading to the hock and carpal areas getting abraded on the rough floors of the shelters. There is a possibility that the hock and carpal lesions could be painful, resulting in lameness, but the possible direction of causation cannot be determined in a cross-sectional study (Solano et al. 2015).

The small area per cow, absence of bedding in most cow shelters and presence of slurry in the shelter premises found in this study could have contributed to the presence of hock joint lesions in the cows. As the hock lesions were negatively correlated with the % dung in the passages, it is hypothesized that the dung may protect the cows lying in the passage from contact with the rough floors. An examination of the effects of dung in increasing slipping or protecting from contact with rough floors is worthy of further study. The presence of bedding prevents abrasions on the limbs and, if absent, as was the case for 96% of shelters in the present study, a hard floor may impede circulation (Brenninkmeyer et al. 2013). Low space allowance, slurry laden floors and abrasive concrete floors have been identified as risk factors for limb lesions and lameness in dairy cows (Weary and Taszkun 2000; Haskell et al. 2006; Rutherford et al. 2008; Brenninkmeyer et al. 2013). The typical lying down and getting up behavior of the cows, in which both the knee joints touch the floor surface explains the injuries on the knee joints, due to the constant abrasions on rough floors causing lameness (Kielland et al. 2009), and the third quartile CoF of shelter floors in the present study was 0.65, which represents quite abrasive/rough floors. Approximately half of the shed floors (42%) of the shelters were made of concrete, which is hard and sometimes abrasive (Kielland et al. 2009), leading to lesions on the joints, and increased susceptibility to lameness (Klaas et al. 2003).

Claw overgrowth was a risk factor for lameness in the present study, which concurs with previous studies (Choquette-Levy et al. 1985; Klaas et al. 2003). According to a review by Ter Wee et al. (1989), 90% of lameness problems in cattle are due to claw abnormalities. Claw overgrowth changes the claw confirmation, which is associated with lameness (McDaniel et al. 1984; Peterse 1986). It often results from an increased rate of horn growth, associated with laminitis, sole ulcers and white zone lesions in cows (Greenough et al. 1990; Vermunt 1990; Vermunt and Greenough 1995). Walking on the hard surfaces found in some shelters could lead to biomechanical injuries to the claws due to the reaction of the forces from the hard floor at the point of interaction of the claw and floor. The consequent overgrowth of the claws, especially the outer ones, predisposes the animal to pathological lesions (Clarkson et al. 1996). Additionally, the slurry in the lying areas and passages wets the floor and keeps the cow hooves continuously wet. This leads to claw overgrowth, irregular weight bearing sole surfaces, claw injuries and disruption of claw horns (Wells et al. 1993; Bicalho and Oikonomou 2013; Solano et al. 2015). This etiology supports the claw overgrowth leading to lameness in the present study, as concrete flooring and the presence of dung on the floors were found in most shelters.

The presence of urine in the shelter passages increases slurry formation, and the constant wetness of the foot in the slurry can erode the soft heel bulb (Phillips 2018), a risk factor for lameness. Furthermore, slurry and wet floors increase floor slipperiness, which predisposes cows to the risk of injuries due to slipping, and the resultant dirtiness of feet and legs causes conformational changes of the claw, also predisposing to lameness (Relun et al. 2013; Solano et al. 2015). The slope of the floors is a risk factor for laminitis in dairy cows (Philipot et al. 1994).

The absence of bedding in most of the sheds in this study, albeit with a small sample size, might be a risk factor for lameness in the shelter cows. Cows prefer bedded floor surfaces for lying and standing (Tucker et al. 2003). The comforting cushioning effect of the bedding while standing, and the increased lying times on bedded floors have potential benefits against lameness. The presence of bedding decreases the prevalence of lameness in dairy farms (Cook and Nordlund 2009; Chapinal et al. 2013).

A significant association of lameness with the gradient of the shed passages in the present study might be due to discomfort during lying, leading to more standing on the floors, restlessness, increased muscle activity and possible fatigue (Rajapaksha and Tucker 2014). Hock swellings are a cause of lameness in dairy cows and have been observed to increase with gradient of the stall floors (Haskell et al. 2006). An increase in floor gradient may increase the risk of slipping and consequent hock lesions in the form of abrasions and swellings. However, another study has shown that prolonged standing time on a sloped floor (a 5% slope) improved claw health because it allowed better drainage and reduced hoof contact with excreta (Vokey et al. 2003). The floor gradient should be adequate to provide drainage without contributing to lameness and limb injuries. Therefore, the proper design of the cowsheds may reduce lameness and associated lesions on the limbs of the cows.

The strength of this study lies in a large number of cows and shelters assessed, producing a comprehensive set of animal- and resource-based welfare parameters in a unique context in which cows are not yielding milk. The cross-sectional study revealed numerous associations but inferences about causality are limited.

6.7 Conclusions

The prevalence of lameness in the cows in the shelters was less than has usually been recorded for cows in dairy farms. The risk factors identified in this study for lameness in the sheltered cows were inadequate cleaning of the premises, improper flooring and probably a lack of a balanced feeding regimen. These shortcomings in the management of the shelters have manifested in the form of the reduced body conditions of the cows, dirty udders, dirty limbs, lesions on the hock and carpal joints and the overgrowth of claws, which were risk factors for lameness. Improvement in these aspects will improve cow welfare by reducing the prevalence of lameness. The shelter cleanliness of the shelter premises by the elimination of slurry in the lying areas and the passages will promote better foot hygiene. The provision of bedding in lying areas reduces hock lesions and standing times, and provides comfort (Wechsler et al. 2000), ultimately reducing lameness. The flooring of the cow shelters should be improved as many had concrete flooring that was hard and rough, or slippery in the absence of bedding. The flooring is implicated as a major cause of lesions in the limbs and joints. Sand as a bedding material can be considered as an option for a softer lying area, though labor costs involved should be accounted for. Further work is required on the effect of floor slope on lameness taking into consideration the flooring material characteristics. Good feeding management is very important to maintain good body condition in the retired and abandoned cows in the shelters, as a low BCS risks the cows developing lesions on the hock and carpal joints, predisposing them to lameness, as well as compromising the general health of the cows. Improving the managerial aspects in terms of cleanliness, feeding and floor comfort will reduce lameness and lead to the better welfare of the cows in the shelters.

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Chapter 7

Avoidance distance in sheltered cows and its association with other welfare parameters

7.1 Abstract

The human–animal relationship is an important welfare parameter in animal welfare assessment in cows, and the avoidance distance of cows to a stranger at the feed bunk is measured to assess this relationship. The assessment of the human–animal relationship in cow shelters in India, where old, unproductive, and abandoned cows are sheltered, is important to explore the welfare of cows in these shelters. The cows observed were of indigenous Indian breeds and breeds which were crosses between indigenous breeds and pure bred exotic cows. The human–animal contact in this context is of particular interest for welfare assessment as traditional Indian farming and sheltering systems involves regular close human–animal contact. In a cross-sectional study across 6 states, 54 cow shelters were visited and 30 cows in each shelter were randomly selected (1620 in total) for the assessment of avoidance distance and other cow-based (27 parameters) and resource-based (15 parameters) welfare parameters. Avoidance distance was assessed 1 h after morning feeding. Cows standing at the feeding manger were approached from the front at a rate of one step/s, starting 2 m away from the manger. The distance between the assessor's hand and the cow's head was estimated at the moment the cow moved away and turned its head, using a four-point scale (0, touched; 1, 0–50 cm; 2, 51–100 cm; and 3, >100 cm). The majority, 52%, of the cows allowed touch by the assessor and another 32% allowed approach within 50 cm, demonstrating tolerance, or even solicitation of close human–animal relationships by the cows. Avoidance distance increased with the proportion of cows with dirty hind limbs, hock joint swellings, and hair loss, and the extent of rumen fill. There was also evidence of reduced avoidance distances in cows with high levels of body condition score (BCS), dirty flanks, hock joint ulceration, carpal joint injuries, diarrhoea, hampered respiration, lesions on the body due to traumatic injuries, and body coat condition, probably as a result of moving difficulties. The avoidance distance was thus related to the health and welfare of the cows, providing a vital insight into the factors affecting human–animal contact in the shelters.

Keywords: human–animal relationship; cow shelters; avoidance distance; welfare; assessment

7.1 Introduction

Fear of people can be major source of stress in animals resulting in physiological changes in animals and negative effects on animal welfare (de Passillé and Rushen 2005). The human–animal relationship, defined as the mutual perception of human and animal manifested in their mutual behaviour (Waiblinger et al. 2006), is an important parameter in any dairy cow welfare assessment protocol. The quality of stockpersonship affects the welfare of animals in the performance of routine tasks such as feeding, cleaning, etc. (Rushen et al. 2008). Aversive handling of cows reduces their milk productivity (Munksgaard et al. 1997; Rushen et al. 1999; Munksgaard et al. 2001). This could be due to restlessness and nervous activity, stress hormone effects on lactogenesis or cows withholding their milk in the parlour as response to a stressful situation. Assessment of this relationship underlines the importance of stockpersonship in animal welfare (Waiblinger et al. 2003). Negative behaviour and handling of animals induces stress and risks injury to animals as well as humans (Hemsworth and Coleman 2011).

Measurement of avoidance behaviour is important in assessment of animal behaviour because it demonstrates initial responses of an animal towards a change in the human environment (Hutson et al. 2000). Pioneering work on this aspect of animal behaviour as an indicator of poor welfare was initiated in experiments on pigs, in which they were found to be highly fearful of humans, with a pronounced stress response (Broom 1986; Hemsworth et al. 1993). Subsequently, studies on avoidance behaviour as a response to fear of humans were initiated in sheep and cattle (Vandenheede and Bouissou 1993; Boissy and Bouissou 1995). Measurement of avoidance distance (AD) of cows at a feed bunk to an approaching human is now an established test of the human–animal relationship. However, the results are dependent on several factors, including the animal's genetic predisposition, the situation in which the test is conducted, and previous interactions of the animals with humans (Grandin 1987; Purcell et al. 1988). Avoidance distance (AD) has recently been included as an important welfare indicator in most contemporary cattle welfare assessments protocols in different parts of the world (Ebinghaus et al. 2017; Jurkovich et al. 2017; Destrez et al. 2018; Lürzel et al. 2018; Beggs et al. 2019).

Animal husbandry in India usually involves close contact of humans with animals due to the traditional non-mechanized animal production operations practiced in many parts of the country. India has the largest cattle population in the world (Sserunjogi and Kaur 2016), and cow slaughter is not permitted by law in most of its states (Sarkar and Sarkar 2016; Bruckert 2018). The surplus, old, abandoned, and non-productive cows are sheltered in age-old traditional shelters known as 'gaushalas' until they die due to natural causes. The points of contact between the cows and the stockpersons in cow shelters are substantially different than the conventional farming because these cows have no economic value. Most of the shelters have indoor housing and hence the cows are more dependent on human care than in farms. Close contact of cows with humans is normal as a result of the strong socio-cultural functions of the cows in the Indian context. Therefore, the assessment of human–animal relationships becomes more important in order to investigate whether cows are treated well in the shelters. In shelters, AD is likely influenced by the extent of habituation of the cows with people (Windschnurer et al. 2009). Regular contact with humans who deliver feed to the cows at the feed bunks may result in reduced AD at the feed bunks, but this may not be generalized to other situations. Nevertheless, a simple visual contact, particularly of a person providing food without any negative experiences, has a positive effect on the human–animal relationship (Waiblinger et al. 2006). Research on AD in dairy cattle suggests that it is not 'context-specific', i.e., the behaviour of cows under a variety of different type of AD tests is significantly related to the AD at the feed bunk test (Waiblinger et al. 2003; Windschnurer et al. 2008). Human–animal relationships are a dynamic process, and changes in human behaviour towards animals can improve this relationship (Waiblinger et al. 2006). Fear of humans in cattle can be reduced within 2–5 weeks through routine positive behaviour (Breuer et al. 2003; Schmied et al. 2008). However, cows learn to differentiate between positive and negative interaction between two different individuals, and their previous experience with handlers at a place affects their avoidance distance towards their handlers as well as a stranger (Munksgaard et al. 1997; Rushen et al. 1998).

Most of the studies on human–animal relationships have emphasized the role of stockmanship on productivity rather than the welfare of animals. As well as the factors described above, it is highly likely that AD will be affected by cow health, but there is a paucity of literature on this (Mülleder et al. 2003). Disease which impairs movement may reduce AD, but other diseases may be related to a negative perception of humans, who may have treated them badly or been involved in their treatment for the disease with the involvement of pain and distress. The objective of this study was to assess the human–animal relationship in cow shelters through the measurement of AD at the feed bunk (manger) and explore the relationship with other cow disease and shelter-based welfare assessment parameters. To the best of knowledge, no studies exist on the assessment of human–animal relationships on sheltered cows, for whom profitability is not the goal but perpetuation of cow welfare is the only motivation, mandated by religion and culture. There are isolated studies (Winckler et al. 2003) on the relationship between AD and comprehensive cow health measures, which could be important in the incorporation into cow welfare assessments.

7.2 Materials and Methods

This study was conducted with animal and human ethics approval from the University of Queensland's Animal and Human Ethics Committees (approval numbers SVS/CAWE/314/16/INDIA and 2016001243, respectively). A total of 54 cow shelters (gaushalas) located in six states of India (Gujarat, Maharashtra, Rajasthan, Punjab, Haryana, and Himachal Pradesh) were used for the study. These states either have large numbers of shelters and a traditional history of sheltering of cows, or newly established shelters. These six states are located in the north, west, and northwest India. A single two-day visit to each shelter occurred between December 2016 and July 2017. Out of the 54 shelters, 26 were selected by state veterinary officers and the Animal Welfare Board of India (AWBI), and the remaining shelters were obtained using a snowballing technique, taking recommendations from shelter managers. There was no significant difference ($p < 0.05$) in any measured parameter between shelters obtained by the two methods, when compared by analysis of variance or a Moods median test (in the case of non-normal residuals).

In each shelter, 30 cows were randomly sampled, following a power calculation to determine the required numbers of cows and shelters (Hsieh et al. 1998), to detect an odds ratio of 4 with a power of 0.8 and $\alpha = 0.05$. The sample size of 30 cows was sufficient to estimate within-herd prevalence with an error of 10% at a 95% level of confidence. Cows were selected by choosing every third cow in the shed or the yard. The cows observed for the assessment of AD were of indigenous Indian breeds (48.6%) which were Gir, Red Sindhi, Tharparkar, Kankrej, Sahiwal, Dangi, Deoni, Hariana, Nimari, Khillari, Nagauri, Rathi, and Pahari, cross breds with exotic cows (29.1%), cross breds between indigenous breeds (21.5%) and very few pure bred exotic breed (0.7%) of Jersey and Holstein Friesian type. Data collection included recording of direct observations of the cows and cow measurements (animal-based parameters), as well as the recording of resource-based parameters in the shelters and a structured interview of the shelter managers. All the recordings were performed by one single assessor. A three-month training was undertaken in scoring the cows for AD, BCS (body condition score), lameness, claw overgrowth, dirtiness, lesions on the limbs, joints and body, rumen fill, faecal consistency, and skin tenting time at the University of Queensland's School of Veterinary Science. In order to validate the selected welfare measures, pilot trials were conducted in two shelters before the commencement of actual study.

7.2.1 Cow-Based Measures

A total of 1620 cows were assessed for the 27 animal-based parameters based on a literature search (mainly taken from the Welfare Quality® multi-criteria model) (Botreau et al. 2007a; Botreau et al. 2007b; Botreau et al. 2009), and author's experience of welfare issues in shelters. Lactation status and age of the cows were ascertained from the physical examination and the interview of the shelter manager. The details of the scoring systems followed on the welfare assessment of individual cows in the study are listed in Appendix 1.

The avoidance distance was assessed at the beginning of the shelter visit one hour after the morning feeding of the cows, as recommended in the Welfare Quality® protocol (de Vries et al. 2013c). A cow was approached immediately in front at a rate of 1 step/s, starting at 2 m from the manger. The distance between the assessor's hand and the cow's head was estimated at the moment the cow moved away and/or turned its head, in the following four categories: touched, and hand within 50 cm, 51–100 cm, and >100 cm. For each shelter, the median AD classification and % of cows which could be touched on the head were calculated. In shelters where cows were tethered, they were untied and moved outside the shelter to assess AD and lameness, and then retied for all remaining animal-based measures.

Body condition score (BCS) was determined using a 1–5 scale (Edmonson et al. 1989; Thomsen and Baadsgaard 2006) and scored to quarter points. Each sampled cow's demeanour was assessed during restraint on a dichotomised scale (docile or aggressive), which was derived from a five-point scale (Cafe et al. 2011) for loosely restrained cattle in a particular area of the shelter shed.

7.2.2 Health Measures

Dirtiness of the hind limbs, udder, and flanks was classified by visual inspection of the cows from the left side, right side, and from behind, according to the method of Whay et al. (2003b). The body hair loss score was assessed as per the method described by Whay et al. (2003a). Hock lesions assessment included hair loss, ulcerations, and swellings, a modification of the methods of Wechsler et al. (2000) and Whay et al. (2003a). Carpal joint injuries were scored according to the method of Wechsler et al. (2000). Neck lesions were classified according to the method of Kielland et al. (2010a). Respiratory problems were measured as the presence or absence of coughing in any of the 30 cows sampled in the sheds during the total examination period of the sampled cows in each shed. A cow expressing frequent coughs (more than five) during the 10–15 min examination time for assessment of the welfare parameters was considered to be having respiratory problems. Ocular lesions, nasal discharge, hampered respiration, diarrhoea, and vulvar discharge were assessed on a binary scale, i.e., present or absent in the sampled cows (Coignard et al. 2013).

Rumen fill score (RFS) was visually scored according to the method of Zaaijer and Noordhuizen (2003), standing behind the cow on the left side and observing the left paralumbar fossa between the last rib, the lumbar transverse processes, and the hip bone. The consistency of the faeces of the sampled cows was visually inspected and rated on a five-point scale formulated by Zaaijer and Noordhuizen (2003). Skin lesions or integument alterations on the body were recorded using the method of Leeb et al. (2004). Hair Coat condition was assessed as per a modified scale derived from Huxley and Whay (2006b) modifying their categorization from dull, thick or excessively hairy to dull and short, shiny and short, or dull and hairy. Claw overgrowth was visually inspected on each sampled cow and scored according to the scale devised by Huxley and Whay (2006c).

Lameness was scored using a numerical rating scale for walking cows (1—not lame to 5—severely lame) followed by Flower and Weary (2006) and Sprecher et al. (1997). Ectoparasitism was assessed by visual examination of each sampled cow as per the method described by Popescu et al. (2010). The protocols for teat and udder scoring (score 0–5) and skin tenting time (score 1–3) were designed by the authors, because of anticipated emaciation, teat and udder abnormalities, and advanced age would be more common in the shelters than in dairy cow farms, for which other scales are designed. Dehydration was assessed with skin turgor meaning the time a skin tent takes to return to its original position period (Roussel 1990). The scoring pattern and scales for skin tenting time and teat and udder abnormalities are also described in Appendix 1 for easy reference.

7.2.3 Shelter-Based Measures

The total number of sheds per shelter and the number of cows per shed in the shelter was assessed by visual inspection (the latter using a maximum of two sheds per shelter). The length, breadth, and height of the sheds were recorded using a laser distance meter (CP-3007 model, Ultrasonic distance meter 40KHz frequency, Chullora, New South Wales, Australia) and confirmed using a traditional measuring tape each time. From these measurements, the area of the shed and area per cow was calculated. The space allowance per cow in shelters having loose housing was calculated by dividing the floor area of the shed by the total number of cows within the shed. In shelters with stalls, the area/cow was calculated using the floor area of each stall housing a cow (von Keyserlingk et al. 2012; Otten et al. 2016). In tethered stalls, the area per cow was calculated by measuring the distance from the end of the rope at the point of attachment to a peg to the end of the hind limb of the cow at full extension. This length was used as a radius to calculate the maximum potential area of movement of the tethered cows in the sheds. The number of cows per shed was also counted during inspection of the sheds.

The gradient of the floors in the sheds and the yards were measured at three different places using vertical and horizontal measurements at each place using an inclinometer (Bosch Professional, 600MM, DNM60L Model, Clayton, Australia). The traction of the floors was determined as the coefficient of friction (CoF) (the force required to move an object over a floor divided by the weight of that object) (Phillips and Morris 2001; Phillips 2018). This was estimated using a 1 kg/10 N spring balance attached by a hook to a cuboid wooden block (mass 156 g). The block was gently pulled across the floor at a speed of 0.17 m/s and the minimal frictional force (F) required to keep it moving was recorded (Sharma et al. 2019a).

The type of shed flooring (brick, stone, earthen, concrete, or other), presence of bedding in the sheds (present or absent, if present its thickness), type of bedding if present (hay, straw, rubber mats or other) and presence of yards were recorded during the inspection of the shelter facilities

(Cook 2002; Brenninkmeyer et al. 2013; Otten et al. 2016). The cleanliness of the shelter premises was recorded by visually estimating the mean percentage of the floor that was covered by dung and urine in each shed, passage, and yard separately, as % of the area covered by dung in the shed lying areas and passages, urine in the shed lying areas and passages (present or absent), run-off in the shed (present or absent), and cleaning frequency of floors of the sheds (Regula et al. 2004).

7.3 Statistical Analysis

Descriptive, principal component analysis (PCA), Spearman's rank correlation, and multivariate analyses were conducted using Minitab 17 Statistical Software (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA). Variables were tested for normality by the Anderson–Darling test (Evans et al. 2017).Two models were generated for the data analysis. In the first, cow specific risk factors for AD were examined by multivariate analysis of the animal-based measures. An ordinal logistic regression analysis was conducted using the four AD scores as outcome variable. Categorical parameters having more than three categories were treated as continuous variables. Observations within shelters were accounted for by including shelter as a clustering effect in the model.

In the second model, resource-based parameters were analyzed at the shelter level. Shelter level AD estimates were used as the outcome in analyzing the risk factors. A principal component analysis (PCA) was employed to reduce the number of variables and to minimize the multicollinearity. The resource-based variables dropped from the analysis were the % of dung lying in the shed passages, the thickness of shed bedding and % of urine in the shed passages. Univariate analysis was conducted to explore associations between the variables using Spearman's rank correlation because the variables were not normally distributed as ascertained by the Anderson–Darling test. The multivariate analysis of the resource-based parameters with AD was done by a stepwise selection of terms in a general linear model (GLM) with α to enter at 0.15. The residuals were analyzed to explore the basic assumptions of logistic regression and model fit according to Dohoo et al. (2009b). Levels of significance were set as $p \leq 0.05$ for all the analyses. The residuals were normally distributed ($p = 0.12$) and were also inspected graphically. The r^2 (adjusted) for this dataset was 45.9%.

7.4 Results

Descriptive statistics for cow-based and shelter-based parameters are shown in Tables 7-1 and 7-2. None of the parameters were normally distributed.

7.4.1 Cow-Based Measures

In the AD test, one half of the cows (51.2%) allowed themselves to be touched and most of the other half (46.6%) had an avoidance distance up to 100 cm (scores 1 and 2) (Table 7-1). As a precondition in this study, the majority of the cows were non-lactating (87.9%). The physical and clinical examination revealed that the majority of cows (76.4%) were of a docile temperament. The median age of the cows was 11 years and median BCS 2.68. The majority of the cows (75.4%) were in the normal BCS category scores (between 2.25 - 3.75).

The dirtiness of the hind limbs (85.6%), udder (76%), and flanks (74.2%) was mostly in the mild and medium categories. There was no body hair loss in almost half of the cows (45%) and a mild hair loss in other one third (30.3%). Hock joint swellings (86.1%) and hair loss (76.7%) were predominantly in the mild to moderate category scores. The majority of cows (86.9%) either had no or mild hock joint ulcerations. More than half of the cows (54.9%) had mild to moderate carpal joint injuries.

Table 7-1: Distribution of different cow-based welfare parameters in 54 cow shelters (n = 1620)

Parameter	% Score and Number					
	0	**1**	**2**	**3**	**4**	**5**
Avoidance distance score (Scale 0–3)	51.2 (830)	31.4 (508)	15.4 (249)	2.0 (33)	-	-
Lactation (0: non-lactating; 1: lactating)	88.0 (1425)	12.0 (195)	-	-	-	-
BCS	≤1.25 (emaciated 0.1 (2)	1.5–2 (thin) 22.9 (371)	2.25–3.75 (normal) 75.5 (1233)	4 or more (obese) 1.5 (24)	-	-
General demeanour (0: docile; 1: aggressive)	76.4 (1238)	23.4 (382)	-	-	-	-
Dirty hind limbs score (Scale 0–3)	2.4 (38)	42.6 (690)	43.0 (697)	12.0 (195)	-	-
Dirty udder score (Scale 0–3)	17.5 (283)	44.6 (722)	31.4 (509)	6.5 (106)	-	-
Dirty flanks score (Scale 0–3)	19.6 (316)	42.2 (684)	32.0 (519)	6.2 (101)	-	-
Body hair loss score (Scale 0–3)	45.0 (728)	30.3 (492)	23.0 (373)	1.7 (29)	-	-
Hock joint swelling score (Scale 0–3)	11.8 (191)	22.4 (362)	63.7 (1032)	2.1 (35)	-	-
Hock joint hair loss score (Scale 0–3)	23.0 (372)	49.4 (800)	27.3 (443)	0.3 (5)	-	-
Hock joint ulceration score (Scale 0–3)	53.6 (869)	33.3 (539)	13.0 (210)	0.1 (2)	-	-
Carpal joint injuries score (Scale 0–3)	44.8 (726)	31.9 (516)	23.0 (373)	0.3 (5)	-	-
Neck lesions score (Scale 1–4)	-	5.4 (1546)	3.8 (62)	0.4 (6)	0.4 (6)	
Ocular lesions score (Scale 0–1)	91 (1474)	9.0 (146)	-	-	-	-
Lesions on the body score (Scale 0–3)	45.3 (734)	32.3 (524)	20.5 (332)	1.9 (30)	-	-
Body coat condition score (Scale 1-3)	-	47.1 (764)	52.0 (843)	0.8 (13)	-	-
Nasal discharge score (Scale 0–1)	90.7 (1470)	9.3 (150)	-	-	-	-
Diarrhoea score (Scale 0–1)	95.7 (1551)	4.3 (69)	-	-	-	-
Faecal consistency score (Scale 1–5)	-	0.3 (5)	4.9 (79)	35.1 (569)	58.3 (944)	1.4 (23)
Rumen Fill Score (Scale 1–5)	-	0.1 (2)	3.7 (60)	36.8 (594)	58.7 (952)	0.7 (12)
Lameness score (Scale 1–5)	-	84.7 (1373)	11.0 (178)	3.2 (53)	1.0 (15)	0.06 (1)
Claw overgrowth score (Scale 0–3)	52.5 (850)	36.4 (589)	9.6 (156)	1.5 (25)	-	-
Teat score (Scale 0–5)	14.5 (235)	83.2 (1348)	0.4 (6)	0.4 (7)	0.0 (0)	1.5 (24)
Ectoparasitism score (Scale 0–4)	0.4 (6)	53.1 (861)	34.5 (559)	11.8 (191)	0.2 (3)	-
Skin tenting time score (Scale 0–4)	92.2 (1494)	5.3 (86)	2.1 (35)	0.3 (5)	-	-

The prevalence of neck lesions, ocular lesions, coughing, nasal discharge, hampered respiration, diarrhoea, and vulvar discharge was predominantly below 10% in the shelter cows. Body/skin lesions were absent in nearly half of the cows and the other half had mild to moderate lesion scores. Body coat condition was almost equally distributed between dull and short coats (47%) and shiny and short coats (52%). The rumen fill score, which is an assessment of the dry matter intake, ration composition, digestion and rate of passage of ingesta [44], was scored as 3 and 4 in most of the cows, which are usually the common scores for lactating and dry cows. Faecal consistency scores were 3 and 4 in the majority of the cows.

Moderate to severe claw overgrowth was observed in 11.1% cows only. Clinical lameness (score 3 to 5) was present in only 4.26% cows. Teat and/or udder abnormalities were observed in very few cow (2.3 %) cows. Skin tenting time representing dehydration, was normal (≤ 2 s) in 92.2% cows.

7.4.2 Shelter-Based Measures

The median number of cows per shed was 70 and the median area per cow was 2.73 m^2 (Table 7-2). The average gradient of the flooring of lying areas and passages of the sheds was 1.46% and 2.36%, respectively. The CoF of shed flooring was 0.43. The median % dung in the lying areas and passages of the sheds was 15% and 10%, respectively.

Half of the shelters had concrete floors followed by earthen (24%), brick (22.2%), and stone (3.7%) floors. There was absence of bedding in majority of the shelters (96.3%) and the only two shelters which provided bedding used paddy straw of 0.5 cm thickness or less. In 87% of the shelters, yards were present for the cows to loaf out of the sheds. The median dry bulb temperature and humidity in the sheds was 29.5 °C and 34%, respectively. The median luminosity in the sheds was 582 Lux and the median noise level was 27.6 decibel.

Table 7-2: Descriptive statistics of shelter-based resource measures (n = 54)

Parameter	Median	First Quartile (Q_1)	Third Quartile (Q_3)	Interquartile Range (IQR)
Cows/shed	70	47.8	137.3	89.5
Area/cow (m^2)	2.73	1.56	3.62	2.06
Gradient of shed lying area flooring (%)	1.46	0.96	2.20	1.23
Gradient of shed passage flooring (%)	2.36	1.27	3.52	2.24
CoF of shed flooring	0.43	0.27	0.65	0.37
% dung in lying areas of shed	15	5	40	35
% dung in passages of shed	10	5	42.5	37.5
Dry bulb temperature of the shed (°C)	29.5	27.2	32.8	5.6
Shed humidity (%)	34	24.7	45.2	20.5
Shed luminosity level (Lux)	582	89	1036	946
Shed noise levels (Decibel)	27.6	21.3	37.1	15.8

7.4.3 Relationship between Cow-Based Measures and Avoidance Distance

The univariate analysis of the cow-based welfare measures at cow level using the Spearman’s rank correlation (Table 7-3) revealed significantly positive correlation between AD and BCS, dirty udder, dirty flanks, body hair loss, hock joint ulceration, carpal joint injuries, ocular lesions, nasal discharge, diarrhoea, lameness, lesions on the body, claw overgrowth, coat condition, ectoparasitism, skin tenting time, and age of the cows. There was a significantly negative correlation between AD and general demeanour, rumen fill score, and faecal consistency.

Table 7-3: Spearman’s rank correlations between avoidance distance scores for each cow (n = 1620) and cow-based welfare parameters

Parameter	Variables	Correlation Coefficient (r_s)	*p*
Avoidance Distance (Score 1–4) 0—touched 1—50 cm to >0 cm 2—100 cm to >50 cm 3—>100 cm	Carpal joint injuries	0.232	≤0.001
	Dirty flanks	0.216	≤0.001
	Dirty udder	0.186	≤0.001
	Claw overgrowth	0.173	≤0.001
	Diarrhoea	0.158	≤0.001
	Lesions on the body	0.155	≤0.001
	Hock joint ulceration	0.154	≤0.001
	Skin tenting time	0.138	≤0.001
	Lameness	0.119	≤0.001
	BCS	0.093	≤0.001
	Body hair loss	0.090	≤0.001
	Age of the cows	0.082	0.001
	Ectoparasitism	0.063	0.01
	Ocular lesions	0.055	0.02
	Nasal discharge	0.056	0.02
	Coat condition	0.056	0.02
	Rumen Fill Score	−0.279	≤0.001
	General demeanour	−0.069	0.005
	Faecal consistency	−0.071	0.004

In multivariate analysis, the ordinal logistic regression was used to examine the relationship between the cow-based welfare measures as predictors and the AD as the ordinal response variable. The BCS, dirty hind limbs, dirty flanks, hock joint swelling, hock joint hair loss, hock joint ulceration, carpal joint injuries, hampered respiration, diarrhoea, rumen fill score, lesions on the body, and coat condition of the cows were significantly associated with AD as an ordinal outcome variable (Table 7-4). The odds of a greater AD was negatively associated with their BCS (OR = 0.57, CI = 0.46–0.71).

In relation to health measures, the odds of a greater AD was positively associated with dirty hind limbs of the cows, but negatively associated with dirty flanks. The odds of a greater AD were positively associated with hock joint swellings and hock joint hair loss, but negatively associated with hock joint ulceration, carpal joint injuries, lesions on the body, and coat condition of the cows. They were also negatively associated with the presence of hampered respiration and diarrhoea. The odds of a greater AD were positively associated with rumen fill score.

Table 7-4: Association of avoidance distance of shelter cows (n = 1620) with animal-based parameters using ordinal logistic regression

Predictor	Mean	Coefficient	SE Coefficient	*p*	Odds Ratio	95% CI
Dirty hind limbs		0.68	0.114	0.000	1.98	1.58–2.48
Rumen fill score		0.58	0.093	0.000	1.79	1.49–2.15
Hock joint swelling		0.24	0.080	0.002	1.28	0.09–1.50
Hock joint hair loss		0.23	0.095	0.012	1.27	1.05–1.53
Lesions on the body		−0.22	0.018	0.006	0.80	0.68–0.94
Hock joint ulceration		−0.27	0.091	0.002	0.76	0.63–0.91
Carpal joint injuries		−0.33	0.070	0.000	0.72	0.62–0.82
Coat condition		−0.39	0.129	0.002	0.67	0.52–0.87
BCS		−0.56	0.109	0.000	0.57	0.46–0.71
Dirty flanks		−0.58	0.150	0.000	0.56	0.42–0.75
Diarrhoea						
Reference 0	1.65					
Reference 1	2.34	−0.72	0.280	0.010	0.48	0.28–0.84
Hampered respiration						
Reference 0	1.67					
Reference 1	2.57	−1.71	0.736	0.020	0.18	0.04–0.76

7.4.4 Relationship between Avoidance Distance and Shelter-Based Measures

The univariate analysis of the shelter-based measures by Spearman’s rank correlation (Table 7-5) found a significantly positive correlation ($p < 0.05$) between AD and cows/shed, luminosity in the sheds and noise levels in the sheds. There was a significant negative correlation ($p < 0.05$) between AD and shed area/cow and shed dry bulb temperature.

Table 7-5: Spearman's rank correlations between mean shelter (n = 54) avoidance distance scores of the selected cows and shelter-based welfare parameters

Parameter	Variables	Correlation Coefficient (r_s)	*p*
Avoidance distance (Score 1–4)	Cows/shed	0.337	0.01
0—touched	Shed average luminosity	0.293	0.03
1—50 cm to >0 cm	Shed noise levels	0.278	0.04
2—100 cm to >50 cm	Shed area/cow	−0.308	0.02
3—>100 cm	Shed dry bulb temperature	−0.416	0.002

In the multivariate analysis model (Table 7-6; r^2 adjusted = 45.9 %; residuals normally distributed, $p = 0.12$), AD had a significant positive association with noise levels in the sheds and cleaning of the sheds. There was a significant negative association of the AD with % dung in the lying areas, dry bulb temperature, and humidity. The relationship was described by the equation

Avoidance Distance = c + 3.87 (±0.506, p ≤ 0.001) − 0.008% dung in the shed lying area (±0.002, p = 0.004) + 0.008 shed noise level (±0.003, p = 0.02) − 0.04 shed dry bulb temperature (±0.011, p ≤ 0.001) − 0.02 shed humidity % (±0.004, p ≤ 0.001) + 0.21 cleaning of sheds (±0.084, p = 0.01) (4)

where c is the intercept, which was 4.10 for sheds that were cleaned and 3.66 for sheds which were not cleaned.

Table 7-6: Regression analysis of shelter-based measures significantly related (p < 0.05) to avoidance distance score

Term/Parameter	Coefficient	SE Coefficient	*p*
Constant	3.87	0.506	≤0.001
Shed clean at the time of measurement	0.21	0.084	0.01
Noise levels in the shed (decibels)	0.008	0.003	0.02
Shed humidity (%)	−0.02	0.004	≤0.001
Dry bulb temperature in the sheds (°C)	−0.04	0.011	≤0.001
% dung in the lying area of the shed	−0.008	0.002	0.004

7.5 Discussion

Avoidance distance of cows towards an unfamiliar human has been validated as a stable behaviour indicator of human–animal relationship (Waiblinger et al. 2003; Winckler et al. 2007; Ebinghaus et al. 2016). These studies measured AD at the feeding manger and validated the protocols to assess the human–animal relationship. This test of assessment of the human–animal relationship is easy to perform in an on-farm welfare assessment and has a high correlation with avoidance distance in a pen and moderate correlation with cows' response to a human walking through a herd and touching standing or lying cows (des Roches et al. 2016). The welfare quality protocol was replicated quite closely—i.e., the avoidance distance of 30 cows in each shelter in the morning one hour after the feeding time (Botreau et al. 2007b; Botreau et al. 2009) —and utilized the data generated to determine correlations between AD and other measures, and reported these, together with the proportions of cows with AD of zero and the median AD score. More than half of the cows in the present study had an avoidance of zero (allowing touch), which is proportionately higher than the European dairy cattle herds, which had a wide range of 2–67% of cows (Waiblinger and Menke 2003; Waiblinger et al. 2003). Australian dairy herds have been measured with 30% with this score (Windschnurer et al. 2009; Beggs et al. 2019). In terms of AD, the sheltering of cows may be more similar to the traditional management of dairy cows, which had frequent contact with handlers during feeding, watering, and cleaning (Rushen et al. 1999), in contrast to the present day intensively managed factory farming of dairy cows. The results of the present study indicate an overall good level of the human–animal relationship and reflect a high level of confidence for the cows in the presence of humans, as inferred by previous authors that have used the measure and discussed its relevance (Ivemeyer et al. 2011). The cows which allowed touch by humans may be assumed to be the ones with very good human–animal relationships (des Roches et al. 2016).

7.5.1 Relationship between Cow-Based Measures and AD

The human–animal relationship has been found to have some correlations with health in dairy cattle: positive interactions between the stockpersons and their cows can reduce somatic cell numbers in milk (Whay et al. 2003d). However, these relationships are generally unexplored.

The significant negative association between AD and BCS in this study could be due to the low BCS cows being weak and energy deficient, body condition being a general indicator of health and nutrition of the cows (Rushen et al. 1999; Chaplin et al. 2000). Thus, they were not able to move away from an approaching stranger. Similar findings were reported in a French dairy herd where more cows with low BCS allowed being touched by the observer at the feeding rack (des Roches et al. 2016). Another explanation could be that since the cows were tested in the morning at the shelter feed bunks, in the low body condition cows a higher motivation could exist for feeding than escaping from the observer (des Roches et al. 2016).

The significant association of dirty hind limbs with AD could be explained by cows with a higher AD moving away more from approaching strangers and get their limbs soiled due to the slurry present in the lying areas and passages of the sheds. Dirtiness scores of the hind limbs have been associated with contamination of the floor surface of the dairy stalls (Abe 1999). Conversely, the negative association of dirty flanks with AD could be attributed to cows suffering from diarrhoea being reluctant to move. Diarrhoea renders cows weak due to loss of energy, electrolytes, and subsequent by dehydration. The loose faeces which soils the tail is often transferred to the flanks, rendering the flanks dirty (Kloosterman 1997). The relationship is further supported by the negative association of AD with cows having diarrhoea. The correlation between AD, diarrhoea dirty flanks, and lameness was tested using the Spearman's rank correlation and found significant ($p \leq 0.001$) relationships between AD and diarrhoea ($r_s = 0.158$, $p \leq 0.001$), dirty flanks ($r_s = 0.216$, $p \leq 0.001$), and lameness ($r_s = 0.119$, $p \leq 0.001$). There are several possible explanations for these associations. Lame cows may spend more time lying down due to the pain of lameness, with greater chance that they will lie on dung (Herlin 1997); lame cows pass urine and dung while lying as they find difficulty in standing (Zurbrigg et al. 2005b); during standing lame cows also might have difficulty to adopt a normal urination and defecation posture, making the lying area dirty and wet, leading to dirty hind limbs (Lensink et al. 2001). There is also likely to be a relationship between stockperson's attitude towards animals and their health by virtue of the former's approach to the maintenance of cleanliness of farm premises (Hemsworth et al. 2002). Intervention studies have shown that training of the stockpersons to improve their attitudes towards dairy cows reduced aversive handling of these animals, leading to reduced stress levels and improved productivity (Potterton et al. 2011b).

The significant positive association of AD with hock joint hair loss and swelling could be attributed to the higher AD in nervous cows which might sustain hock joint hair loss and swelling due to fear of an approaching human. Most of the shelters had no bedding and nervous cows get injured as they suddenly get up when threatened or collisions with shelter furniture. Hock lesions have been associated with abrasive surfaces of lying areas and inadequate design of the facilities (Aitchison et al. 1986; Haskell et al. 2006; Kester et al. 2014). The human–animal relationship has been identified as a possible factor affecting hock lesions in dairy cows because a negative human–animal relationship might affect the lying comfort of the cows as sudden rising movements out of fear of stockperson can lead to hock joint injuries (Brenninkmeyer et al. 2013).

The significant negatively association of AD with hock joint ulceration and carpal joint injuries could be explained by the reluctance of the cows to move away or move away slowly from the approaching human, due to the pain associated with these lesions. Significant relationships were found in the univariate analysis using the Spearman's rank correlation between AD and lameness ($r_s = 0.119$, $p \leq 0.001$), hock joint ulceration ($r_s = 0.154$, $p < 0.001$), and carpal joint injuries ($r_s = 0.232$, $p < 0.001$). Lameness was not found to be a confounding factor to AD assessment in a study in Austrian dairy herds, but the researchers advocated further investigations of the relationship (Mülleder et al. 2003).

The significant negative association of AD with cows having hampered respiration in the present study could also be due to the inability of the cows to move away from the approaching stranger, as a result of weakness or poor health. Visual examination of such signs is a significant aspect of health evaluation in cows.

The positive association of AD with rumen fill score could be due to the fact that cows consuming adequate feed were in a position to avoid the approaching experimenter. The rumen fill indirectly reflects adequate energy and alertness of the cows to avoid and move away from a stranger. The rumen fill score represents the amount of dry matter and fluid in the rumen (Zaaijer and Noordhuizen 2003). It is related to dry matter intake, feed formulation, digestibility, and the rate of passage of ingested food through the alimentary tract (Llamas-Lamas and Combs 1991; Burfeind et al. 2010). This score has also been used to identify diseased cows, with a low score indicating poor condition. This association is interpreted cautiously because the dry matter intake in cows varies over the day, which alters the rumen fill score (Huzzey et al. 2007). However, a positive correlation was also observed between rumen fill score and BCS (Spearman's rank correlation coefficient, $r_s = 0.132$, $p \leq 0.001$). The present study is different from the previous studies on the association of rumen fill scores and health (Otis et al. 2003; Zaaijer and Noordhuizen 2003; Oetzel 2004), as these focused on healthy lactating dairy cows whereas most of the cows in the present were non-lactating and sustained on dry fodder only.

The significant negative association of AD with lesions on the body and coat condition of the cows could be explained by the poor health condition of the cows exhibited by these conditions. Research has demonstrated a strong relationship between chronic pain and generalized anxiety in humans leading to distress (Woo 2010). Furthermore, a biopsychosocial model of experiences of chronic pain has suggested that there is an interaction of physical trauma, psychology, and environmental factors (Lean 2001). A poor hair coat condition is a common clinical sign of chronic ill health status of the cows, which might due to feeding poor quality fodder, the lack of access to a balanced diet, inadequate fodder, or parasitism (Galindo and Broom 2002; van der Tol et al. 2005; Huxley and Whay 2006b; Constable et al. 2017). The poor health of the cows demonstrated by these alterations on the body and coat could have affected their strength to move away from the approaching experimenter due to chronic pain and generalized distress.

7.5.2 Relationship between Shelter-Based Resource Measures and AD

The negative relationship between AD and the % of dung in the lying area in the shelter sheds may reflect greater ease of movement of the cows away from the approaching person when the sheds were clean. The presence of dung mixed with urine to form a slurry affects the locomotion of the cows as it reduces the coefficient of friction of the flooring (Galindo and Broom 2002). This reduction in the floor friction leads to slipping and cows adopt an unnaturally stiff gait (Phillips and Morris 2000; Phillips 2009).

A weak positive association of AD with noise levels in the shelters could be due to the cows' getting alarmed and stressed by the noise. Cattle tend to get disturbed at noise levels above

90–100 dB (Lanier et al. 2000) and dairy cows are more sensitive to noise than beef breeds (Arnold et al. 2007). The median noise levels in the shelters (27.6 dB) in the present study was far below the threshold limits of getting alarmed and probably reflects the fact that most shelters were situated in quiet locations. Nevertheless, the noise had an effect on the AD, despite the observer remaining silent while approaching the cows to avoid affecting the sensitivity and temperament of the animal (Arnold et al. 2007). The weak association could be due to general agitation of the cows in noisier environments and the presence of novel sounds in the shelters (Brouček 2014), which affected the cows but was not detected at the time of the measurements in the present study, such as the noise of the shelter machinery and sounding of horns in shelters located near busy highways. Noise therefore clearly impacts on the behaviour of cows and this result suggests that it can adversely affect its welfare, hence this environmental parameter should be considered during designing and construction of cow housing (Večeřa et al. 2016).

The highly significant negative relationship between AD and dry bulb temperature and humidity levels in the shelters can be attributed to impact of the microclimate on the behaviour of cows (Lefcourt and Schmidtmann 1989; King et al. 2006; Fournel et al. 2017). The median dry bulb temperatures of 29.5% and 34% humidity levels found in the cow shelters depict moderate levels of heat stress. Heat stress may make cattle focus on coping with the high temperature rather than the threat posed by the person, which could be the reason for this relationship in the present study.

There are differences between farms and animals in the extent to which animals are fearful of people. There are breed and individual differences in the degree of fearfulness in animals but much of the fear of humans is due to the way animals are handled (Hanna et al. 2006; Hanna et al. 2009). The breed differences in cows in this study were not taken into consideration because the cows were predominantly of the local indigenous type. There is a linear relationship between stockpersons' attitude, belief, and behaviour while handling animals and its effect on the animals (Hemsworth and Coleman 2011). Most of the pioneering correlational studies in this subject area describe the relationship between the manner of animal handling affecting the productivity and welfare, through fearfulness in animals (Seabrook 1984; Breuer et al. 2000b; Waiblinger et al. 2007; Potterton et al. 2011b).

The major limitation of the study was that, being a cross-sectional study, there was no confirmation of evidence of causation despite the correlations observed between AD and other welfare parameters. Nonetheless, the large sample size in this study can provide reliability to the results. There is a risk that all the important factors involved in cow health or shelter resources were not measured in this study, leading to spurious correlations being observed. The inherent limitation of a cross-sectional study is its difficulty to identify the causal relationship between the variables.

Some factors were difficult to identify, for example AD in cows could be influenced by the typical genotype of the cows, but there was an insufficiently clear evidence of distinct genotypic factors that could be included in the model. Some of the relationships could be influenced by associations between negative attitudes of stockpersons' towards cows, which were correlated with careless attitudes towards other tasks of stockpersonship such as maintenance of cleanliness and good feeding practices. The multiple regression used in this study helps to identify the most important relationships but still the understanding of causal relationship requires intervention studies.

7.6 Conclusions

Relationships were observed between AD and other animal and resource-based welfare indicators in the cow shelters. The measurement of AD at the feed bunk appears to be a promising test for the assessment of human–animal relationship in the cow shelters but recording of cow health parameters and some resource-based parameters may help to explain variation between cows. The results of the present study show that AD is dependent on various health and welfare parameters, which makes it relative to the state of the animal. A cautious interpretation is suggested as AD in circumstances in which health variables described in this study are influencing AD, as well as it being a reflection of stockpersonship. Thus, although previous studies have reported it to be a highly repeatable test (Hanna et al. 2006), further refinement could improve its usefulness. The results of this study also suggest that the human–animal relationship in most cow shelters is cordial and in line with the animal welfare principles, because one half of the cows allowed touch by the assessor. Welfare assessment protocols for shelters could usefully include this measure. Further studies on the repeatability and validity of AD in cow shelters are needed, and this study can be regarded as a preliminary investigation into the human–animal bond in the cow shelters at a particular point of time. The low AD values observed in this study suggest that the positive behaviour of the handlers towards cows in the shelters have produced a good human–animal relationship, which helps in guaranteeing good cow welfare in the shelters.

Publication included in Chapter 8

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Author Contributions to the paper

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Chapter 8

Public attitudes towards cow welfare and cow shelters (gaushalas) in India

8.1 Abstract

Public attitudes towards cows and cow shelters in India need to be assessed in the contemporary context, as India is facing an overpopulation of street cows, leading to traffic hazards, public health issues, and pollution. The attitudes of the general public in India towards cow welfare in general and cow shelters (gaushalas) in particular were investigated. Eight hundred and twenty-five members of the public, residing in the vicinity of 54 cow shelters, were interviewed for this purpose. Their perception of animal welfare centred on animal care, cows as goddesses and mothers, and doing things properly. More than half visited a shelter daily for religious reasons. Most believed that cow shelters were the best way to manage the stray cow population and felt a community responsibility towards all breeds of cows for animal welfare reasons. Space availability for the cows was the key welfare issue voiced. Older people were more likely to identify animal welfare and culture as the main reason for sheltering cows. Better educated, wealthier, and more religious people visited the shelters most, rating religion and breeding higher as the shelter's main purpose. Males favoured indigenous cow breeds more than females. Village respondents were more likely to consider the facilities adequate compared with country town and urban respondents. In contrast to married respondents, single people were more likely to say that they visited for leisure rather than for religious purposes. The survey indicated that the Indian community was generally supportive of cow sheltering and that visits to the shelters helped them to know that unwanted cattle were being well cared for.

Keywords: India; cattle; cow shelters; gaushalas; public attitudes; welfare

8.2. Introduction

Religiously-inspired attitudes towards animals are found worldwide, however the Indic traditions of Hinduism, Buddhism and Jainism are particularly unique in their promotion of *Ahimsa* (non-harm to all living beings including animals) (Kemmerer 2012). Religious beliefs in many parts of India have exerted a special influence on the human-animal bond, and hence the welfare of animals. The cow has an important role in the culture and religion in contemporary Hinduism in India. It represents abundance and fertility, embodying the concept of motherhood and the abode of 330 million gods (Korom 2000; Nadal 2017). Cows are also symbols of non-violence and generosity in Hindu culture, they are central to debates on vegetarianism, and are associated with many Hindu gods (Doniger 2009). The concept of bovine sanctity developed within the Aryan culture during the end of the Vedic period (4th century B.C.), with the first reference in the text *Chandogya Upanishad* (Lodrick 2005a).

A complicated nexus of social, religious, historical and political factors have contributed to the widespread acceptance of this belief in the Hindu public (Lodrick 2005a). Protests against cow killing became politicised during the Muslim invasions of the 11th and 12th centuries A.D, during India's struggle for freedom from the British rule in the mid-20th century, and more recently with the rise of the Hindu right nationalist movement (Doniger 2009). These events peaked again during the last decade especially, during the rule of the present political dispensation, linking concepts of a nationalistic identity, spiritual/ caste purity and pollution, and anti-Muslim sentiment. This has resulted in vigilante cow protection groups attacking people suspected of harming cows (Sunder 2019). However, not all Hindu's are vegetarians or avoid beef (Staples 2018), India is the second largest exporter of beef, and has one of the largest live export markets in the world (Ghosh 2013). Therefore, as Staples (2018) aptly writes, the picture that emerges is not straightforward and "the stereotypical image of India as a nation squeamish about cattle slaughter starts to unravel". Certainly in this cow contentious and highly politicised environment, the sheltering of cows in gaushalas has gained prominence once again. Due to this reverence cow slaughter is banned in most Indian states and the overpopulation of abandoned cows in the streets is a public health risk, traffic hazard and an animal welfare concern (Fox 1999; Bijla et al. 2019; Sharma et al. 2019b).

The establishment and consolidation of the institution of 'gaushalas' began in the 3rd to 4th century B.C (Lodrick 1981, 2005b) and persists today. Gaushalas house cows affected by recurrent droughts and famines, as well as old, infirm, infertile and abandoned cows. Despite economic growth in the secondary and tertiary industry sectors, agriculture is still the mainstay of the Indian economy. There are more than 5000 gaushalas and nearly 5.30 million street cows in India, according to a recent livestock census report (Department of Animal Husbandry Dairying and Fisheries 2014). Rapid urbanization, mechanization of farming operations, fragmentation of pastures and grazing lands, and bans on cow slaughter and euthanasia, are the main factors leading to the overpopulation of the street cows in India (Singh et al. 2013; Ghatak and Singh 2015). These and other factors result in the overpopulation of abandoned cows in the streets, causing public health risks, traffic hazards, and a large animal welfare concern (Fox 1999; Sharma et al. 2019b).

This overpopulation has challenged the capacity of gaushalas to shelter street cows and ultimately the welfare of cows housed in them. The majority of these shelters are located in the northern and western parts of the country, where an Aryan culture predominates, with very few in the southern states, probably due to the older Dravidian culture there (Lodrick 1981; Fox 1999). The shelters are supported by philanthropists, temple trusts, the government, and donations from the business community and the general public. There is no uniform pattern of funding pattern for the cow shelters and many of them suffer from limited financial support. Those located near Hindu temples and pilgrimage sites are well funded by devotees' donations. Others have serious limitations with little government support, inadequate feed and fodder availability and poor infrastructure to house the ever-increasing street/abandoned cow population in India. Despite these problems the cow shelters manage to sustain themselves, but it is not clear to what extent they garner popular public support, nor what the Indian public attitudes towards gaushalas are.

Public attitudes are the drivers of change and can be determined by social science research revealing societal issues and concerns. Beliefs guide public attitudes and attitudes determine public behaviour as citizens (Coleman 2010); understanding both attitudes and beliefs are of prime importance for coordinating and guiding improvements in the welfare of animals (Serpell 2004). Beliefs and understanding of animals by any society is species specific, especially the extent to which it is given priority and resources (Kirkwood and Hubrecht 2001). There has been significant research conducted on the public attitude towards farm animals, and specifically cows, in Europe, North America, and Australia (Boogaard et al. 2006; Heleski et al. 2006; McGrath et al. 2013; Ryan et al. 2015; Hötzel et al. 2017; Weary and von Keyserlingk 2017). However, no study has exclusively focussed on public attitudes towards cattle welfare in India, a country that has the world's largest cattle population (FAOSTAT 2019) and some apparently quite unique perspectives on managing unwanted cattle.

Three types of motivations have been proposed for the response of public toward animals: self-interest, empathy and values about the status and nature of the animals (Hills 1993).While religion, culture and socio-economics moderate public attitudes towards animals (Kendall et al. 2006), an animal's nature and its characteristics also influence public attitudes (Herzog and Burghardt 1988).

Attitudes affect the way animals are treated and, according to the Theory of Planned Behaviour, the intent of an individual to behave in a certain manner is a prerequisite for the implementation of a particular behaviour (Ajzen 1991; Waiblinger et al. 2002). Self-evaluation of the behaviour (attitude), a belief that the behaviour can be realised (perceived behaviour control) and the opinions of individuals whom the person considers important (subjective norm), determines the intent of performing a behaviour (Ajzen 1991; Kauppinen et al. 2013). A study in the USA found that love for animals, as well as economic and practical considerations, was the primary motivational factor in the attitude of American public towards animals (Kellert et al. 1980).

Understanding the attitude of the public towards animal welfare is important both at an individual level as well as at a societal level. Policy formulation and legislation to improve animal behaviour are influenced by public attitudes and how they are changing (Kirkwood and Hubrecht 2001). Scientific studies providing evidence to improve welfare will be inconsequential in bringing about changes unless they are supported by positive public attitudes and cultural values (Serpell 2004). Attitudes towards animals develop early in life but are also transformed during adulthood, which justifies widespread public education (Takooshian 1998; Coleman 2010). Cultural practices and attitudes towards animals can change over time, but they may also persist, reflecting historical traditions (Serpell 2004). Although there have been studies on the attitudes and knowledge level of Indian farmers towards animals and animal welfare (Heleski et al. 2004; Hanna et al. 2009; Patil et al. 2009; Kielland et al. 2010b), to date no study has assessed public attitude towards cows and cow welfare in gaushalas.

Therefore, the aim of this study was to assess the public attitudes surrounding cow welfare and cow shelters in India. It was hypothesized that the attitudes of the public towards cows and cow shelters would be influenced by key demographic factors, and that this would influence behaviour. It was also anticipated that due to the rapid urbanisation and modernisation of Indian society, the spiritual symbolism of the cow, its special status, associations with the goddess, and people's interaction with cows in shelters might have waned or transformed.

8.3. Material and methods

The Indian public's perception of cow welfare and cow shelters constituted this study's objective. Public perception was considered as a social normative derived from knowledge explained and shared socially (Guimelli 1993; Kling-Eveillard 2007). A quantitative questionnaire was designed that addressed 1) the public's understanding of the cow shelters and 2) the public's attitude towards cow shelters and cow welfare in India. Socio-demographic questions were included to further elucidate the contemporary perception and attitude of the Indian public towards cow shelters and about cow welfare. The questionnaire was designed considering the scarce literature on public knowledge and attitudes towards cows in India (Heston 1971; Lodrick 1981; Serpell 2004; Marsden and Wright 2010).

At the same time as visits to shelters were made in six states of India (Gujarat, Maharashtra, Rajasthan, Punjab, Haryana and Himachal Pradesh) (Sharma et al. 2019b), a face-to-face public survey was conducted in the vicinity of each of the 54 shelters from December, 2016, to July, 2017. Initially, a pilot survey was conducted by randomly selecting 15 individuals near the first cow shelter visited in the state of Himachal Pradesh. Following the pilot survey, a minor adjustment was made in the language and order of questions to avoid any possible bias or leading responses. During each shelter visit, people were approached to request an interview in areas around shops, in fields and by knocking on houses door to door, in order to obtain a broad spectrum of views from those who resided within a 1 km radius of the shelters. Qualifying factors were that people should be 18 or over, that they resided within the 1 km radius of the cow shelter, and that they should not be working or have worked in the cow shelter. This generated a total of 810 responses, to which were added the 15 from the pilot survey. Each interview lasted about half an hour. The University of Queensland Institutional Human Ethics Committee granted the Human Ethics Clearance (approval number 2016001243).

8.3.1 Questionnaire design

The questionnaire focussed on the public knowledge and attitudes[1] towards cow shelters (termed gaushalas in India) and cow welfare (Appendix 3). Initial questions addressed their attitude towards gaushalas, how often they visited gaushalas (once a day, once a week, once a fortnight, once a month, once in 6 months, once a year, less than once a year or never visited); why they visited them (for religious reasons, feeding cows, educational reasons, examining welfare standards, leisure and enjoyment from seeing cows, to buy cow products or other reasons); to rank the importance of different reasons for the establishment of gaushalas, one being most important to six being least important (for cow welfare, production and sale of milk, breeding of cows, attracting funds from rich people, religious purposes and making a profit from the sale of milk, manure, cows and calves); the best way to deal with unwanted cows (keep them in gaushalas, let them roam the streets, export them to neighbouring countries, or slaughter them); whether they preferred local Indian breeds of cows over cross breeds or exotic breeds; community responsibilities to stray cows, and to what extent whether the respondents felt it important that cows should be housed in gaushalas. The questions also covered the extent of agreement on the reasons for keeping cows in gaushalas (for tradition/culture, for animal welfare, for breeding or for milk production). Importance and agreement questions were rated on a five-point scale.

Further questions related to the particular gaushala located near the respondents' residence: a) the maximum number of cows for acceptable animal welfare (< 50, 50-100, 101-150, 151-200, 250, 500, 1000 or according to space availability), b) agreement that the gaushala gave adequate shelter, food and water, freedom to move and socialize, bedding, flooring and opportunities to lie down, veterinary care and humane treatment for the cows; c) whether they supported or had any issues with their local gaushala. An open-ended question was also posed to each respondent: "What do you understand by the term 'welfare of cows'?" Finally, demographic questions were included to

[1] defined as the psychological tendency expressed after the evaluation of a particular entity with some degree of favour or disfavour (Eagly and Chaiken 1993)

determine the respondents' gender, age, religion, religiosity level, ethnicity, education level, marital status, number of children, income, place of residence and whether they grew up with cows nearby. Answers to all these questions were self-declared except for place of residence, which was classified as urban, suburban, country town or village by the research team and confirmed by the shelter manager.

8.4 Statistical analysis

Data was initially collated, and controls were employed to remove data errors, using Minitab 17 Statistical Software (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA) for analysis. A series of chi-square tests were conducted to examine the differences in response patterns for questionnaire items based on demographic variables. Independent variables were categorical, and included gender, age, religion, religiosity, ethnicity, education level, marital status, number of children, income level and place of residence. The dependent variables were either ordinal, such as frequency of visits to a gaushala, or nominal, such as their reason for visiting a gaushala, reason for and importance of establishment of the gaushalas, what was best for unwanted cows, preference for a specific cow breeds and responsibility of the community to specific breed types. Some of the ordinal dependent variables in some items in the questionnaire consisted of the level of agreement with the given items, from one (strongly disagree) to five (strongly agree). Cross tabulations between demographic variables and agreement level and opinion items were analysed by Chi-square analysis of association, ensuring that no more than 20% of the expected counts were less than five, and all individual expected counts were one or more than one (Yates et al. 1999; Fienberg 2011). Logistic regression analyses (either binary, nominal or ordinal as appropriate to the response structure) were used to analyse the effects of demographic variables on attitude questions. Public behaviour (frequency of visiting shelters) was also analysed against public attitudes towards gaushalas and the cows using ordinal logistic regression. Logistic regression analyses were also used to assess the significance of the relationships between respondent demographics (categorical independent variables) and the distribution of Likert scale responses for each attitude questions (continuous dependent variable). An iterative reweighted least squares algorithm with a logit link function was used in the model. All models achieved convergence. Referent groups were selected as those with the most responses. All probability values were considered significant at $p < 0.05$.

Thematic analysis of the open-ended question about what the respondent understood by the term 'welfare of cows' was conducted using NVivo Pro 12 software (NVivo qualitative data analysis software; QSR International Pty Ltd. Version 12, 2018, https://www.qsrinternational.com/nvivo/nvivo-products/nvivo-12-plus). The different responses were analysed and the main trends extracted. A manual inspection of the source data was conducted and the word frequency and word cloud function identified themes to the responses. Through NVivo, words were chosen for analysis based on the total number of times they appeared. However, conjunctives (such as 'and') and words that drew no relevance or usefulness to the theme of study were excluded manually from the output and the analysis repeated.

8.5 Results

In the multivariable analysis of the demographic data, only the significant results are reported. However, in the descriptive analysis of the data all the responses to the questions have been reported as numbers and percentages.

8.5.1 Respondents demographics

Completed questionnaires were obtained from 825 respondents, with equal gender representation. The response rate in this study was 80%, as on an average three out of every 15 people per shelter we approached declined to participate in the survey. The median age bracket was 36-45 years of age, slightly older than the Indian mean age (Table 8-1). The majority of the respondents were Hindus (96 %), with very few Muslims (2 %) and Sikhs (2 %), both being less than the national average. Nearly all (98%) were of Indo-Aryan ethnic descent, which is higher than the national demographic. Most respondents felt they were religious, either moderately (50 %) or very (47%). Just over a quarter did not attain a grade 10 educational level, 36% completed grades 10 or 12, 14% succeeded to a university graduate and 13% had no formal education. Educational levels were higher than the national average. Most respondents were married (85 %) and most had two (38%) or three (21 %) children. The most commonly reported (26%) annual income level was 100,001-500,000 INR (US$1461 – 7300). Most respondents (70 %) resided in villages, and 22 % in urban areas, less than nationally. Nearly all (93%) had grown up in close contact with cows during their childhood and 99 % were aware of the existence of their local gaushala.

Table 8-1: Descriptive statistics of public survey for the assessment of attitudes towards cow shelters and cow welfare

Demographic	Descriptor	No. of respondents	% of respondents	Indian national statistics http://censusindia.gov.in/
Gender	Males	415	50.3	51.47 %
	Females	410	49.7	48.53 %
Age (years)	18- 25	108	13.09	Mean: 27.6
	26-35	195	23.64	
	36-45	195	23.64	
	46-55	170	20.61	
	56-65	98	11.88	
	66 & above	59	7.15	
Religion	Hinduism	788	95.52	80%
	Islam	14	1.70	13%
	Sikhism	13	1.58	1.9%
	Judaism	5	0.61	0.4% (others)
	Zoroastrianism	4	0.48	
	Jainism	1	0.12	
Religiosity	Not religious at all	17	2.06	
	Not very religious	9	1.09	
	Moderately religious	411	49.82	
	Very religious	388	47.03	
Ethnicity	Indo-Aryan	808	97.94	72%
	Dravidian	2	0.24	25%
	Others	15	1.82	3%

Education level	No formal education	108	13.09	
	Under grade 10	225	27.27	41.3%
	Grade 10	161	19.52	8.74%
	Grade 12	128	15.52	6.43%
	Diploma	19	2.30	0.59%
	Graduand	118	14.30	Graduand & above – 3.47%
	Post -graduand	66	8.00	
Marital status	Single	85	10.30	
	Married	705	85.45	
	Widowed	35	4.24	
No. of children	No children	111	13.45	
	One	107	12.97	
	Two	312	37.82	
	Three	171	20.73	
	Four	82	9.94	
	Five or more	42	5.09	
Annual Income (INR)	< 10000	38	4.61	
	10000-25000	112	13.58	
	25001-50000	105	12.73	
	50001-75000	116	14.06	
	75001-100,000	135	16.36	
	100,001-500,000	218	26.42	
	500,001-1000,000	52	6.30	
	1000,001-5000,000	31	3.76	
	5000,001-10000,000	10	1.21	

	> 10000000	8	0.97	
Place of residence	Village Urban Suburban Country town	580 177 46 22	70.30 21.45 5.58 2.67	(Rural) 68.85% 31.15%

Table 8-2: Respondents' awareness of, and relationship with gaushalas, and their attitudes to the welfare of cows in gaushalas

Contact with cows at home or nearby as a child?	Yes	767	92.97
	No	58	7.03
Are you aware of the gaushala existing nearby?	Yes	821	99.5
	No	4	0.48
How often you visit your local gaushala?	Daily	203	24.61
	Weekly	193	23.39
	Fortnightly	43	5.21
	Monthly	151	18.30
	Every 6 months	105	12.73
	Yearly	44	5.33
	< once a year	14	2.91
	Never visited	62	7.52
Why do you visit gaushalas?	Religious reasons	534	64.73
	Examine cow welfare	100	12.12
	Feed the cows	97	11.76
	Leisure/enjoy seeing cows	81	9.82
	Educational reasons	9	1.09
	Buy cow products	4	0.48
What is best for unwanted cows?	Sheltered in gaushalas	818	99.15
	Export to neighbouring countries	4	0.48
	Slaughter	2	0.24
	Left roaming on the streets	1	0.12
On your gaushala visit, which is your favourite type of cow?	All are favourites	541	65.57
	Local Indian breeds	273	33.09
	Jersey	5	0.60
	Holstein	4	0.48
	Cross breeds	2	0.24
Community responsibility to cow breed types?	Equal to all cows	631	76.48
	More for local breeds	193	23.39
	More for exotic breeds	1	0.12
How important is it for cows to be sheltered in gaushalas? On a scale of 1 to 5 (1, strongly	Strongly unimportant	7	0.85
	Unimportant	6	0.73
	Neither unimportant nor important	20	2.42
	Important	33	4.00
	Strongly important	759	92.0

unimportant - 5, strongly important)			
To what extent do you agree that cows should be kept in gaushalas? (1, strongly agree to 5, strongly disagree)			
Tradition/culture	Strongly disagree	175	21.45
	Disagree	70	8.48
	Neither agree nor disagree	19	2.30
	Agree	384	46.55
	Strongly agree	177	21.45
Animal welfare	Strongly disagree	195	23.64
	Disagree	21	2.55
	Neither agree nor disagree	10	1.21
	Agree	359	47.15
	Strongly agree	210	25.45
Breeding cows	Strongly disagree	99	12.00
	Disagree	393	47.64
	Neither agree nor disagree	107	12.97
	Agree	214	25.94
	Strongly agree	12	1.45
Milk production	Strongly disagree	92	11.15
	Disagree	416	50.42
	Neither agree nor disagree	98	11.88
	Agree	202	24.48
	Strongly agree	17	2.06
How many cows should be housed in your local gaushalas for acceptable animal welfare?	< 50	10	1.21
	51-100	47	5.70
	101-150	70	8.50
	151-200	41	4.98
	201-500	56	6.80
	501-1000	31	3.76
	> 1000	62	7.52
	According to space available	502	60.92
On a scale of 1-5 (1, strongly unimportant - 5, strongly important), do you feel the gaushala near you provides adequate			
Shelter for the cows	Strongly disagree	5	0.61
	Disagree	32	3.88
	Neither agree nor disagree	82	9.94
	Agree	169	20.48

	Strongly agree	537	65.09
Food and water	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree	4 17 91 159 554	0.48 2.06 11.03 19.27 67.15
Freedom to move about and socialize with other cows	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree	5 34 67 174 545	0.61 4.12 8.12 21.09 66.06
Bedding, flooring and facility for cows to lie down	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree	6 37 85 187 510	0.73 4.48 10.30 22.67 61.82
Humane treatment of the cows	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree	6 13 109 172 525	0.73 1.58 13.21 20.85 63.64
Veterinary care	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree	3 19 116 189 498	0.36 2.30 14.06 22.91 60.36
Do you support your local gaushala?	Yes No	822 3	99.63 0.37
Do you have any issues with your local gaushala?	Yes No	104 721	12.61 87.39

8.5.1.1 Perceptions regarding gaushalas and abandoned cows

Almost one half of respondents reported visiting their local gaushala regularly, once a day or once a week (Table 8-2). The most common reason for visiting the gaushalas was religion, followed by the examination of cow welfare standards, and then feeding the cows. Almost all indicated that sheltering abandoned/unwanted cows in gaushalas was the best solution to manage unwanted street cow populations. The majority had no favourite breed of cow, but one third favoured local Indian cow breeds, and most said that the community has equal responsibility towards all cow breeds.

Nearly all participants said it was important for cows to be sheltered in gaushalas (96%), usually for animal welfare reasons, and most believed that this was culturally important. Most disagreed with using gaushalas to breed cows or for milk production purposes.

The majority of the respondents thought that the available space for cows in the gaushala was the key welfare issue, however, most agreed that their local gaushala provided adequate resources for the cows – shelter, adequate food and water, freedom of movement and opportunities for socialization, bedding, floor space, and opportunities to lie down. Most agreed that the cows in their local gaushala were treated humanely by the workers and that there was adequate provision of veterinary care. Nearly all actively supported their local gaushala through voluntary work, donations and moral support, and only a small minority said they had issues with their local gaushalas, which were mainly the problems of flies and mosquitoes, offensive odours and waste management.

8.5.2 Demographic Effects

8.5.2.1 Age

In relation to the purpose of gaushalas, the youngest age group (18-25) were more likely to rank animal welfare either very high or very low, and also rank breeding lower, compared with the older age groups (see Table 8-3 for the number of respondents in each category). Those in the 46-55 year-old age group were more likely to rank milk sales higher than older or younger respondents. The oldest age group were more likely to rank attracting funding higher, and the 26-35 year-old respondents were more likely to rank it lowest. The youngest age group was more likely to rank earning a profit at a higher level than older age groups.

When asked the reason for keeping cows in gaushalas, older people (> 55 years) were more likely to strongly agree that it was for animal welfare and cultural traditions than younger people (<36 years). Young people (<36) were more likely to be neutral about whether cows had adequate shelter.

8.5.2.2 Educational level

As education increased so did visit frequency, and the respondents were more likely to rate religion and breeding as the most important the purposes for establishing gaushalas and less likely to rate animal welfare and milking highly (Table 8-4). Similarly they were more likely to disagree that milk sales are an important reason for keeping cows in gaushalas, and they were more likely to say that bedding and lying space, humane treatment of cows and veterinary treatment were inadequate. As education levels increased, respondents were less likely to cite examining cow welfare as the reason to visit cow shelters.

8.5.2.3 Gender

Men said that they visited the shelter more often, weekly, whereas women said that they only visited approximately monthly (Table 8-5). However, women believed the establishment of gaushalas to be slightly more important for the welfare of cows. Women ranked milk sales and breeding cows as reasons to keep cows in gaushalas higher than men. Men agreed more than women that cows in gaushalas have adequate freedom to move about and socialize with other cows. When asked to choose one reason for visiting the gaushala, males (15.7%) were more likely than females (8.5%) to say that they would visit to examine cow welfare standards, compared with visiting for religious reasons (M 62.9, F 66.6%) (OR, 2.70, CI 1.38-5.29, P = 0.004). Males (40%) were more likely than females (26%) to say that their favourite type of cows were local Indian breeds.

Table 8-3: Significant effects (P < 0.05) of age on public perception about cow welfare and gaushalas in India

Criterion	Coefficient	SE Coefficient	P-value	OR	95% C.I
Rank of importance of different purpose of establishing gaushalas					
Animal welfare	0.17	0.059	0.003	1.19	1.06 – 1.34
Milk sales	0.30	0.063	<0.001	1.35	1.20 – 1.53
Breeding cows	-0.12	0.062	0.04	0.88	0.78 – 1.00
Attracting funding	-0.13	0.065	0.03	0.87	0.77 – 0.99
Earning a profit	-0.28	0.069	<0.001	0.75	0.66 – 0.87
Reasons for keeping cows in gaushalas					
Animal welfare	0.18	0.058	0.002	1.20	1.07 – 1.35
Breeding cows	0.12	0.058	0.03	1.13	1.01 – 1.27
Culture/tradition	0.16	0.058	0.005	1.18	1.05 – 1.32
Provision of shelter by gaushalas is adequate	-0.16	0.068	0.01	0.85	0.74 – 0.97

Table 8-4: Education level effects on public perception about cow welfare and gaushalas in India (P < 0.05)

Criterion	Coefficient	SE Coefficient	P-value	OR	95% C.I
Frequency of visiting the local gaushala	-0.13	0.042	0.001	0.87	0.80 – 0.95
Rank of importance of the purpose of establishing gaushalas					
Animal welfare	0.13	0.045	0.003*	1.14	1.05 – 1.25
Milk sales	0.09	0.047	0.03	1.10	1.00 – 1.21
Breeding cows	-0.14	0.048	0.002	0.86	0.78 – 0.95
Religious purposes	-0.09	0.044	0.02	0.91	0.83 – 0.99
Reasons for keeping cows in gaushalas (1 strongly agree – 5 strongly disagree)					
Milk sales	0.09	0.044	0.03	1.10	1.01 – 1.20
Provision of resources by gaushalas is adequate (1 strongly disagree – 5 strongly agree)					
Bedding, flooring and lying down	0.12	0.047	0.006	1.14	1.04 – 1.25
Humane treatment	0.10	0.048	0.03	1.11	1.01 – 1.22
Veterinary care	-0.37	0.113	0.001	0.69	0.55 – 0.86
Reason of visit to gaushalas					
	0.43	0.100	<0.001	1.54	1.27 – 1.88

Table 8-5: Gender effects on public perception about cow welfare and gaushalas in India (P < 0.05)

Criterion	Parameter	Mean	Coefficient	SE Coefficient	P-value	OR	95% C.I
Frequency of visiting the local gaushala (1 daily, 2 weekly, 3 fortnightly, 4 monthly, 5 biennially, 6 annually, 7 < annually, 8 never)	Referent: Female	3.71					
	Male	3.01	0.63	0.132	≤0.0001	1.89	1.46 – 2.45
Importance of gaushalas for cows (1 strongly unimportant – 5 strongly important)	Referent: Female	4.90					
	Male	4.80	0.86	0.303	0.004	2.38	1.32 – 4.32
Reasons for keeping cows in gaushalas (1 strongly agree – 5 strongly disagree)							
Milk sales	Referent: Female	3.58					
	Male	3.30	0.39	0.139	0.004	1.49	1.13 – 1.95
Breeding cows	Referent: Female	3.54					
	Male	3.30	0.24	0.137	0.07	1.28	0.98 – 1.68
Provision of resources by gaushalas is adequate (1 strongly disagree – 5 strongly agree)							
Freedom to move about and socialize with other cows	Referent: Female	4.42					
	Male	4.53	-0.34	0.156	0.02	0.71	0.52 – 0.96
Humane treatment	Referent: Female	4.39					
	Male	4.51	-0.33	0.152	0.02	0.71	0.53 – 0.96
Reason for visiting gaushala (select most important - Religious, Feed the cows, Educational, Examine welfare, Leisure, Buy products or other)	Referent: Female	1.92					
	Male	2.05	0.99	0.342	0.004	2.70	1.38 – 5.29

8.5.2.4 Income

As income level increased, the frequency of visits to the cow shelters increased. High income respondents ranked the breeding of cows higher as one of the important purposes of the gaushala (OR 1.12, 95% CI 1.04-1.21, p = 0.003). Middle income categories were less likely to say that they visited a gaushala to feed the cows (9.3%) than for religious purposes (16.9%) (OR 1.15, CI 1.0-1.33, P = 0.05).

8.5.2.5 Religion effects

Hindus said that religious purposes of gaushalas were more important and making a profit less important, compared with non-Hindus (Table 8-6). Hindus were also less likely to agree that milk sales was a reason for keeping cows in gaushalas and less likely to agree that shelter and bedding, flooring, and lying provisions were adequate in the gaushalas.

8.5.2.6 Religiosity effects

People who that said that they were very religious were more likely to visit daily and less likely to visit infrequently. They were less likely to rate profit as the most important purpose for gaushalas, and more likely to rate religious purposes (Table 8-7). They were also more likely to say that shelter, freedom to move around, bedding, flooring and lying down, humane treatment and veterinary care were adequate. The number of respondents who visited for religious reasons increased with self-declared religiosity, and visiting for other reasons, for to feed the cows, to examine cow welfare standards, become educated, or for leisure, decreased with increasing religiosity.

8.5.2.7 Place of residence effects

Urban respondents said they visited more often than village respondents (Table 8-8). Village respondents said that gaushalas were more important for cows than did country town respondents. Suburban, urban respondents, and to a lesser extent, village respondents, thought that animal welfare and religion were more important purposes for gaushalas, and milk sales, breeding cows, attracting funding and earning a profit were less important, compared with country town respondents. Village respondents were more likely to consider shelter, freedom to move about and bedding, flooring and lying down adequate compared with country town respondents, and more likely than urban respondents to consider shelter and bedding/flooring/lying down adequate. Suburban respondents were less likely than urban respondents to cite leisure as their reason for visiting compared with for religious reasons.

8.5.2.8 Marital status

In contrast to married respondents, single people were more likely to say that they visited gaushalas for leisure rather than for religious purposes (OR 6.47, CI 1.56-26.84, P = 0.01). Single people (14%) were less likely than married people (35%) or widowers (40%) to prefer Indian cattle breeds to all breeds (OR 4.07, 95% CI 1.94-8.49, P<0.001). There was only one significant effect of the number of children - as it increased, the sale of milk was ranked as a more important function of the gaushalas (OR 0.84, CI 0.73-0.97, P = 0.02).

8.5.3 Influence of attitudes towards cows to frequency of visits to gaushalas

People who frequently visited gaushalas were more likely to cite that cows were humanely treated (OR 1.45, CI 1.10-1.89, P = 0.007) than those who rarely visited them (Figure 8-1). Respondents who visited daily were more likely to cite welfare as the reason for establishing gaushalas (OR 1.31, CI 1.08-1.58, P = 0.005) than those who visited fortnightly but respondents who visited monthly or less frequently were again more likely to cite welfare as the reason for establishing gaushalas. Respondents who cited profit making as the reason for establishing gaushalas were likely to visit gaushalas more frequently which could be for buying milk (OR 1.28, CI 1.05-1.57, P = 0.01), as most of the respondents have ranked sale of milk as the second most important reason for establishing gaushalas. Respondents who ranked religion higher as the reason of visit to gaushalas were more likely to visit them frequently than the ones who cited other reasons to visit (OR 0.90, CI 0.82-0.98, P = 0.01). People who rarely visited the gaushalas did not have clear reasons to visit them.

Table 8-6: Religion effects on public perception about cow welfare and gaushalas in India (P < 0.05)

Criterion	Parameter	Mean	Coefficient	SE Coefficient	P-value	OR	95% C.I
Rank of importance of purpose of establishing gaushalas (1 most important to 6 least important)							
Earning a profit	Referent: Hinduism	4.87					
	Others	3.94	1.29	0.336	<0.001	3.64	1.88 – 7.05
Religious purposes	Referent: Hinduism	2.33					
	Others	2.97	-0.86	0.318	0.006	0.42	0.22 – 0.78
Reasons for keeping cows in gaushalas (1 strongly agree – 5 strongly disagree)							
Milk sales	Referent: Hinduism	3.46					
	Others	3.00	0.68	0.322	0.03	1.97	1.05 – 3.71
Provision of resources by gaushalas is adequate (1 strongly disagree – 5 strongly agree)							
Shelter	Referent: Hinduism	4.44					
	Others	4.70	-0.96	0.440	0.02	0.38	0.16 – 0.91
Bedding, flooring and lying down	Referent: Hinduism	4.39					
	Others	4.62	-0.91	0.416	0.02	0.40	0.18 – 0.91

Table 8-7: Religiosity effects on public perception about cow welfare and gaushalas in India (P < 0.05)

Criterion	Coefficient	SE Coefficient	P-value	OR	95% C.I
Frequency of visiting the local gaushala (1 daily, 2 weekly, 3 fortnightly, 4 monthly, 5 biannually, annually, 6 < annually, 7 never)	0.27	0.102	0.008	1.31	1.07 – 1.60
Rank of importance of purposes of establishing gaushalas (1 most important to 6 least important)					
Earning a profit	-0.28	0.122	0.01	0.75	0.59 – 0.95
Religious purposes	0.41	0.107	<0.001	1.51	1.22 – 1.86
Provision of resources by gaushalas is adequate (1 strongly disagree – 5 strongly agree)					
Shelter	-0.27	0.117	0.02	0.76	0.61 – 0.96
Freedom to move about and socialize with other cows	-0.28	0.117	0.01	0.76	0.60 – 0.95
Bedding, flooring and lying down	-0.27	0.114	0.01	0.76	0.61 – 0.95
Humane treatment	-0.34	0.114	0.002	0.71	0.56 – 0.88
Veterinary care	-0.37	0.113	0.001	0.69	0.55 – 0.86

Table 8-8: Place of residence effects on public perception about cow welfare and gaushalas in India (P < 0.05)

Criterion	Parameter	Mean	Coefficient	SE Coefficient	P-value	OR	95% C.I
Frequency of visiting the local gaushala (1 daily, 2 weekly, 3 fortnightly, 4 monthly, 5 biannually, annually, 6 < annually, 7 never)	Referent: Village	3.55					
	Urban	2.63	1.09	0.177	<0.001	3.00	2.12 – 4.25
Importance of gaushalas for cows (1 strongly unimportant – 5 strongly important)	Referent: Village	4.84					
	Country town	4.45	1.4	0.516	0.004	4.48	1.63 – 12.33
Rank of importance of the purposes of establishing gaushalas (1 most important to 6 least important)							
Animal welfare	Referent: Village	2.49					
	Urban	1.94	0.57	0.183	0.002	1.78	1.25 – 2.56
	Suburban	1.69	0.75	0.310	0.015	2.12	1.15 – 3.90
	Country town	5.05	-3.01	0.476	<0.001	0.05	0.02 – 0.12
Milk sales	Referent: Village	3.35					
	Suburban	3.10	0.67	0.319	0.03	1.96	1.05 – 3.66
	Country town	2.25	2.49	0.495	<0.001	12.09	4.58 – 31.90
Breeding cows	Referent: Village	3.62					
	Suburban	3.93	-0.73	0.325	0.02	0.48	0.25 – 0.91
	Country town	2.06	3.64	0.514	<0.001	38.37	13.99 – 105.24
Attracting funding	Referent: Village	4.30					
	Urban	4.63	-0.44	0.200	0.02	0.64	0.43 – 0.95
	Suburban	4.97	-1.14	0.333	0.001	0.32	0.17 – 0.61
	Country town	2.43	2.47	0.486	<0.001	11.85	4.56 – 30.78

Earning a profit	Referent: Village	4.75					
	Urban	5.19	-0.80	0.220	<0.001	0.45	0.29 – 0.69
	Country town	2.00	2.74	0.538	<0.001	15.49	5.39 – 44.49
Religious purposes	Referent: Village	2.39					
	Urban	2.16	0.36	0.181	0.04	1.44	1.01 – 2.06
	Suburban	1.80	0.58	0.302	0.05	1.79	0.99 – 3.24
	Country town	4.68	-1.99	0.439	<0.001	0.14	0.06 – 0.32
Provision of resources by gaushalas is adequate (1 strongly disagree – 5 strongly agree)							
Shelter	Referent: Village	4.52					
	Urban	4.29	0.46	0.195	0.01	1.59	1.09 – 2.34
	Country town	4.00	1.08	0.410	0.008	2.95	1.32 – 6.60
Freedom to move about and socialize with other cows	Referent: Village	4.51					
	Country town	4.00	1.02	0.409	0.01	2.80	1.25 – 6.25
Bedding, flooring and lying down	Referent: Village	4.48					
	Urban	4.20	0.44	0.190	0.02	1.56	1.07 – 2.26
	Country town	3.63	1.53	0.402	<0.001	4.66	2.12 – 10.25
Reason for visits to gaushalas (Religious, Feed the cows, Educational, Examine welfare, Leisure, Buy products or other)	Referent: Village	2.02					
	Urban	1.65	-1.38	0.688	0.044	0.25	0.06 – 0.96

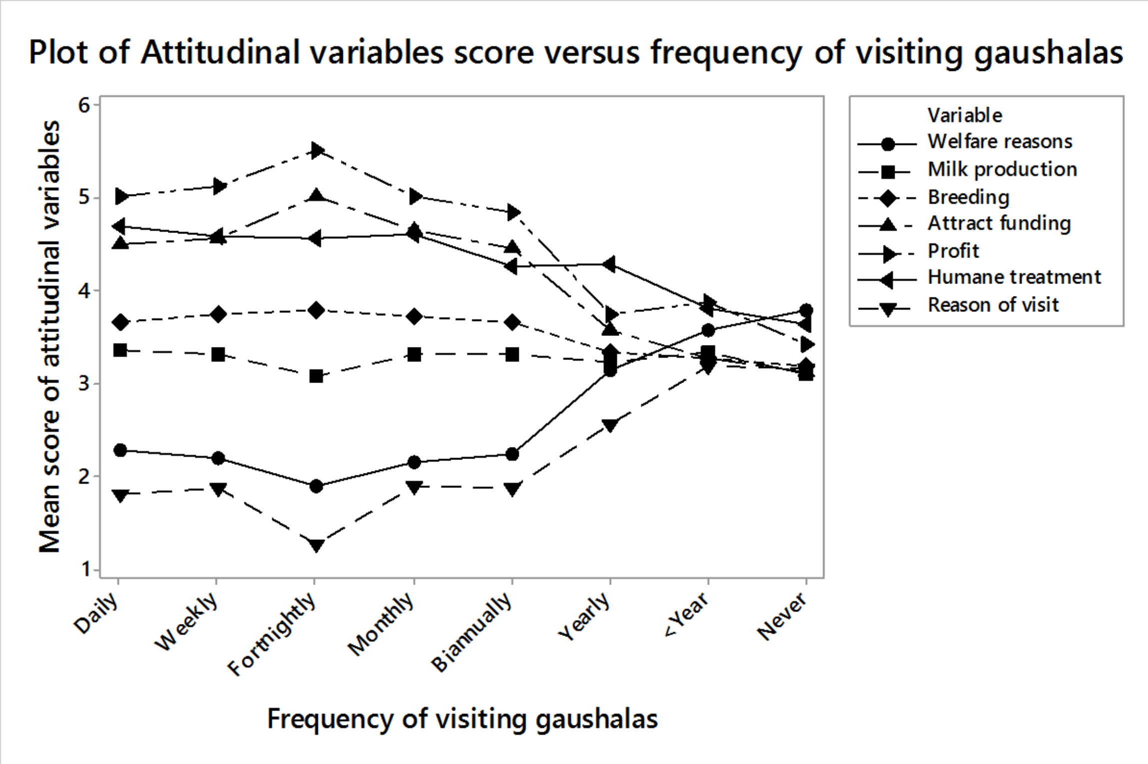

Figure 8-1: Relationship of various attitudinal variables with the frequency of visits of the public to the gaushalas

8.5.4 Qualitative assessment

All respondents answered the following open-ended question: What do you understand by the term ‘welfare of cows’? One hundred and forty -seven word frequencies were developed in response to the answers (Table 8-9). Words that were detected > 10 times were as follows: care (n= 369), goddess (316), mother (314), proper (313), feeding (176), rescue (71), abandoned (49), slaughter (34), welfare (29), duty (27), religion (26), sheltering (26), human (23), religious (22), watering (20), creatures (15), dumb (13), Hindu (10) and worship (10). The word cloud (Figure 8-2) generated emphasized the almost equal and predominant importance of four related concepts: care, goddess, mother and proper.

Table 8-9: Word frequency count of the question 'What do you mean by the term welfare of cows?'

	Word	Count	Weighted Percentage (%)	Similar Words
1	care	369	17.35	care, cared, caring
2	goddess	316	14.86	goddess, goddesses
3	mother	314	14.76	mother, mothers
4	proper	313	14.72	proper, properly
5	feeding	176	8.27	feeding
6	rescue	71	3.34	rescue, rescued
7	abandoned	49	2.30	abandoned, abandoning, abandonment
8	slaughter	34	1.60	slaughter
9	welfare	29	1.36	welfare
10	duty	27	1.27	duty
11	religion	26	1.22	religion
12	sheltering	26	1.22	shelter, sheltered, sheltering, shelters
13	human	23	1.08	human, humane, humanity, humans
14	religious	22	1.03	religious
15	watering	20	0.94	watering
16	creatures	15	0.71	creature, creatures
17	dumb	13	0.61	dumb
18	Hindu	10	0.47	Hindu
19	worship	10	0.47	worship

Figure 8-2: Word Cloud for the question' What do you understand by the term 'welfare of cows'?

8.6 Discussion

This was the first study undertaken to investigate the attitudes and beliefs of the Indian public about gaushalas, and about cow welfare. The aim of this study was not only to explore public beliefs about gaushalas and cow welfare, but also the factors associated with these beliefs. Additionally, this study aimed to investigate preferences for the different cow breeds, the suitability of gaushalas for managing unwanted street cows, and factors associated with the preferences for the management of cows in gaushalas.

The response rate in this study was higher than other animal welfare surveys (Heleski et al. 2006; Gurusamy et al. 2015), giving confidence that it accurately depicted the attitude of the communities surrounding these gaushalas, with little non-response bias (Hawkins 1975). The demographic profiles of the samples in this study appear to be similar to the national profile of the population in some respects, however, the proportion of Hindus was greater in this study because it is likely that gaushalas were mainly established in Hindu-centric communities. The ethnicity of most of the respondents was Indo-Aryan because the area of the study (north and north-western states of India) is predominantly composed of this ethnic group. Similarly, few of the respondents were urban as most of the gaushalas studied were located in the villages and country towns. It is possible that the response rate was higher due to the data collection method (face to face interviews), compared to using the internet or phone calls. This became relevant as the majority of the respondents had limited internet access and low literacy levels. Face to face interviews take more time, but they are better at obtaining a representative sample and can use a flexible questionnaire construction and design (De Vaus 2013). However, the assumption that web surveys have low response rates may be incorrect (Manfreda et al. 2008). The random selection of respondents from the general public who were not aware of the nature of the survey, and with the preconditions that they were not employed in the nearby cow shelter and yet living within a one km radius of the shelter, might have induced a potential bias in this study. But these selection criteria were important for eliciting the opinions and attitudes of the public who were neutral, but also lived near enough to a shelter to be aware of them and their conditions. Additionally, the recent highly politicised cow conservation movement may have contributed a positive bias on responses in the survey.

The median age group of the respondents of this study (36-45 years) is higher than the national average of 27 years. This might be due to those age groups being at work or college during the day. Moreover, as most of the respondents were from rural areas, younger people may have lived away from home, for work, and only occasionally return to meet elders (Kumari Bhat and Dhruvarajan 2001). There might be an overlap in the age groups in this context as in India persons aged between 15-59 years are supposed to form the working age population (India 2016). However, 70% of our respondents were rural and the age group of 45-65 years primarily constitute the agricultural farmers living in the rural areas working on their traditional land.

Only those survey results that were significant and had high levels of correlation to demographics were reported in the results, and the implication of some of these results will be briefly discussed here. The following sections discuss the findings of this study and suggest preliminary conclusions, particularly where existing social science research exists to help explain these results.

8.6.1 Perceptions about shelters and abandoned cows

There were consistently positive responses to gaushalas across multiple districts in six states of India where the majority of people report visiting regularly and contributing towards the running of the shelters. This finding suggests that the gaushalas and cows are an important part of the community in these areas and have become integrated into their social and spiritual life. While this important aspect of Hindu spiritual life has been reported in the literature (Simoons et al. 1981), the extent to which gaushalas are integrated into the fabric of the community has not been explored in depth by social scientists and anthropologists and would be an important focus for future research, particularly given the recent prominence cow protection movements have come to occupy in the current political climate in India.

Cow are venerated as goddess by Hindus and all religious occasions in Hindus households has worship of the cow as an important aspect of the ceremony right from the birth of a child to the death of an individual. Festivals like *Gopashtami and Govardhan puja* are cow centric occasions which underline the sacred cow concept in Hindu society as people visit shelter homes and make donations for the welfare of cattle in shelters (Lodrick 1981). Circumambulation of the cow, similar to the one done by Hindus around their temples, is considered auspicious and equivalent to a pilgrimage to a sacred Hindu city (Simoons et al. 1981).

Despite the arguments against the economic viability of the cow shelters and the cows housed in them, the Hindu society holds the welfare of cow as a duty towards the religion which professes the concept of ‘Ahimsa’ or non-violence towards all forms of life. Though this motivation comes from religion, sheltering of cows is an example to prevent animal wastage through active public support.

Regular visits to cow shelters for religious reasons reflect the veneration of cows in the daily life of these members of the Indian public and confirms the reverence of cows in Indian society (Simoons et al. 1981). This reverence for the cow was further confirmed by the absence of choice of any particular breed of the cow (exotic or local), and the fact that many in the community (65%) responded that they felt responsible for the cows’ welfare. A majority of the respondents favoured community responsibility for all abandoned and street cows, again reflecting the spirituality ethic embedded in Indian society towards the welfare and protection of the cows (Fox 1999).

The disagreement of the public that the cow shelters were meant for breeding and milking purposes in this study confirms the ascribed Hindu values and belief system in which sheltering of the cows has a religion based welfare motivation, though in the post-independence era economic returns from shelters were encouraged by the Government. (Simoons et al. 1981). Hence, the cows are utilized for milk, draft and manure as well as cared for until they die of natural causes in gaushalas. This might be due to greater awareness of the public about the importance of cow shelters in the contemporary context, as limited space allowance was identified as a welfare issue in this study, suggesting that respondents believed that there should be adequate space for all cows. Most of the respondents (> 82%) expressed agreement that the cows in the shelters provided a good level of welfare, similar to that described by the RSPCA’s ‘five freedoms of animal welfare’, with strong agreement that cow shelters provide adequate shelter, food and water, humane treatment and adequate veterinary care. Additionally, active volunteering and very few issues raised by the public indicates that they were satisfied with the adequacy of cow welfare in the shelters. The responses reflect a loyalty towards their local cow shelter, supported by the fact that half of the respondents visited the shelters daily or at least weekly. However, the knowledge levels of the public about cow welfare were not assessed, which limits the validity of the conclusion that the welfare of the cows was adequate in the shelters.

8.6.2 Demographic analysis

8.6.2.1 Age and number of children

During this survey, it was observed that the younger age groups spent less time per shelter visit and had less social interaction. They also ranked the welfare of cows at either end of the spectrum, either very high or very low which may be due to a lack of interest or time spent to accurately observe welfare. They also ranked breeding lower as traditionally cow shelters have not served this purpose. The older generation witnessed the times when breeding was one of the prime purposes of the gaushalas and accordingly, they ranked the purpose of breeding higher. Similarly, older people tend to donate regularly to support the cow shelters, which could be the reason why they ranked attracting funding higher than younger people. The older generation listed animal welfare and cultural tradition as the reasons for keeping cows in shelters more, probably because they have witnessed the sacred cow social movements in the post-independence era, when Government actively supported the opening of cow shelters (Murray 2018).

The utility of cow shelters to feed the rural poor through the sale of milk could be the reason that milk sales were ranked higher as a function of cow shelters as the number of children increased in a family. The finding that respondents with children at home agree with the shelter selling milk but disagree that profit making is an important reason to establish shelters is an interesting contradiction and invites further research. However, sale of dairy products and dung by the cow shelters has been the traditional practice to cover the running costs (Sharpes 2006).

8.6.2.2 Educational level

The frequency of cow shelters visits increased with higher educational levels, and those visits were mainly for religious reasons. In general, as educational levels increase, so do income levels (Gregorio and Lee 2002) and disposable income allows people the freedom, mobility and time to pursue leisure activities such as frequent gaushala visits. Moreover, education tends to make citizens more discerning and could have empowered such respondents in this study to objectively assess the availability of food, water, space and treatment for the cows, and to voice concerns over these aspects of comfort and welfare.

However, it was strange to find that as the education level increased, examining cow welfare as the reason to visit cow shelters decreased. By contrast in Europe, religious beliefs and participation in religious practices has decreased with rising education levels and living standards in Europe in the 20th century (Schofer and Meyer 2005; Meisenberg et al. 2012). A negative relationship has been observed between religion and education (Johnson 1997). However, religion plays an important role in daily life in developing and emerging economies, as religious beliefs and involvement run deeper in these communities (Tamney 1980; Brañas-Garza and Neuman 2004; Meisenberg et al. 2012).

8.6.2.3 Gender

The neutrality of female respondents about the cow's freedom of movement and opportunity to socialise with other cows is intriguing as most of the animal husbandry work at home in India is done by women. There is a general perception and published evidence that women have more sensitivity and empathy towards animal welfare and animal issues (Heleski et al. 2004; Phillips and McCulloch 2005; Serpell 2005; Herzog 2007; Phillips et al. 2011), and women are found to be more sympathetic towards animal welfare and sensitive to animal suffering (Herzog 2007). However, major gender inequalities exist in India and women's level of confidence to express their opinions about animal husbandry has a strong correlation with socio-cultural elements from their place of residence (Patel et al. 2016). Male domination due to the patriarchal Indian society may inhibit women from expressing their opinions freely, as traditionally men are in the position of power (Mullatti 1995; Pandey 2011). However, cross-cultural studies have suggested that in countries with a low gender inequality index women express their views on animal welfare more freely (Phillips et al. 2011), being more supportive than males (Heleski et al. 2004; Phillips and McCulloch 2005; Herzog 2007). In India, the gender empowerment index value is low (0.53), with a ranking of 125th in the world (United Nations Development Programme 2016), which suggests that women would not feel empowered to express their animal welfare concerns.

In the Indian context, males are given more authority and may enquire more into the affairs of the local cow shelter than females, who tend to be restricted to the household duties and have lesser opportunity and time to closely monitor the welfare of cows in the shelters. This could explain why men said the main reason to visit shelters was to examine cow welfare standards compared to women, who cited religion as their main reason. The cultural feminist theory suggests that women tend to make moral judgements more on the basis of relations than the general view of what is right or wrong (Phillips et al. 2011), which could explain women making more critical judgements about the provisions to the cows in the shelters.

Males favoured the local Indian breeds of cows more than females. In a patriarchal Indian society, there may be discrimination against the crossbred or exotic cattle from being sheltered in cow shelters and protected by law, as they are considered inferior to the native Indian breeds (Narayanan 2018). Females hold a more romantic view of animals with affection and concern for them, whereas males favour the Darwinian approach, where nature is controlled and exploited (Kruse 1999). The male preference for the local Indian cow breeds indicates that they are spirited nationalists, whereas women, despite being equally nationalistic, might identify a broader perspective of motherhood in cows irrespective of their breed. The patriarchal Indian society and households (Mullatti 1995) could therefore be the driver of such attitudinal differences between the genders.

8.6.2.4 Income level

The increased visits to cow shelters with increasing income levels could be due to the availability of more time compared with those in the lower income groups. Feeding and worshipping the cow is considered to attract more wealth in Hindu mythology because the cow is also believed to be an incarnate of the Hindu goddess of wealth “Lakshmi” (Lodrick 2005b). Similarly, the breeding of cows is also equated with growth in wealth (Somvanshi 2006) and this could be the reason why breeding was ranked higher as a function of the cow shelters by high income earners.

Those in middle income categories may have had a strong desire to uplift their economic status, and their visits to the cow shelters being for religious reasons rather than to feed cows might be have been due to the Hindu belief that one can attract wealth through the worship of cows. This is a deeply ingrained in Hindu philosophy, together with the tradition of non-violence and reverence for the cow (Heston 1971).

8.6.2.5 Religion

Non-Hindus in this study lay more emphasis on the adequacy of sheltering, bedding and flooring, indicating that they viewed the cow shelters through a prism of cow welfare and comfort rather than from a religious angle. However, they represented just 5% of the sample which limits any conclusions. However, studies have shown that eastern religions (Hinduism, Buddhism, Confucianism) induce less religiosity than Christianity and Islam, and within India, average religiosity scores of Hindus is significantly lesser than Muslims (Meisenberg et al. 2012).

8.6.2.6 Religiosity

More religious people took a very optimistic view on the existence and performance of the cow shelters. They frequented the cow shelters more and attached more religious importance to the cow shelters rather than for economic reasons. Their overwhelming faith in religion and their local gaushala might be the reason they did not see, or rather ignored, the inadequacies in the welfare levels of the cows. Religiosity has been a factor influencing social behaviours, and is also affected by the precise religious affiliation, some demanding more than others (Poria et al. 2003). Since the majority of the respondents were Hindu, a religion which traditionally attaches importance to cow shelters, this was reflected in the strength of religious beliefs (religiosity) expressed by the adherents.

Self-declared, very religious respondents visited the cow shelters for religious reasons rather than for examining the welfare standards, becoming educated or for leisure. These visits to the cow shelters follow a ritualistic pattern in Hindu society that might be an individualistic passion towards religion or sometimes ordained by religious priests to bring about abundance in life, personified by the mythical *'Kamdhenu'* cow, representing abundance and fertility (Nadal 2017). Studies have shown high correlations between religiosity and low animal welfare concerns (Heleski et al. 2005). It could be that a deep faith in the Hindu religion and its cultural traditions might override other reasons for visiting the cow shelters. However, a limited study in the United States (Lifshin et al. 2018) found a curvilinear relationship between religiosity and support for killing animals, as very religious or irreligious participants supported animal killing more than moderately religious participants.

8.6.2.7 Place of residence effects

There were varied and sometimes conflicting results for this category. Due to the rapid pace of urbanisation and changing social, economic and spatial demographics of modern India, extensive and recent sociology studies into these changes which may better explain some of these findings are few (Bhattacharya 2006; James 2008, 2011). Rapidly expanding country towns in India are inhabited by low income working class or middle class citizens who cannot afford to reside in the urban areas due to financial constraints (Bhagat 2011). The higher literacy levels in urban and suburban areas as compared to rural areas in India (Kotni 2012) could be the reason for this awareness of animal welfare and their objectivity.

Suburban people were observed to subscribe to a utilitarian view about the cow shelters, as milk production, breeding of cows, attracting funding and earning profit were the ranked higher than cow welfare and religion as reasons for establishing cow shelters. During the field surveys, gaushalas were observed supplying subsidised milk to suburban people and this may influence their views about the utility of shelters.

The higher rank of animal welfare and lower rank of profit making and attracting funding by urban and sub urban respondents than rural ones in this study could be due to a greater awareness and frequency of visits by these residents to the cow shelters. Urban dwellers also pointed out the lack of proper sheltering, bedding and floor space. High awareness levels of the residents in the urban and country towns about cow welfare could be the reason for this perception.

Suburban residents comprise of the working class which might be religious but have less time for leisure than the affluent urban residents. This could be why suburban residents visited cow shelters more for religious reasons than for leisure.

8.6.2.8 Marital status effects

Indian single people are more likely to occupy the younger age group in this study and therefore similar correlations would be expected between unmarried and younger age effect. Interestingly, however this was not the case. Single people in general have less obligations and more leisure time than married people, which could be why they rate leisure as the purpose to visit gaushalas.

Since the 1950s, exotic cow breeds were introduced into breeding programs across the country. The very older age groups witnessed the gradual transition of genotype from indigenous to exotic breeds and may hold a sentimentality towards the local breeds of their youth

The reason why single people visited cow shelters more for leisure as compared to married people who visit for religious reasons could be that there are more social obligation on the families to follow cultural / religious traditions and duties than single people. Visiting cow shelters for religious reasons could be a social and community need in close knit Indian families (Brinkerhoff et al. 1997).

Single people rated all types of cows as equal in contrast to married people and widowers who rated local Indian breeds higher. Single people in this study were mostly younger in age and seem to be have a broader view about animal welfare, as evident in the earlier results of marital status effects in this study. They might be less sensitized to the sacred cow concept and view universality of compassion towards all living creatures.

8.6.3 Influence of attitude towards cows to visiting frequency to gaushalas

The results clearly showed that more frequent visitors to shelters cited higher levels of religiosity, ranked welfare and profit making as the reason for establishing the gaushalas, and strongly said that cows were treated humanely. Interestingly, those that visit monthly or more also cite welfare as the reason to establish shelters. Attitudes and personality explain human behaviour (Ajzen 1991) and in this study a positive correlation was found between attitudes and behaviour like visiting shelters. The positive influence of human attitude on behaviour towards cows has been researched (Breuer et al. 2000b; Hemsworth et al. 2000). Such attitudes might indirectly affect and influence welfare of sheltered cows.

8.6.4 Qualitative assessment

Results of the qualitative analysis indicated that cows still hold a sacred position of the 'Mother Goddess' in Indian society and this is the reason for taking care of them. The word query and count results reflect the concern for the abandonment and slaughter of cows. The care of cows through rescue from slaughter and the proper feeding for their welfare was perceived as a duty of the adherents to the religion.

8.7 Limitations of the study

The random selection of respondents in this study significantly reduces the potential for selection bias but it is very difficult to estimate the response rate of the survey. The selection of only those respondents who lived near the cow shelters might induce a bias, but it was intended to get information about the day to day working of the cow shelters from persons who had had the opportunity to visit them.

There is a possibility that these residents might not portray their true feelings in comments about their local cow shelter. However, the face to face technique has the ability to rapidly collect data from a large number of people with less false reporting than other methods. It is also possible that the respondents were not representative of the Indian public. The sample size was large enough, but the study surveyed only a small sector of the population within six states of India.

However, while this research constituted the first attempt at eliciting attitudes towards cows and gaushalas in these areas of India, it was a brief survey and has implicit bias and limitations. More in-depth ethnographic research will be required to fully examine people's relationship with these ancient institutions and with cows before drawing conclusions as to their motivations, influences, and beliefs.

8.8. Conclusions

Public attitude towards cows and cow welfare in cow shelters was guided by the overriding concept of the cow as sacred, literally having the status of 'mother goddess' in Indian society. Visiting the cow shelters frequently for religious reasons further strengthens this status of the cow. The majority of the respondents in this study believed in the welfare of all cows irrespective of their breeds. Welfare and religious reasons were ranked higher as reasons for the establishment and running of the local cow shelters by the respondents, which symbolises the 'protectionist conservationism' approach of the Indian society in the context of this study. The older respondents had a focus on the utilitarian and religious values of the cow shelters, whereas the younger people viewed them as institutions for cow welfare and protection. Reverence for cows and concerns about their welfare in the cow shelters increased with increasing education levels. The patriarchal structure of the Indian society was reflected in the neutral views about cow welfare in shelters shown by females. Higher incomes leading to more frequent visits to cow shelters for religious reasons indicates the status of the cow as an incarnation of the ‘goddess of wealth’ in Hindu mythology (Lodrick 1981). Increased religiosity levels and the Hindu religion were the main reasons for establishing and visiting cow shelters, and there was some evidence of community responsibility towards local Indian cow breeds. Place of residence revealed attitudinal differences towards cows and cow shelters. Rural populations held a utilitarian as well as religious view of cow shelters and reported fewer welfare issues. Increased education levels did not reduce reverence for the cow, but it enabled them to report welfare and cow comfort issues in the shelters. Key differences in the attitudes of the public towards cows and cow shelters across the demographic profiles delineated in this study need to be understood and incorporated into initiatives to improve the welfare of cows in shelters. This will maximise public engagement to successfully manage the cow shelters with modern scientific concepts of animal welfare-based management in order to perpetuate these unique institutions in a sustainable way. Further studies are needed to assess the knowledge levels of the public about cow welfare. This will reveal more about the dichotomy of thoughts of the Indian public towards cows in the context of religion and animal welfare. Future research should identify and address key welfare issues with a broader range of stakeholders and examine the potential impacts of improvements in cow welfare in the cow shelters.

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Author Contributions to the paper

The conceptualization, design and methodology was done by Arvind Sharma, Clive J.C Phillips and Catherine Schuetze. The data collection and investigation was done by Arvind Sharma. The formal analysis and interpretation was done by Arvind Sharma and Clive J.C Phillips. Original draft of the paper was prepared by Arvind Sharma. The writing review and editing was done by all the authors.

Chapter 9

The management of cow shelters in India, including the attitudes of shelter managers to cow welfare

9.1 Abstract

Gaushala management is a specialized profession relating to the management of cow shelters or gaushalas, which are traditional and ancient Indian institutions that shelter old, unproductive and abandoned cows – is believed to be a specialized job requiring particular skills. The 1800 registered cow shelters in India have managers who are important stakeholders in the management of cows in these unique institutions. It is important to survey the routine management of these shelters and attitudes of the managers towards cow welfare to identify the constraints and welfare issues. Fifty-four shelters in six states of India were visited for a face to face structured interview of the managers. Quantitative data collection included questions on demographics, routine management operations, protocols followed in the shelters and attitudes of the managers towards cow welfare. All shelters except one were managed by males, half of them were, in the age range of 45-65 years, were university graduates or post-graduates, with 5-15 years shelter management experience, with the majority having lived in rural areas for most of their lives. Each shelter housed a median of 232 cattle were housed, out of which 13 were lactating cows. The majority of managers vaccinated their animals against endemic diseases like foot and mouth disease, haemorrhagic septicaemia and black quarter (*gangraena emphysematosa*) and administered endo-and ectoparasiticidal treatments, however, hardly any screened the cattle for brucellosis and tuberculosis. Only 17% of the shelters had in house veterinarians and most cows died of old age, with an annual mortality rate of 14%. The majority of the shelters allowed the cows to breed. Access to pasture was available in only 41% of the shelters, while most allowed some access to yards. Most (57%) had limited biosecurity measures, but 82% of the shelters disposed off the carcasses by deep burial on their own premises or through the municipality, with 18% disposing of them in open spaces or nearby creeks. About one half of the shelters maintained records of the protocols followed routinely. Charitable societies ran half of the shelters, mostly through public donations, with accounts audited regularly. Most managers thought that shelter's cow welfare was important and that they should attempt to improve it. They were less in agreement that their knowledge of animal welfare was adequate. Local support, more moral than financial, was recognized more than government support. Managers perceived cow welfare as important from a religious perspective, citing the mother god and caring for abandoned animals as frequent themes in their definition of cow welfare. Caring for animals, mother and goddess were key elements in managers' perception of animal welfare. The recommendations arising from this survey include that the shelter managers should be involved in the decision-making process for the welfare of cows in shelters, which is vital for the sustainability of these unique institutions. Welfare could be improved by strict compliance with biosecurity measures and disease surveillance protocols, avoidance of indiscriminate breeding and separation of males and females.

Keywords: shelters; cows; managers; survey; attitudes; welfare; India

9.2. Introduction

In India cows in their late lactation, with reduced production and competing with other cows for the costly feed are often abandoned to the streets. In urban areas, they then forage on garbage dumps, potentially consuming plastics and wires, as well as potentially suffering fatal traffic injuries (Fox 1999). Abandoning of cows in streets is contentious as these cows are often injured, even causing human mortality, and potentially causing a public health risks to humans and animals (Singh et al. 2013; Ghatak and Singh 2015). According to the Indian Government, stray animals caused 1604 road accidents in 2016, leading to 629 human deaths (Government of India 2017). Stray cows in the roads and streets have specifically been implicated as the causes of these road accidents (Arya et al. 2019). In the villages, crop-raiding by abandoned cows has led to human-animal conflict, with farmers sometimes having to abandon cropping and cows beaten and chased away. In this scenario, gaushalas are the only alternatives to shelter these stray cows, as a religious ban on cow slaughter is increasing their numbers every year.

Sheltering of old, abandoned, unproductive, infertile and infirm cows in shelters referred to as “Gaushalas” is a traditional practice in India. The exact origin of these shelters is not known but documentary evidence of their existence is available from the 3rd to 4th century BCE (Lodrick 1981). Over time they diversified, based on their religious affiliations and ownership (Evans 2013). Cows are worshipped as a mother goddess by the Hindu majority population. Cow slaughter is illegal in most Indian states (Sarkar and Sarkar 2016; Narayanan 2019b). The 12th century Muslim invasion of India and the later European colonization created socio-political conditions linking the cow with symbols of purity and Hindu identity. More recently, political parties strengthened cow sheltering and the cow protection movement (Lodrick 1981; Gupta 2001; Lodrick 2005; Narayanan 2018). Mahatma Gandhi emphasized the role of shelters in the economic growth of India rather than any religious role, by advocating dairying and breeding of shelter cows (Burgat 2004). In the early independence years, the role of gaushalas changed from sacred cow sanctuaries to potential breeding and dairying centres for high yielding cows, with active financial support from the government (Valpey 2020).

India is the largest producer of milk and has the largest number of dairy cows in the world (58.5 million), as well as the largest cattle population (190.9 million). In the last livestock census (2012) there were 5.2 million stray cattle (Department of Animal Husbandry Dairying and Fisheries 2014). In a Government survey conducted in 1956 there were 1020 gaushalas in 21 states of India (Chakravarti 1985), which has grown to the current 1837 registered gaushalas, according to the Animal Welfare Board of India (AWBI), the statutory body under the Government of India's Prevention of Cruelty to Animals Act 1960 (PCA, 1960). However, there are reports that the total number, including unregistered gaushalas, is approximately 5000 (Federation of Indian Animal Protection Organisations 2018b; Mandi et al. 2018).

Managers are employed by either the gaushala trustees, charitable societies, temple trusts, municipalities or government, according to who owns the shelter. A two thousand year old Hindu text, the '*Arthashastra*', describes the administration of gaushalas, including a position of '*Godyaksa*' (Superintendent of Cows) (Lodrick 1981; Evans 2013). Nowadays managers provide an interface with visitors, who come to donate to, worship, feed or just see the cows. Managers have multiple roles, as cashiers, cattle and worker superintendents, and receptionists. They are in a unique position to understand the challenges to the welfare of cows in shelters and evolve solutions that improve their lives, based on the results of this research. Despite this, their attitudes towards cow welfare and gaushalas have never been studied, and these are perceived to be useful for improvement in cow welfare. Studies investigating attitudes towards animal welfare issues are common in developed countries (Vanhonacker et al. 2008; Verbeke 2009; Kauppinen et al. 2010), including aspects of dairy farm management (Mishra 2001; Caraviello et al. 2006; Gourley et al. 2007), and even dairy farms in India (Saha and Jain 2004; Tiwari et al. 2009; Sreedhar and Sreenivas 2015).

The paucity of studies on gaushala management is evident (Lodrick 1981; Federation of Indian Animal Protection Organisations 2018a; Bijla et al. 2019), even though there are qualitative studies critical of the management of cow shelters in a philosophical context (Narayanan 2018, 2019b). There is a lacuna in literature on the quantitative assessment of the routine management of cow shelters in the contemporary context, when the sheltering of cattle has gained importance in the wake of an increasing problem of street cows and impetus for strengthening the shelters from the Indian Government.

Therefore, a survey was designed to collect and analyse information about the routine animal husbandry operations and practices of shelters and to elicit the attitudes of managers of the gaushalas to cows and their welfare. Information about the routine working of the gaushalas, husbandry practices followed, demographics of the sheltered animals, preventative health and biosecurity measures undertaken, income and expenditure of the gaushalas, constraints and visitor profile are important to objectively assess the welfare of the cows in these shelters. The opinions and attitudes of these managers towards cows and cow welfare is also important to provide feedback to these stakeholders for training and recruitment of managers.

9.3. Materials and Methods

Human ethics approval for this study was provided by the University of Queensland's Human Ethics Committee (approval number 2016001243). Interviews were conducted with shelter managers between November 2016 and July 2017, as a part of a welfare assessment of cows in shelters in six states of India (Gujarat, Maharashtra, Rajasthan, Punjab, Haryana and Himachal Pradesh) (Sharma et al. 2019b). The states were selected on the basis of having the largest concentration of shelters in India and a tradition of sheltering cows (Gujarat, Rajasthan, Maharashtra, Punjab and Haryana) and one state (Himachal Pradesh), which was actively establishing cow shelters to tackle the stray cattle problem (Figure 9.1). Each shelter manager of the 54 cow shelters assessed was interviewed for approximately 35 minutes, before assessing the animals and resources present. The sample size of shelters ($n = 54$) was determined using a power calculation (Creative Research Systems n.d) which determined that 50 shelters would adequately represent the number of shelters in major Indian states having shelters. The study was designed to detect an odds ratio of 4 with a power of 0.8 and $\alpha = 0.05$. The prerequisite for selection of the shelters was that they should be sheltering at least 30 cattle and should not be selling more than 20 litres of milk per day. A good geographical distribution of the shelters in each state was ensured for sampling in the study along with a mixture of good or bad shelters. Shelters were selected on the basis of recommendations of the AWBI, veterinarians working in the state animal husbandry departments and through a snowballing technique.

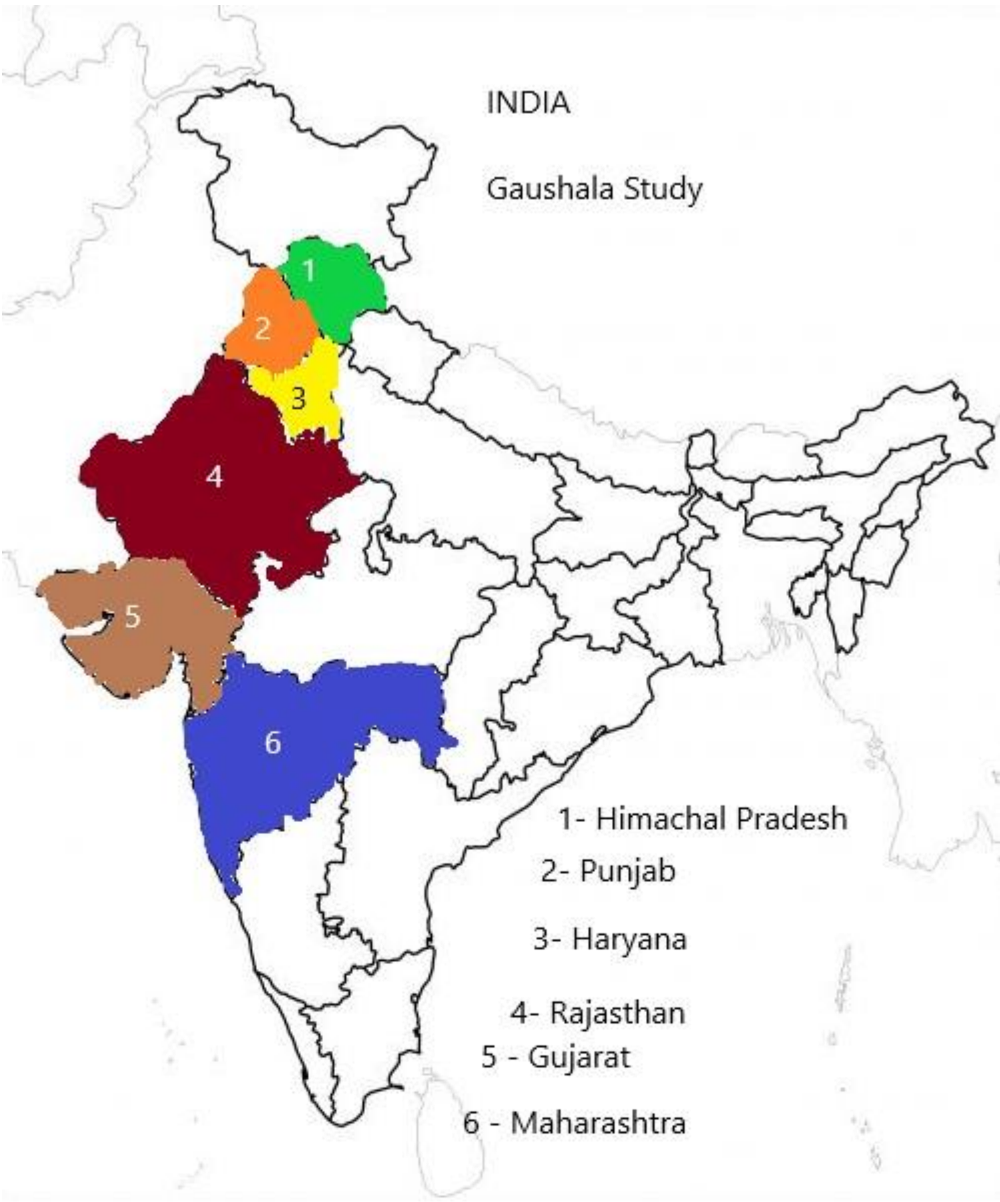

Figure 9-1: Schematic Map of India depicting states covered under the Gaushala study

9.3.1 Questionnaire Design

Interviews with the shelter managers in Hindi were conducted using a questionnaire with multiple-choice, semi-closed and open-ended questions to collect socio-demographic data, data about shelter management and husbandry practices and attitudinal data of the managers to cows and cow welfare (Appendix 4). The first section had three screening questions about whether the shelter housed at least 30 animals, whether infertile, abandoned, rescued, stray, old and infirm cows were being sheltered, whether the shelter had any religious connection and age of the shelter. The second section on demographics asked their gender, usual place of residence, age, religion and religiosity and education level. They were then asked to describe their job in the shelter, their level of understanding and knowledge about cow shelters, source of gaining this knowledge, any animal welfare activity outside of the shelter, and the length of time they had spent working in that shelter. The third section addressed cattle numbers and cattle management: the number of lactating cows, mean milk yields, the proportion of horned cattle, the number of other cattle (bulls, bullocks, non-lactating cows and heifers, males and female calves, less than 6 months of age), the fate of calves born in the shelter (sold, donated or reared); vaccination and deworming practices, including frequency of use and for which pathogens; veterinarian involvement (in house or visiting; frequency of visits), number of male and female workers and the length of time they had worked there, whether there was induction training, whether the manager kept records, sold livestock products and ran a biogas plant at the shelter.

The fourth section asked about the status of the shelter (public or private trust, government, charitable society, board of directors, municipality, individual or any other), the source of funding, annual income and expenditure, including whether audited, affiliation with the AWBI. The fifth section addressed husbandry: mortality and its major causes, whether colostrum was fed to calves, whether cows and calves were separated after birth, the cattle feeding regime, including whether visitors fed the cows, the time spent by the cattle outdoors in the yard or at pasture, whether the cows bred or not, and if they did the purpose of the breeding; whether there were any animal enrichment and/or biosecurity measures (the latter particularly during the introduction of new animals, disposal of carcasses, and isolation of diseased animals), the disposal of cow excreta, the maintenance of cows in segregated groups; use of loading/unloading ramps; whether animal experimentation was allowed; natural disasters plans; volunteering by the public, and any public relation or outreach activity done by the shelter.

Finally managers responded to attitude questions on a Likert scale (1, strongly disagree to 5, strongly agree): the welfare of this gaushala's cows is satisfactory and important to me; my knowledge of animal welfare is adequate; the feed the cows receive is adequate; I am willing to adopt measures that will improve the welfare of the cows, if provided to me; the local community and government financially and morally support the gaushala; I intend to make improvements to the welfare of the cows under my care; in the past I have tried to make improvements to the welfare of the cows in my care; the staff at this gaushala have a close relationship with the cows. Finally, an open-ended question was asked: what you understand by the term 'welfare of cows'?

9.4 Statistical Analysis

Data was screened for errors, and analysis completed with Minitab 17 Statistical Software (Minitab® version 17.1.0, Minitab Ltd., Pennsylvania State University, State College, PA, USA). Descriptive statistical analysis on the questionnaire was performed and respondent demographics, complimentary data, and responses to attitude questions expressed as numbers and percentages.

The association of the dependent variables, income of the shelter and mortality rate of cow shelter with various categorical and continuous independent variables was explored using a general linear model (GLM). Logistic regression analyses (either binary, nominal or ordinal, as appropriate to the response structure) were used to analyse the significance of relationships between type of administration, affiliation with AWBI and financial support of the Government (which had Likert scale response), the income of the shelter , mortality rate, disease outbreaks in the last 5 years , biosecurity measures, breeding of cows in shelters, time cows spent outdoors, training of workers, frequency of veterinarian visits, frequency of deworming, ectoparasiticidal treatments and vaccination, numbers lactating cows in the shelters, total milk yield of the shelters and the total number of animals in the shelters. Cross tabulations between dependent variables and independent variables were also inspected, ensuring that all individual expected counts were ≥1. An iterative reweighted least squares algorithm with a logit link function was used in the models. All models achieved convergence. All probability values were considered significant at $p < 0.05$.

The type of administration of the shelter (whether managed by a public trust, private trust, Government or a charitable society), affiliation with the Animal Welfare Board of India (AWBI) and income of the shelter were used as outcome variables against animal health and welfare based variables: mortality rate, vaccination status, vaccination frequency, status and frequency of deworming and ectoparasiticidal treatment, total number of animals in the shelter, milk yield of cows in the shelter, number of dairy cows in the shelter, frequency of veterinarian visits to the shelter, training of workers, biosecurity measures for new cattle admitted, time spent by the cows outdoors and disease outbreaks in 5 years. According to the nature of outcome variable (continuous, binary or ordinal) GLM, ordinal or nominal regression models were used to explore associations between these variables.

A one way ANOVA was used to determine whether any significant differences in the responses to the twelve attitude questions existed. Each attitude question was taken as a response and the other 11 questions were used as factors with the possible answers to each question as levels of the factor variable (1-strongly disagree to 5- strongly agree). The level of significance was fixed at 5%. Tukey’s method was used to compare the means for each pair of factor levels to control the rate of type 1 error. Chi-square test for association was used to test for any differences in the disposal of male and female calves.

Thematic analysis of the open-ended question about what the gaushala manager understood by the term ‘welfare of cows’ was conducted by a single thematic coder, using NVivo Pro 12 software (NVivo qualitative data analysis software; QSR International Pty Ltd. Version 12, 2018, https://www.qsrinternational.com/nvivo/nvivo-products/nvivo-12-plus). This extracted the main trends from the word frequency and word cloud functions. Conjunctives (such as ‘and’) and words which were irrelevant to the study theme (such as ‘a’ or ‘it’) were manually excluded from the output and the analysis repeated.

9.5 Results

9.5.1 Respondent demographics

All 54 shelter managers completed the questionnaire, a 100% response rate. There was only one female shelter manager. The majority of the managers had lived most of their lives in villages (63%), some in urban areas (28%), country towns (7%) and suburban areas (2%). Most were aged 46-55 years (26%), or over 65 years (22%), with fewer 36-45 years (18%), 56-65 years (17%), 26-35 years (15%) and 18-25 years (2%). Twenty-eight percent of the managers were university graduates, 24% were post-graduates, 21% ended their education after passing grade 12 and 9% at grade 10, 13% were diploma holders, and 5% were either below grade 10 pass or had no formal education.

Almost all of the managers were Hindus (96.3%), with many considering themselves very (55.5%) or moderately (43%) religious. Nearly all (94%) considered their job as being team leaders supervising people working directly with the cows; only 6% indicated that they worked directly with the cows. The majority of the managers (67%) thought that they had good knowledge and understanding of cow shelters, 18% considered themselves to be experts, 13% considered that they had some knowledge and 2% little knowledge. A majority (81%) believed that hands-on experience of working on farms was the main source of their knowledge about cow welfare, 7% had their knowledge from formal qualifications and 3% from newspapers, periodicals, television programmes and the internet. Although most (59%) were not involved with animal welfare organisations, some (61%) were involved in other animal welfare activities: animal activism, humane education or feeding stray animals. Only 30% were involved with professions unrelated to animal welfare before joining the shelters. Thirty-three percent had long experience of similar work in animal welfare, more than 15 years, followed by 21% between 5-9 years, 17% between 10-15 years, 13% between 2-3 years, 11% between 3-5 years and only 5% being there for less than an year. Twenty-eight percent of the managers had spent 10-15 years working at their current shelter, followed by 19% -3-5 years, 17% - 5-9 years, 17% >15 years, 13% - 2-3 years and 7% < one year.

9.5.2 Establishment of the shelters and their financial performance

Half of the managers reported the shelter’s religious connection to Hinduism (27 shelters), 11% to Jainism, 9% to Jainism and Hinduism, 8% to others (Sikhism and Islam) and 22% had no religious connection. The earliest shelter established among the shelters included in this study was in the year 1766, from records available with the shelter managers. Five shelters were established in the 19th century, five in the first half of the 20th century and the rest were established in the second half of the 20th century and in the 21st century. Almost half of the shelters (48%) visited in this study were administered through charitable societies, followed by 33% by public trusts, 13% by private trusts and the rest by government, municipalities or temple trusts, respectively. Philanthropy by public, business houses, trusts and funding by the state governments were the principal sources of funding to the shelters. Only 46% of the shelters were affiliated to the AWBI. Regular auditing of the shelter funds was done in 96% of the shelters.

Fifty out of the 54 shelter managers interviewed in the study provided the estimated income and expenditure of their shelters. The median annual expenditure of the shelters was 3,525,000 Indian rupees (approximately US$ 50,000).The median annual income was 125,000 rupees (approximately US$ 1800). The maximum annual expenditure being incurred by a shelter was 150,000,000 Indian rupees (approximately US$ 2,000,000). Some of the shelters reported no incomes (five shelters) and the maximum annual income reported was 12,444,000 Indian rupees (approximately US$ 174000).

Income was provided by sales of milk, manure, urine and hides. Milk was sold in only 37% of the shelters but 54% of the shelters sold dung as manure. Partial disposal of dung by shelters was done in the form of donation of manure free of charge to the local farmers (37%), sale as manure alone (37%) and sale as vermicompost and manure (17%). Biogas as an alternative fuel to use the dung-generated in the shelters was only produced in 19% of the shelters. In 9% of the shelters dung was not disposed of but left lying as a mound within the shelter premises. In case of urine, 76% of the shelters just let off drain off without proper sewerage facilities to treat the slurry, whereas in 24% of the shelters urine was collected for use as a biopesticide or traditional medicine. Hides of dead animals were sold in 11% of the shelters.

Recording of milk yield in the shelters was done only in half of the shelters. Calving and mortality records were maintained in 63% and 81% of the shelters, respectively. Health records were maintained in 80% of the shelters. An inventory of veterinary drugs was maintained in 76% of the shelters. Feed records were maintained in 91% of the shelters while 76% of the shelters also maintained records of any sales.

9.5.3 Cattle, worker and visitor demographics

The median number of animals housed in the shelters was 232. The median number of cows, heifers, bulls, bullocks, female and male calves were 137, 48, 12, 9, 11 and 15, respectively. The median number of lactating cows in the shelters was 13, with a median milk yield of 12 l/d/ shelter. Nearly all (90%) cattle were horned. In each shelter the calves were usually reared there (mean/shelter/year, n = 64, 59% of total calves), some donated to villagers if requested (n = 31, 29%) and a small proportion sold (n = 13, 12%), with no significant difference between males and females (Chi Square = 0.98, P = 0.61).

The median number of male workers was six and females two, with 32% of the shelters having no female worker. The maximum number of male and female workers in a shelter was 300 and 110, respectively. Induction training of the workers was performed in 65% of the shelters.

Regular volunteering in the shelters by the local public was reported in 30% of the shelters, occasional volunteering in 26% of the shelters and the absence of volunteering in 44%. In order to have an outreach to the public, 72% of the shelters organized activities such as the celebration of cow specific holy festivals (like '*gau ashtami*', '*govardhan pooja'*), recitation of religious scriptures by saints, open days and community feasts, according to their financial capacities.

All shelters allowed visits for a variety of purposes: exclusively for religious reasons was reported by 9% of the managers, 39% for seeing or feeding the cows and 52% for all the above reasons. Most of the shelters (98%) did not allow anyone to conduct experiments on their animals. Nearly all shelters (96%) allowed visitors to feed the cattle, and 87% of the shelters monitored it.

9.5.4 Health management, breeding, housing and disaster management

Almost all the shelters (96%) vaccinated their cattle, for foot and mouth disease (FMD), haemorrhagic septicaemia (HS) and black quarter disease (BQ) in 85% of the shelters and FMD and HS only in 11%. Only one shelter vaccinated against brucellosis along with the other diseases and one shelter did not vaccinate their animals at all. Most of the shelters (81%) vaccinated the cattle twice a year and 15% thrice a year. Endoparasiticidal treatment was given twice a year in 35% of the shelters, thrice a year in 17%, four times in 30%, once a year in 5% and 3 shelters never did it. Regular schedules of endo and ectoparasiticidal treatment were used by 7% and 50% of shelters, respectively. Twenty-one percent of the shelters did it four times a year, 11% twice a year, 5% thrice a year and 3% once a year. Seven percent of the shelters did not use this treatment.

Only 17% of the shelters had in-house veterinarians but a further 26% of them had veterinarians on call. Some 13% of the shelters had daily visits, 13% weekly, 13% fortnightly and 5% monthly visits. The median mortality rate of the cattle in shelters was 30 animals/year or 13.8%. Old age was ranked as the main cause of mortality (53%), followed by animals brought in in a moribund state (28%), disease (8.5%), chronic debility (5.5%), other causes (3%, such as fatal injuries due to fights within herd mates, impaction of the gastrointestinal tract with plastics) and malnutrition/ fodder shortage (2%).

Biosecurity measures in the shelters were followed in 57% of the shelters in the form of separate sheds during the introduction of new animals, isolation wards for separating and treating sick cows (72%); disposal of carcasses took place by their deep burial within the shelter premises in 43% of the shelters whereas 39% shelters allowed the municipalities to dispose off the carcasses. However, 18% of the shelters left the carcasses in the open or just threw them in the nearby creek or ravine. Disease outbreaks in the last five years, predominantly FMD, were reported by 43% of the shelters.

The majority of the shelters (91%) allowed the cows to breed, 44% of which was mating by bulls housed with the cows and 44% was planned, with cows taken to bulls when estrus was observed. The purposes of breeding was usually (56%) for indigenous breed conservation, breed improvement and increased productivity; with 44% allowing it without any purpose. Colostrum was fed to all calves born in the shelters and 94% of the shelters fed it immediately after the birth. Calves were kept with their mothers in most (57%) shelters. In 68% of shelters the cows were segregated into different sheds according to their age and length of stay. Access to pastures was available only in 41% of the shelters, whereas 81% had access to yards. Approximately the same proportion of shelters (46%) sent their cows outdoors to the yards for less than six hours and more than 6 hours (44%). Nine percent of the shelters did not allow their cows outdoors, mostly due to the absence of yards and pastures. Loading and unloading ramps for the cows were available in 57% of the shelters.

Most shelter managers (76%) expressed ignorance about any disaster management plans for their shelters, and 74% believed that their shelter was not located in a disaster-prone area (areas prone to flooding, avalanches, landslides, and bushfires). Animal enrichment measures were employed in 52% of the shelters but were mostly restricted to the provision of playing devotional music.

9.5.5 Association of shelter administration, affiliation, income and financial support of government with various health and welfare parameters

No significant association was observed between the income of the shelters with other independent variables using a General Linear Model, though there was a trend towards shelters affiliated to the AWBI having more income ($p = 0.07$). There was a significant positive association between the mortality rates in the shelters with total milk yield/day (SE of coefficient = 0.001, $F = 10.37$, $p = 0.004$) and presence of an in-house veterinarian (SE of coefficient = 166, $F = 4.86$, $p = 0.002$). The r^2 (adjusted) for the model was 61%.

There was a significant association between the type of administration of the shelters (government, public trust, private trust or a charitable society) and the presence of biosecurity measures for newly admitted animals (OR = 18.94, 95% CI 2.73 – 131.22, p-value 0.003). Shelters run by charitable societies were less likely (10/26) to use biosecurity measures for newly admitted animals than the public trust run shelters (14/18). Acknowledgement of the managers of financial support of the government to the shelters was associated with frequency of vaccination (OR = 10.23, 95% CI 1.34 – 78.15, p = 0.02). Those shelters that disagreed that government provided financial support were relatively more likely to vaccinate their cattle twice a year (5/13) than those who agreed that government provided financial support (3/21).

9.5.6 Attitude of managers to cow welfare and support for the shelter

Attitudes are presented as bar charts (Figure 9-2), with comparison between mean responses presented in Table 9-1. Most agreed that welfare was important to them (Table 9-1 and Figure 9-2), that they were willing to adopt measures to improve welfare, that feed was adequate and that they had made or intended to make welfare improvements. There was less agreement that their knowledge of animal welfare was adequate and that the local community morally supported the shelter. There was only marginal agreement that the local community morally and financially supported the shelter and that the government morally supported the shelter. There was no clear agreement that government financially supported the shelter.

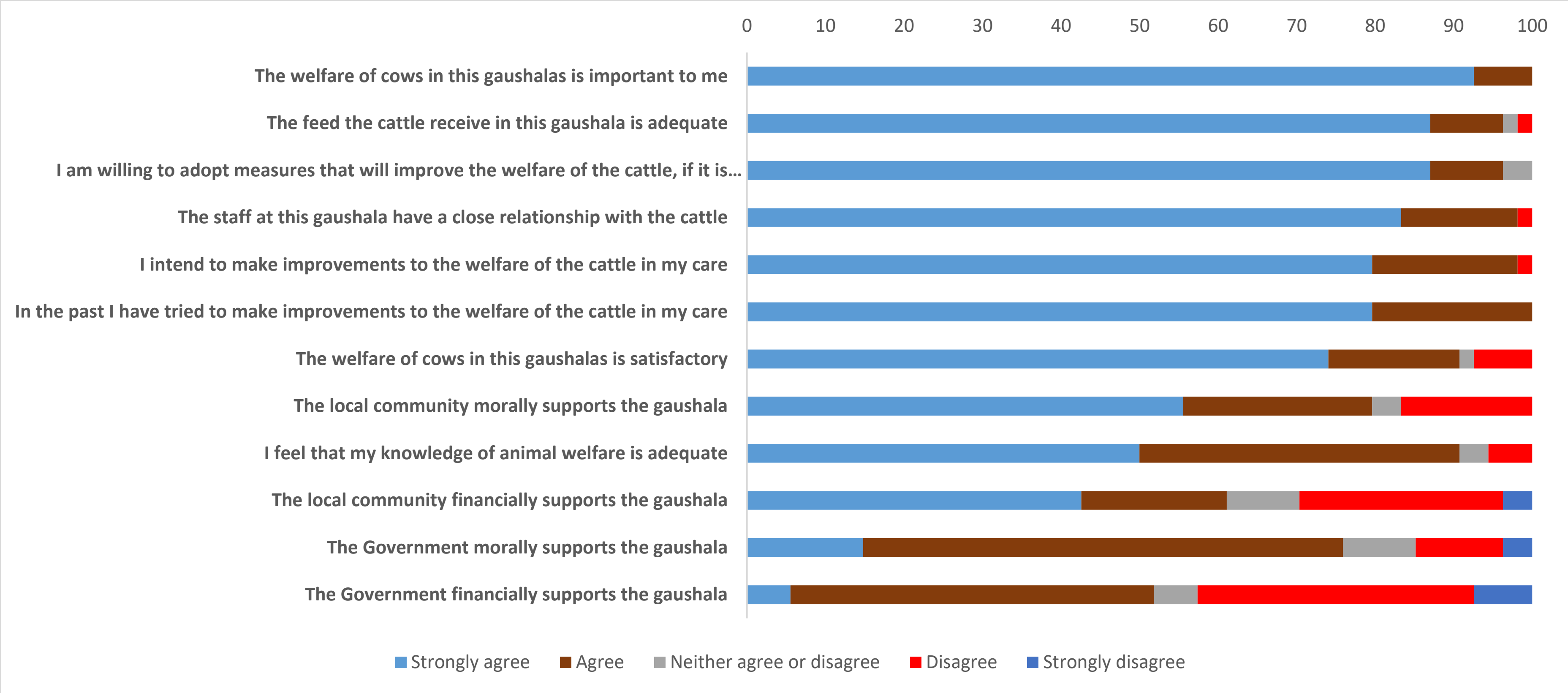

Figure 9-2: Perceived beliefs and attitudes expressed by 54 gaushala managers

Table 9-1: Mean responses to various attitudes questions posed to cow shelter managers on a scale of 1 strongly disagree to 5 strongly agree (r^2 = 31.4%)

Factor	Mean	SEM	95% CI
The welfare of the cattle in the gaushala is important to me	4.92[a]	0.035	4.70 - 5.14
I am willing to adopt measures that will improve the welfare of the cattle if it is provided to me	4.83[a,b]	0.063	4.61 - 5.05
The feed the cattle receive at this gaushala is adequate	4.81[a,b]	0.075	4.59 - 5.03
In the past, I have tried to make improvements to the welfare of the animals in my care	4.79[a,b]	0.055	4.57 - 5.01
The staff at this gaushala have a close relationship with the cattle	4.79[a,b]	0.071	4.57 - 5.01
I intend to make improvements to the welfare of the cattle under my care	4.75[a,b]	0.074	4.53 - 4.97
The welfare of the cattle in this gaushala is satisfactory	4.57[a,b,c]	0.117	4.35 - 4.79
I feel that my knowledge of animal welfare is adequate	4.35[b,c]	0.109	4.13 - 4.57
The local community morally supports the gaushala	4.18[c,d]	0.152	3.96 - 4.40
The government morally supports the gaushala	3.72[d]	0.133	3.50 - 3.94
The local community financially supports the gaushala	3.70[d]	0.184	3.48 - 3.92
The government financially supports the gaushala	3.07[e]	0.158	2.85 - 3.29

Means with different superscript differ significantly ($P < 0.05$) by Tukey's test

9.5.7 Qualitative Assessment

All the gaushala managers answered the open-ended question: What do you understand by the term 'welfare of cows'? Fifty word frequencies were developed from the responses (Table 9-2). Words that were found more than 8 times were as follows: care (n=27), mother (16), goddess (16), rescued (12), abandoned (10), feeding (9) and proper (8). The word cloud (Figure 9-3) generated emphasized the interrelated concepts: mother, care, goddess, abandoned and rescue.

Table 9-2: Word frequency count of the question 'What do you understand by the term 'welfare of cows'?

Word	Length	Count	Weighted Percentage (%)	Similar Words
care	4	27	16.56	care, cared, cares
mother	6	16	9.82	mother
goddess	7	16	9.82	goddess
rescued	7	12	7.36	rescue, rescued
abandoned	9	10	6.13	abandoned, abandonment
feeding	7	9	5.52	feeding
proper	6	8	4.91	proper
duty	4	4	2.45	duty
freedom	7	4	2.45	freedom, freedoms
religious	9	4	2.45	religious
watering	8	4	2.45	watering
dumb	4	3	1.84	dumb
heritage	8	3	1.84	heritage
protected	9	3	1.84	protected, protection, protections
slaughter	9	3	1.84	slaughter
five	4	2	1.23	five
granting	8	2	1.23	granting
service	7	2	1.23	service

Figure 9-3: Word Cloud for the question 'What do you understand by the term 'welfare of cows'?

9.6. Discussion

Gaushala management of gaushalas in the contemporary context is challenging and complex due to the regular influx of cattle of different age groups and varied health and body condition. The performance of the managers is under the constant scrutiny by the trustees/board of directors and the public due to the religious status of the cow in the Indian society and high expectations from the cow shelters in attending to the welfare of the cows sheltered in them. This study is the first to inform about the routine gaushala management and husbandry practices across the North Western, Northern and Western parts of India, which have the highest concentration of gaushalas in the country. Overall, several positive and negative aspects of welfare and management were identified that deserve the attention of all stakeholders for improving these traditional institutions to enhance their sustainability.

9.6.1 Human and cattle demographics

Mostly male workers worked in shelters as it is a full-time job and females were required to manage housework. Females more often worked in those shelters that provided worker accommodation within the shelter premises. As well, managing cow shelters is clearly a male-dominated profession, to add to the great imbalance in favour of male workers employed in the shelters. In a recent study on public attitudes towards cow shelters, males were more likely to credit shelters as being religiously important (Sharma et al. 2019c). Traditionally, decision making and managerial roles have been either denied or constrained for women in the animal husbandry sector in India due to the paternalistic bias of Indian society (Patel et al. 2016). Further, gender inequalities favouring males exist in access to information, ownership of land and livestock in Indian society (Thakur et al. 2001). The women are mostly confined to household work, including tending to livestock at home whereas the men work outside the homes to earn a stable income. The percentage of rural and urban backgrounds of the shelter managers was almost equal to the rural and urban population in the current demography of India (Bhagat 2011). The majority of the managers were in the age range of 46-65 years, had graduate and postgraduate qualifications and experience of working in cattle farms, which gives confidence in their maturity, education level and experience levels to handle the complex routine management of the gaushalas. The majority of them also identified their role as being team leaders supervising the workers.

The static nature of this survey does not reflect what is the dynamic process, with intake of cattle at regular intervals into the shelters all through the year, rather than tending to a fixed number of cattle. Managers' monthly stock records were made available on some shelters and revealed a regular influx of cattle through the year. Most of the milk produced was distributed free of cost to the workers working in the shelters by the gaushala managers. No discrimination was observed in rearing of male and female calves in the shelters and more than half of them were reared in the shelters to adulthood. Both male and female calves (almost equal numbers of each) were donated to the villagers nearby on demand. If they are sold, it is for a much lower price than market value, because of the risk of them carrying disease. Over time it is likely that male calves will be in less demand due to the gradual mechanization of agricultural operations (Fox 1999); suggesting that more male animals will be abandoned. Cows obtained as calves free or at low cost are more likely to be abandoned, hence it would be better to improve disease management in the gaushalas, which would then enable the calves to be sold at market price.

9.6.2 Health Management

The majority of the cattle sheltered in gaushalas are immunocompromised, and infectious disease-causing agents like Listeria sp., Streptococcus sp., Staphylococcus sp. and Corynebacterium sp., predominate due to the unhygienic environment prevalent (Kumar 2008; Ramanjeneya et al. 2019). Vaccination against FMD, Black Quarter, and haemorrhagic septicaemia was quite satisfactory in this study. However, 4% of the shelters did not vaccinate their animals at all, which is a concern as many diseases, particularly FMD, are enzootic in India, with recurrent outbreaks leading to economic and social losses (Subramaniam et al. 2013; Diaz-San Segundo et al. 2017; Sreenivasa et al. 2017). These shelters might be the potential reservoirs of the disease threatening the local cattle population. A positive role has been played by the government through State Animal Husbandry Departments, by distributing vaccines free of cost to the gaushalas, and in many cases offering veterinarians for the vaccinations. However, a high cost of veterinary services has reported as one of the constraints faced by gaushalas in a couple of Indian states (Patel et al. 2013; Bijla et al. 2019).

Vaccination and testing for brucellosis was rare and this could present a public health threat to the personnel working in the shelters and consumers, besides the sheltered cattle. There have been cases of Brucella positive cattle being culled by dairy farms and then sheltered in gaushalas (Singh and Bist 2009; Sharma et al. 2015). A study has found a 15.5% prevalence of brucellosis in gaushala cattle and 4.5% in the workers employed in the gaushalas (Singh et al. 2004b). None of the shelters were testing their cattle for tuberculosis, a zoonotic disease with considerable public health implications. There are chances of tuberculosis positive retired cattle being admitted to the gaushalas as tuberculosis is prevalent in both the organized and unorganized dairy sector in India, generating cows for the shelters (Singh et al. 2004a; Filia et al. 2016). Gaushala cows have been found positive for tuberculosis and have higher prevalence rates than organized and rural farms (Taggar and Bhadwal 2008; Srinivasan et al. 2018). India has the world's highest burden of human tuberculosis (Thoen et al. 2006) and the possible role of gaushalas in the zoonotic transmission of this disease is concern. Another disease of zoonotic importance, listeriosis has been isolated from gaushala cattle as the organism causing the disease is shed through faeces, vaginal secretions and can survive for prolonged time in harsh conditions, leading to increased risk of further transmission (Linke et al. 2014; Hurtado et al. 2017; Ramanjeneya et al. 2019).

Use of both endo and ectoparasiticides was practised in most cow shelters, though the frequency of application varied widely. The prevalence of tick infestation in gaushalas and unorganized dairy farms has been reported as 45% and 4% in the organized sector (Singh and Bist 2009). Besides, the ticks feeding on blood leads to anemia and loss of body condition (Jonsson 2006), and they transmit babesiosis, anaplasmosis and borreliosis (Ghosh et al. 2007; Surbhi et al. 2018). Deworming in this study was more common than previously reported in a localized study (Chandra and Kamboj 2019). A 44% prevalence of gastrointestinal parasitism has been reported in gaushalas in one part of the state of Gujarat (Hirani et al. 2006), and this state was also a part of this study. Gastrointestinal parasitism and lungworms reduce growth (Charlier et al. 2009; Choubisa and Jaroli 2013).

The lack of permanent veterinarians in the majority of shelters is likely to hinder management of sick cows and routine health initiatives. There is no requirement for mandatory veterinary attendance at gaushalas, and there is a shortage of field veterinarians in India (Weaver et al. 2019). However, most of the veterinarians employed with the state animal husbandry departments provide technical assistance to the shelters located within their jurisdiction.

9.6.3 Visitors to the shelter

Most gaushalas welcomed visitors, which suggests that they have an important social and religious function, however, this will also compromise biosecurity. Moreover, many shelters reported outbreaks of FMD in the last 5 years, which might be due to poor biosecurity, as the majority of the shelters vaccinated their animals against the disease. FMD is endemic in India, with vaccination and restriction of animal movements being the main control method (Pattnaik et al. 2012) as the virus spreads by direct contact with infected animals, fomites of workers, fodder and feeding utensils (Kandel et al. 2018). Unhygienic conditions and immunocompromised animals in shelters also contribute to a high prevalence of listeriosis (Ramanjeneya et al. 2019). These highly infectious, communicable and zoonotic diseases and biosecurity and screening protocols are very important to prevent shelters being reservoirs of these diseases.

Most of the shelters allowed feeding of homemade food to cows by the visitors after proper monitoring of the contents of the food. However, on special occasions, there were more visitors offering food to the cows, which might lead to gastrointestinal disturbances, e.g. ruminal acidosis or grain engorgement. Sometimes this is fatal. There are reports of shelter cows getting sick due to eating such food in excessive quantities or eating spoilt food (Kataria and Kataria 2009).

9.6.4 Cow mortality

Mortality rate in cows is an indicator of health and welfare. The median mortality rate of 13.8% was higher than for dairy cows on farms in Western countries, in which it ranges between 1 and 5% (Thomsen and Houe 2006). There is only limited data about mortality rates of dairy cattle in India from single states, ranging from 4-20% (Prasad et al. 2004; Yogesh et al. 2013; Uttam et al. 2015). There are no other estimates of mortality rates in shelter cattle for comparison, but it is expected that it would be higher than dairy farms as most of the sheltered cattle are old, debilitated and infirm. This was confirmed by the shelter managers who ranked old age as the biggest cause of death. Studies on dairy cows have found two times greater mortality in old cows (≥ 6.5 years) than young cows (< 6.5 years) (Faye and Perochon 1995; Stevenson and Lean 1998; Thomsen et al. 2004).

Post-mortems of dead animals in the shelters are advisable to identify possible causes of death but the logistics of disposal, availability of veterinarians and risk of zoonotic diseases may mitigate against them. Cows are often brought into the shelter in a moribund condition after sustaining automobile hits, being rescued from transportation to illegal slaughter houses or enduring a life of on the streets with a lack of adequate food and shelter. However, these were confirmed as less important reasons than old age as causes of mortality. Fodder shortages in overpopulated shelters may predispose cows to malnutrition, with competition for meagre fodder, such as poor quality straw. Overstocking increases aggression between the cows especially at the feed bunk, leading to injuries which may sometimes be fatal, as most of cows were found with horns in the shelters (Huzzey et al. 2006; Fregonesi et al. 2007b; Knierim et al. 2015). Therefore, segregation of animals on the basis of sex, age and body condition is recommended for their welfare.

Mortality also occurred following ingestion of plastic bags. Most of the cows are rescued from the streets, especially in urban gaushalas, where they are forced to scavenge on the plastic laden garbage in bins and refuse dumps. In one study 95% of stray cattle had gastrointestinal disorders following ingestion of plastic bags and other foreign bodies (Singh 2005). Plastic ingestion causes gastrointestinal disorders such as ruminal impaction, indigestion and tympany (Ramaswamy and Sharma ; Singh 2005; Tyagi and Singh 2012) and if not treated surgically can be fatal. Cows with plastics lodged in their stomach are immunosuppressed, making them susceptible to other infections (Singh 2005).

9.6.5 Routine management and waste disposal

Breeding of the cows in the shelters should not be encouraged as there is difficulty managing the increasing number of animals being admitted to the shelters. This concept might be a vestige of the past when shelters were encouraged as breed conservation centres by the Government

(Kachhawaha et al. 2015). But such indiscriminate breeding of cows observed in half of the shelters in this study if not checked can severely impact the cows' welfare due to overcrowding. Separation of calves from their mothers in 40% of the shelters is also a welfare concern. Conversely not segregating cows according to their age, body condition and length of stay in the shelters in one-third of the shelters could be a reason for aggression between the cows, leading to injuries that are at times fatal.

The access to pastures in 41% of the shelters is encouraging for cow welfare; most of these shelters were located in the rural areas, whereas the cows in urban shelters did not have the benefit of pasture grazing. Pasture grazing changes the physical environment of the cows, enables exercise, induces changes in diet routines and improves the health of the hooves. Pasture grazing helps cows recover from lameness and allows a more comfortable surface to stand upon and lie down (Hernandez-Mendo et al. 2007). It facilitates behaviours such as grazing, lying and resting and reduces aggression (Arnott et al. 2017). Access to yards is also good for welfare, though it cannot replace the advantages of pasture access. The exercise, interaction and exploration of environment that cows get through outdoor access to yards also improves claw conformation (Loberg et al. 2004). Exercise improves bone and hock strength and prevents hock injuries (Gustafson 1993), through improving circulation of blood to the limbs, enabling proper nutrition and oxygen to the horn tissues of the claws producing the horn (Christmann et al. 2002).

The sale, donation and vermicomposting of dung promotes organic farming, which is especially valuable in rural areas where farmers cannot afford to buy chemical fertilizers. However, this disposal was much less than the amount of dung generated but still useful because the land area is insufficient to absorb the quantity of dung. Mounds of excreta, bedding and fodder waste generated in the shelters are health hazards to the cows in the shelters, the workers and the public living in the vicinity. Improper management and disposal of such wastes, especially in limited spaces of urban areas, are public health and environmental risks (Morse 1995), contributing to point and non-point sources of environmental pollution (Ongley et al. 2010). The offensive smell of the animal waste generated is due to the decomposition of microorganisms; releasing noxious gases such as ammonia, carbon dioxide, hydrogen sulphide, and methane that adversely impact on human health (Copeland 2010). There are a number of parasites in cattle dung which can be transmitted to other cows and to humans handling it (Strauch and Ballarini 1994; Utaaker et al. 2018). Cryptosporidium and giardia are two intestinal protozoan parasites with zoonotic potential that have been found in cattle in shelters and roaming in streets (Utaaker et al. 2018). The dung breeding flies are potential sources of transmission of diseases and parasites in humans and animals (Peter et al. 2005; Baldacchino et al. 2013).

Urine was used in a quarter of the shelters for processing into traditional medicine or as a biopesticide for crops. In traditional Indian medicine, cow urine is claimed to cure many chronic human health disorders (Saunders 1982; Jarald et al. 2008; Kekuda et al. 2010; Gururaja et al. 2011; Mohanty et al. 2014). It has also been used as a bio-enhancer, increasing the nitrogen content of the soil, and as a bio-pesticide through its larvicidal action on fodder crops (Bharath et al. 2010; Randhawa 2010).

9.6.6 Disaster, human resource and financial management

Disaster management plans for shelter should be present, but were mostly not. As cattle sheltering increases in India new shelters might be established in areas that are uninhabited by humans such as near creeks or around forests, with their attendant flood and fire risks, in which case disaster management plans will be critical.

The availability of workers in large cow shelters has not been an issue, but small shelters sometimes encounter this problem (Chandra and Kamboj 2019). Induction training of workers was reported in two-thirds of the shelters, but is an informal training; most managers felt that workers had prior experience of working with cows when they were from rural areas. This is an area of shelter management that requires attention as managing cows in shelters is different from dairy cows, as the former are malnourished and often in poor condition when rescued from streets. They need additional and humane care as they often have a fear of humans due to previous neglect and ill-treatment on the streets by humans. Therefore, a dedicated worker induction programme is important for improving the human-animal relationship in the shelters. It should not be just skill-based training but aim at behaviour modification of the workers. Research has shown that training of stock persons improves beliefs, and better behaviour towards animals improves their welfare (Coleman and Hemsworth 2014). Cows are venerated by the Hindu population, hence there should be an increased emphasis on the competency levels of workers to care for the cows in shelters. Animal enrichment measures in some shelters may have helped cows to cope with stress (Mandel et al. 2016) by improving biological functioning, reducing frustration, and fulfilling behavior needs. However, enrichment efforts fail if the changes effected in the cows' environment have little practical significance to the animals, are not goal-oriented and are based on incorrect assumptions of causation of problems (Newberry 1995). Environment enrichment requires finances and time, both of which are often deficient in the shelters.

The maintenance of records was variable; feed records were probably the only well-maintained records in the shelters because feed consumption involved the biggest expenditure. Maintenance of records of mortality, calving, veterinary treatment, medicines, and sales should be made mandatory for all shelters and uniformity of recording is needed in order to collect and analyze data for performance analysis, auditing, interventions by advisory services and for future planning. Volunteering (regular or occasional) by the public, at least in half of the shelters, shows the connection of the people to the shelters either due to veneration or simply for animal welfare. The outreach activities organized in the majority of the shelters focused on religious festivals ascribed to the ‘holy cow’, which could promote more volunteering. Teaching the religious scriptures on the holiness of the cows in ancient texts narrating the works of the saints might influence the spirituality of the attendees. However, a more proactive approach to shelter management with advertisements for volunteers will further enhance participation of the local public in shelter management.

The ancient nature and connection of most of the shelters with three main religions in India (Hinduism, Buddhism, and Jainism) proves the religion-driven concept of sheltering cows. The reliance of shelters on private funding or charitable societies or trusts confirms the findings of Bijla and Singh (2019). Almost all shelters audited their funds annually, reflecting their accountability to the donors. This could be why less than half were affiliated with the AWBI, as they were not financially dependent on AWBI to function. However, AWBI is a statutory government body established as a watchdog of animal welfare all over the country and has affiliated shelters. Implementation of this as a mandatory requirement will be important to bring about uniformity in the management of cow shelters up to modern scientific standards of animal welfare, which should be determined by welfare auditing.

Most of the shelters reported higher expenditures than incomes but some were reluctant to share the exact figures of the finances. Feeding incurred the maximum expenditure which corroborates the findings on the only economic study of cow shelters, in one state of India (Bijla and Singh 2019). Positive returns were reported by these researchers as the shelters were able to meet their operating costs in their study, in contrast to the present study, though the median annual income by shelters was approximately similar to the cited study. The reason for this could be the active support of the Government of that particular state to support self-sustainability in its cow shelters, through the sale of milk and other products. The shelters studied in this study were mostly functioning as rescue homes without any economic returns, a function of selection criteria of this study.

Most agreed that welfare was important to them (Table 9-1), that they were willing to adopt measures to improve welfare, that feed was adequate and that they had made or intended to make welfare improvements. There was less agreement that their knowledge of animal welfare was adequate and that the local community morally supported the shelter. There was only marginal agreement that the local community morally and financially supported the shelter and that the government morally supported the shelter. There was no clear agreement that government financially supported the shelter.

9.6.7 Associations between shelter administration, affiliation, income with health and welfare of cows

The shelters affiliated to the AWBI revealed of trend of garnering more income. It could the existence of a proper managemental structure in such shelters that might encourage the public to donate money. Moreover, AWBI also provides financial and material assistance to its affiliated shelters regularly. The positive association of mortality rate with milk yield might be due to more attention of the shelter management to the dairy cows for milk production and sale than the non-productive ones, leading to the neglect and deteriorated health of the latter. High mortality rate in shelters that had in house veterinarian could be due to the high admission of cattle into such shelters. The high intake and thus numbers of cattle might force the shelters to hire a permanent veterinarian to cater for the upkeep of the health of the larger cattle numbers rescued from streets and slaughter. Similarly, shelters run by public trusts had significantly better biosecurity measures for newly admitted cattle than those run by charitable societies. This might be due to shelters in the public domain being more open to public scrutiny and accountable. The shelters that did not acknowledge financial support of the government were more likely to more frequently vaccinate their cattle than those that agreed that the government financially supports them. This relationship could be misleading because the government invariably provides free vaccines to all shelters in order to prevent the spread of diseases from shelter animals to the farmer owned animals. A possible explanation could be that such shelters might be financially sound and hence more efficient in safeguarding the health of their cattle.

9.6.8 Attitudes of shelter managers

All the shelter managers had a high opinion about the adequacy of the welfare of cows, their own work and the human-animal relationships in their respective shelters. However, almost all of them were open to adopt measures to improve the welfare of cows under them and believed that they had made improvements towards cows in their shelters. Animal welfare and public livelihood are interconnected in India (Sinclair and Phillips 2019) and the role of managers in cow shelters is one of such manifestations. The majority of the managers were Hindus from rural backgrounds, having grown up around cows with respect and reverence for cows in their religious beliefs. This could be the reason for many believing themselves to be knowledgeable and taking good care of the welfare of cows in shelters. Animals such as the cow which humans perceive as attractive are shown more empathy (Gunnthorsdottir 2001; Serpell 2005). However, scientifically supported and prescribed guidelines for cow welfare might not be known to the managers. There is a willingness of stakeholders to improve animal welfare, based on science in India (Sinclair and Phillips 2019). Most shelter managers acknowledged the moral, and to a lesser extent financial, support provided by the public. However, even though moral support by government was generally acknowledged, their financial support was acknowledged by only half of the shelter managers. In this study, government provided most of the fodder (straw) and vaccination against endemic diseases. This might not be construed as financial support by managers but can offset a major part of the running costs of the shelters. Similarly, volunteering by the local people can offset labour costs.

The analysis of the qualitative assessment indicated that, despite earning their livelihood through the management of the cow shelters, the managers held the cows in high esteem - as a mother goddess which must be properly cared for and should be rescued from abandonment as a part of their religious duty. The word query and count results defined the status of the cow and the concern of the managers for its abandonment and its proper care after rescue from slaughter.

9.7 Limitations of the study

The random selection of the shelters based on the suggestions from the AWBI, veterinarians from the states covered in the study and snow-balling might generate selection bias as shelters with different levels of welfare and size were studied. There is a possibility that managers might have tried to report to the researcher answers that the researcher wanted. However, the face to face interview technique has less chance of false reporting than other techniques of data collection. It is also possible that 54 shelters in six states were not representative of all the shelters in India but logistical, time and financial constraints made us select a statistically viable sample to report the contemporary situation of shelters in the states which had a tradition of sheltering, and a state, Himachal Pradesh, where there was a government initiative to open new cow shelters.

This research is the first survey of contemporary cow shelter management through a cross-sectional study, which has its inherent limitations and biases. More studies are required to find out the regional differences, issues and constraints in the management of cow shelters in all states of India. Longitudinal studies should also be undertaken to observe the effects of government interventions on the strengthening as well as opening of shelters. Economic analysis of the sheltering of cows also needs more in-depth and focussed studies.

9.8 Conclusions

Managers are very important stakeholders in the welfare of cows in shelters. They are in an ideal position due to their work profile and experience to identify the problems and constraints regarding the routine management of shelters. Therefore, their engagement in all initiatives to improve welfare of cows in shelters is vital for the perpetuation of the sustainability of these unique traditional institutions. A greater role of women in management positions is desirable in the management in shelters as research has demonstrated greater empathy of women than men towards animals (Herzog et al. 1991; Powell and Bullock 2014). Sheltering of cows is a dynamic process, with abandoned and rescued cows regularly entering the shelters. Biosecurity measures in the shelters do need enhancing, to prevent shelters becoming reservoirs of infections, parasitism, and zoonotic diseases. Specific shelter protocols need to be formulated at a national level and enforcement of compliance of these protocols ensured through a central governing body. A greater involvement of qualified veterinarians would benefit the management of animal health. There was evidence from this study of involvement of permanent veterinarians in shelters that witnessed high mortality rates. This also suggests increasing cow numbers in shelters in future would invariably need in house veterinarians to cater to the health needs of the sheltered cows, but that this might not necessarily prevent an increase in mortality rate.

This study identified various welfare issues through the survey of shelter managers that can be resolved by managemental initiative and intervention. Indiscriminate breeding, lack of access to pasture and tethering of cows are the welfare issues that demand a comprehensive policy regulation encompassing all shelters in the country. Proper and complete disposal of dung and urine needs attention as due to increasing cow numbers as well as shelters, this poses a public health risk. Feeding of cows by visitors needs routine monitoring. A uniformity in the maintenance of all records in all shelters throughout the country is important. This will help in welfare interventions, support, auditing and feedback for all stakeholders. Mandatory affiliation of all shelters to the AWBI should be implemented, given its statutory role as an advisor and watchdog of animal welfare in the country. Evidence of shelters affiliated to AWBI being able to generate more income in this study also justifies the above recommendation. Cow shelters can become educational centres for animal welfare through the utilization of their outreach among the public. Shelters run by public trusts were more vigilant towards biosecurity measures than those run by charitable societies. This suggests value in further strengthening of public trusts in cow shelter management, and that ensuring better compliance to biosecurity protocols in shelters runs by charitable societies would be a worthwhile aim. Shelter management need to understand that vaccines entail a huge financial cost to the government, as they are provided free of cost to the shelters along with logistic support by government veterinarians and support staff. This, if accounted into financial terms is a strong support from government to the shelters, which is unfortunately not recognised by many shelter managers.

Welfare centric training of managers and workers should be easily implemented, as all the managers were willing to accept suggestions to improve the welfare of cows in their respective shelters. Training of managers and workers in modern scientific concepts of welfare-based management of cattle will lead an excellent amalgamation of science and tradition to sustain this institution of sheltering cows, which signifies perpetuation of some traditional ethos of Indian society towards cow welfare.

Chapter 10

General Discussion and conclusions

10.1 General Discussion

10.1.1 The relationship to published literature

Most of the published literature before the start of this study dealt with the philosophical and religious aspects of the sheltering of cows. There is a considerable amount of literature dealing with the historical aspects of cow shelters especially about the advent of the veneration of the cows and the historical journey of this concept from the ancient times to the present (Heston 1971; Simoons 1973; Simoons 1978; Korom 2000; Lodrick 2005; Jones 2007). There are few works that to a very limited extent report the welfare situation of the cows in shelters (Lodrick 1981; Harris 1992) that are not contemporary works. Most of the recent literature on cow shelters and cows are critical commentaries on the holiness of the cows, their sheltering and, the impracticality of cow slaughter and beef bans in India (Gupta 2001; Chigateri 2008; Sarkar and Sarkar 2016; Narayanan 2018). These works seem to be motivated by media reports of mob lynching of individuals involved in illegal slaughter of cows. Studies point out that gaushalas are sites of mobilization of Hindu fundamentalism for exploitation and oppression of cows to sustain animal production for human consumption (Narayanan 2019a). Animal sanctuaries should be able to advocate for good cow welfare through highlighting their biological, ecological, psychological, social, political and cultural vulnerabilities (Deckha 2015).

Some studies on the shelters were reports on the various vaccines trials conducted on shelter cows or testing of cows for zoonotic and infectious diseases like Brucellosis, Tuberculosis, and Listeriosis (Singh et al. 2004a; Singh et al. 2004b; Singh and Bist 2009; Sabia amd Saxena 2014; Singh et al. 2015). Few studies report on the parasitic burden and fungal infections in the sheltered cows (Hirani et al. 2006; Kumar and Sangwan 2010; Sharma et al. 2010). Recent studies have highlighted the constraints faced by shelters based on a survey of the managers (Kothari and Mishra 2002; Kachhawaha et al. 2015; Mandi et al. 2018; Bijla et al. 2019; Chandra and Kamboj 2019). The constraints identified in these studies were lack of adequate space, good quality fodder and concentrate ration, green fodder, proper disposal of carcasses, affordable veterinary care, paucity of qualified veterinarians, separation of males and females and separation of weaker cows from healthier ones. These constraints are in agreement with the findings of the present study. Reproductive diseases have also been found highly prevalent in gaushala cows (Yadav 2007). Lack of financial support by the government in running the shelters pointed out in previous studies was also identified as a constraint in this study that affected the improvement in infrastructure of the shelters for proper running of the shelters routinely. However, the shelter managers acknowledged the government assistance in the form of free dry fodder, free vaccines and veterinary assistance through government employed veterinary professionals. This Governmental support if quantified in financial terms constitutes considerable support to the shelters. All these past studies were confined just to one state and the cows housed in the shelters were not physically and clinically examined as done in the present study. These studies were confined to the analysis of information gathered from the surveys of the managers.

There is a lacuna of literature on the welfare assessment of cows and cow shelters based on the measurement of various resources: animal, management, and environment- based indicators that are the basis of animal welfare assessments done all over the world. The welfare indicators selected for this study were chosen from the welfare assessments conducted on dairy cows in different parts of the world, the Welfare Quality® project protocol being the main source (*Welfare Quality® assessment protocol for cattle* 2009). This protocol was chosen because it is the most comprehensive work on cattle welfare assessment extending across different countries in Europe, devised by cattle welfare experts as a team and has been validated over a period of time in different countries under different conditions. The assessment protocol devised in this study also had inputs of the various stakeholders involved in the welfare management of cows in the shelters, through a day-long stakeholder meeting organized prior to the start of the study. Most of the assessment parameters were found to be relevant in the welfare assessment of cows in shelters. However, due to the constraints of time, behavioural assessments were just limited to the evaluation of human-animal relationships through the assessment of avoidance distance and access to pasture. This study did not evaluate criterions such as expression of agonistic behaviours and positive emotional state through a quality behaviour assessment due to low feasibility in a cross-sectional study. The animal-based assessments consume much time and quicker methods are lacking (Waiblinger et al. 2001). Moreover, most of the studies on dairy cattle focussed on assessment of production parameters to assess welfare, as the performance of the animals reveals their internal state. In sheltered cows, the production parameters are not relevant as these cows are not meant for production and achieving the ‘five freedoms of animal welfare’ (Webster 2001) is the sole goal.

There was a wide variation in the herd size of cows in shelters in contrast to somewhat uniform sized dairy cattle herds assessed in Western countries (Napolitano et al. 2005; Krawczel et al. 2008; Plesch et al. 2010; de Vries et al. 2013c). Scientists have indicated low feasibility and applicability of indicators of positive behaviour in welfare assessment of dairy cattle (Napolitano et al. 2009) as some of the behaviours are applicable in younger animals only and the recording of behaviours like social licking is time consuming and a problem in determining the exact periods of recording at different farms without bias. Research on using Quality Behaviour Assessment (QBA) as a whole animal approach by evaluating demeanor of dairy cattle has limitations as an isolated welfare assessment tool (Andreasen et al. 2013). In the present study, demeanor of the cows in the shelters was also assessed on the premise that good welfare is not about animal contentment but also about lack of anxiety. Most of the welfare assessments have concentrated either on the animal-based (Whay et al. 2003a; Rushen et al. 2007; Rushen et al. 2012; Vasseur et al. 2013) or resource-based measures (Waiblinger et al. 2002) and very few assessments (Beggs et al. 2019) have combined the two approaches for a holistic assessment of the welfare situation in a particular set up. This study combines both the animal as well as resource-based welfare measures to assess the overall welfare of cows in shelters.

In addition, this study also analyzed the attitudes, views and concerns of the stakeholders involved in the sheltering of cows to present an integrated contemporary approach to cow shelters in India. Thus, the welfare situation in the shelters was explored through a multi-dimensional approach. Public input is needed in the development of a socially sustainable sheltering of cows, especially in a society that venerates the cow. Shelters are also witnessing a drift from their roles of breed conservation and milk production to primarily focusing on the sheltering of old, unproductive and abandoned cows in wake of the overpopulation of such cows in the streets. This has led to a huge increase in the number of animals per shelter (herd size), stocking density and labour costs (Valpey 2020). The strain on the resources has ultimately increased the risk of adverse welfare conditions in shelters. The quantity (number of cows) has taken precedence over the quality of welfare. Culture, religion and human demographics are some of the key drivers of attitudes of the general public towards animals (Phillips et al. 2012). The influence of human ethical and religious ideologies on animals and animal welfare in developing countries has rarely been investigated (Su and Martens 2017). There are many studies on attitudes of local public towards wildlife conservation and wild and zoo animals (Saberwal et al. 1994; Gurusamy et al. 2015; Mir et al. 2015; Kamble et al. 2016) but no such study was found on human-cow relationship in the contemporary Indian context. Traditionally shelter management and the government have also focussed on milk production and breed conservation in shelters along with serving as rescue homes. But, the present times require the shelters to exclusively reinvent themselves exclusively as rescue homes and sanctuaries in order to address the present societal needs and concerns. The present study is the first one to survey public attitudes towards cows and cow shelters in which human demographics, religiosity and attitudes were identified as key drivers of such attitudes. The survey of the attitudes of two important stakeholders in the sheltering of cows: the general public and the shelter managers, in this study is an endeavor to build a constructive communication channel to collectively work for the welfare of cows to sustain these traditional institutions. Such studies can be significant as the majority of these shelters are dependent on public donations. Understanding the factors influencing public attitudes is essential for devising strategies to improve welfare of cows in shelters and to alleviate the human-animal conflict due to the overpopulation of street cows.

10.1.2 Major limitations of the work

The major limitation of this work is that it is a cross-sectional study that informs about the welfare situation in the shelters at a point in time. Cross-sectional studies have an inherent limitation of not being able to confirm a causal relationship between the various variables in a multivariable analysis of data. These studies provide some insights into the association of various variables that need validation through further longitudinal studies. The repeatability, reliability and validity of the various indicators measured in this study need to be tested over time by different assessors in different cow shelters. The inter-observer reliability and repeatability are important parameters to test the validity of the welfare indicators over time and in different situations. In this study, there was only one observer recording the observations on the cows. However, in order to guarantee the repeatability and validity of these protocols for future welfare assessments, assessors must be trained to run the protocol on a routine basis. The inter-observer reliability and repeatability should be matched to the laid down standards for such assessments, before the commencements of on-field welfare assessments. Periodic testing of the inter-observer reliability and repeatability during the course of field assessments will be needed to maintain their validity. Further research is also required to further investigate the risk factors to the optimum welfare through the association of various parameters over a period of time.

This study might not be a representative of the entire country as only six states were covered in this study. Finances and time were the major constraints to expand this study to the whole country. Care had to be taken to avoid disturbing the work routines of the shelters and availability of the shelter workers for assistance in the measurement of parameters on the cows consumed a lot of time. Limited behavioural assessments were feasible due to time constraints because behavioural studies require dedicated time for recording the behavioural parameters even if it is an automated recording. Research has shown that behavioural studies are becoming more relevant and more valid for welfare assessments as they analyze the response of the animals to the welfare situation provided to them and reflect the animals' overall state and its experience (Wemelsfelder et al. 2001; Wemelsfelder 2007). However, behavioural assessments require time for monitoring of the behaviours, and longitudinal studies are vital for assessing the behavioural changes due to the changes made in the welfare situation.

The animal-based measurements also consume a lot of time (one full day in sampling 30 cows/shelter). However, animal-based welfare assessments are considered more valid as animal -

based indicators are manifestations of responses of the animals to the resources and environment provided to them. Precision and accuracy in measuring these animal-based measures are important for valid assessment (Croyle et al. 2018) and that takes time. A two-day course on low stress livestock handling and a three-month training was underwent in scoring the cows for assessment of various welfare indicators, at the School of Veterinary Science, The University of Queensland. The sole assessor in the measurement of all animal-based measurements might provide consistency to the results in this study but their repeatability and validity need to be studied in future studies through a number of assessors. Moreover, the animal-based indicators have an inherent weakness that they provide a point estimate of the prevalence of a condition on animals on the day of examination and might not be representative of all times of the year. Therefore, longitudinal studies are advocated. The resource-based parameters are applicable for longer time periods but the issue is that the resource might not be used even if present.

The survey of the general public residing around the cow shelters also consumed a lot of time as study prerequisites were of not including respondents who or their family members were working in the shelters, whilst including only ones residing within a 1km radius of the shelter. Approaching and convincing women and their family members in a typical rural setting in India where patriarchal hierarchy exists and females are not allowed to talk to strangers were big challenges in the study. Furthermore, interviewing female respondents in the absence of male members in order to avoid prompting for maintaining the authenticity of the interview affected the time budget of the study. Random selection of only those respondents who lived near the cow shelters for the public survey might have induced a bias in the study. This was done with the intention of getting information from individuals who had the opportunity to visit the shelters. There are chances that respondents might have not expressed their true feelings about cow shelters due to the face to face nature of the survey and the prevailing atmosphere of cow vigilantism in the country. Still this method of survey is considered better for minimizing false reporting. Eight hundred and twenty-five respondents in 6 states of India might not be representative of the attitudes of such a big country as time, logistics and finances will always be the limitations. Online surveys have their limitations in India due to the lack of access to computers, computer literacy and reliable network connectivity for the general public.

Managers' survey from 54 cow shelters, though statistically valid, might not be representative of the situation of cow shelters of the entire country as regional differences in the management and constraints might exist. Differences in the management and constraints might occur due to affiliation or non-affiliation of the shelters to the AWBI. Shelter managers might have overstated their knowledge about cow welfare and animal-based performance of their shelters to impress the interviewer.

10.1.3 Summary of the most important new findings

This is the first study to comprehensively study the contemporary welfare situation of cows in shelters based on the scientific welfare assessment using animal, resource and environment-based welfare parameters. The strength of this study lies in a large number of cows examined (1620) in shelters over a wide geographical spread across 6 states of India utilizing a comprehensive set of animal and resource-based indicators. Contrary to the general belief that the welfare of the cows in the shelters is highly compromised and cows suffer from poor welfare practices and conditions, varying levels of welfare was observed in this study. Small space allowance per cow, non-uniform flooring of shelters' sheds, little freedom of movement, lack of pasture grazing, lack of bedding, absence of ad libitum access to drinking water, less quantity of green fodder availability and compromised biosecurity were the major welfare concerns. Flooring is considered a vital component of welfare in a cow holding facility and is included in all welfare assessments in different parts of the world. The development of an easy, affordable and quick method to assess the friction of the shelter flooring is an interesting innovation in this study that can be replicated in future assessments of this important welfare indicator. The coefficient of friction calculated through this method ranged from 0.3 to 0.7 across range of floors, with lowest for concrete and highest for earthen floors. Moreover, results of the univariate and multivariable analysis in our study identified the risk factors associated with floor friction and confirmed that coefficient of friction of flooring affects welfare.

The prevalence of lameness in cow shelters (4.2%) was comparatively less than the conventional dairy herds in India and the western countries. Lameness in sheltered cows was significantly associated with body condition, the dirtiness of udder, hock joint ulceration, carpal joint injuries and claw overgrowth. Lack of bedding and increased gradient of the floors were also associated with lameness. Undertaking steps to improve cleanliness, flooring and nutrition of cows that might be the causes of these risk factors should help to reduce lameness in shelters.

Assessment of the long term stress levels in sheltered cows through the analysis of hair cortisol concentrations is novel approach undertaken for welfare assessment. Few studies have been done on this parameter and none studied the association of hair cortisol with other welfare parameters. This is a unique study that also explored the association of hair cortisol levels in sheltered cows with the animal and resource-based welfare parameters. Low cleanliness levels, the lower ambient temperature in the shelters and little access to shelter yards increased stress levels in cows. Similarly, at cow level, dirtiness, lesions on the hocks, carpal joints and other parts of the body, dehydration, old age and low feed intake were positively associated with increased hair cortisol concentrations and indirectly with raised stress levels. This study indicates that hair cortisol is a promising biomarker to assess long term stress in cattle and has application in field-based welfare assessments.

Assessment of human-animal relationship in the cow shelters was an important parameter in this study. The existence of cow shelters today is due to the concept of compassion and non-violence towards cows as they are accorded holy status by the Hindu majority population of India. Moreover, traditional Indian farming involves close contact of humans with animals. Avoidance distance is the measure of this human-animal relationship and in this study it assessed whether the cows are humanely treated in the shelters by the stock persons. A positive relationship was observed as majority of the cows (84%) in shelters allowed the assessor to touch or approach within 50 cm distance. The association of this parameter with dirtiness, limb joint and body lesions, hair loss, fullness of the rumen, body condition, diarrhoea, respiration rate and body coat condition demonstrates the multidimensional concept of welfare. This study demonstrated that human-animal relationship is also related to the health of the cows making it relative to the state of the cows in shelters. Overall, this study found a cordial human-animal relationship in the shelters.

Literature search revealed no attempt before this study to solicit attitudes of the general public about cow welfare and cow shelters in India. This study provided valuable insights into the attitudes of the general public and identified potential areas of concern about cow welfare and cow shelters. Survey of public attitudes outlined significant demographic differences in terms of age, gender, marital status, income levels, education levels, religiosity level and place of residence. Public perception centered on proper care of cows in shelters, being mother goddesses and gaushalas being the best place to shelter abandoned street cows. The majority of the people visited shelters for religious reasons. Older people were more likely to identify animal welfare and culture as the main reasons for sheltering cows. Wealthier, more educated and more religious people visited the shelters the most and rated religion and breeding as the main purpose of shelters. Indigenous breed cows found more favour from males than females. Village respondents were more likely to facilities provided to cows in shelters adequate, in comparison to country town and urban respondents. Single people were more likely to visit shelters for leisure than for religious purposes, in contrast to married ones. Overall, the Indian public was supportive of sheltering of the cows and visit to the shelters helps them to know about the care of unwanted cows. The general public still holds an ethic of reverence to the cow as mother goddess that included their proper care in shelters. Attitudes and inputs of general public are needed to induce policy development and changes on animal welfare (Groot Koerkamp and Bos 2008; O'Connor and Bayvel 2012). Understanding public attitudes is important for the development of welfare sustainable sheltering systems in view of the street cattle population being faced all over the country. Persistence with the practices inconsistent with public expectations and welfare principles might undermine social sustainability and acceptability of these traditional institutions.

Management of cow shelters is was almost totally male dominated, with half of the managers being university graduates or postgraduates in the age range of 45-65 years. Vaccination against most endemic diseases and ecto-endoparasiticidal treatments were routinely practiced in most shelters. The annual mortality rate was 13.8% and old age was the main cause of mortality. Limited biosecurity measures were in place and animal waste disposal (carcasses, dung, urine, slurry, left-over foodstuff) was a big concern. Overall a limited access to pastures was available in shelters, though access to yards was available in 80% shelters. Breeding of cows was prevalent in most shelters and sale of milk was undertaken in few shelters. Public donations were the highest source of income for running the shelters.

A highly relevant finding in this study was the lack of uniformity in record keeping in most of the cow shelters. This might be due to the absence of general guidelines about record keeping from the AWBI, absence of affiliation of the shelters to AWBI or simply non-compliance. Uniform maintenance of records in cow shelters all over the country will be able to generate data to identify many animal and resource-based risk factors to the welfare. It will also help in recognizing managemental gaps and other constraints affecting the cows in shelters. Welfare auditing can be made reliable, robust and valid for feedback to the stakeholders for subsequent actions and interventions through proper maintenance of records.

10.1.4 Considering changes to future studies of this nature

Before the commencement of this study, there was no study on the assessment of shelters based on the measurement of welfare indicators. Due to the absence of scientific information on the contemporary welfare in cow shelters, a large number of animal, resource and environment-based welfare indicators were selected and measured in the shelters. This was time consuming and costly. The number of indicators could be reduced, as it is pointed out that in epidemiological studies fewer predictors obtain a good fit in multivariable analysis although their biological plausibility is essential (Dohoo et al. 2009b). Lack of empirical studies lead to the inclusion of larger number of parameters in the protocol. However, this enabled the achievement of a comprehensive assessment of the welfare situation in the cow shelters. Yet again due to time constraints, lack of knowledge about public motivation on this topic and type of respondents, more open-ended questions could not be included in the managers' and public surveys. This might have restricted the inclusion of diverse opinions and attitudes of the respondents.

10.1.5 The practical implications of the work

Welfare assessments based on welfare indicators are reliable monitoring strategies of the welfare situation in animal facilities. Welfare assessment of cows in traditional shelters where cows having no economic utility value presents a unique scenario. The goal of this study was to assess the contemporary welfare situation in the cow shelter through the development of an on-field welfare assessment protocol. The descriptive analysis has highlighted the good and bad aspects of welfare of the cows in shelters. The good welfare aspects are to be maintained and the bad welfare aspects need to be corrected. Multivariate analysis was done to understand the relationships between one or more variables and the outcome of interest that might be causal relationships. Precise estimates of the coefficients of the variables of interest were obtained taking into consideration the interaction and confounding effects. This analysis has shown risk factors to some cow health parameters that might have overall implications on the welfare of cows in shelters. The welfare indicators selected in this study should be further studied in future interventional and longitudinal studies to confirm and strengthen the relationships identified.

This study provides a possible roadmap on how to assess and improve the welfare of cows in shelters based on the contemporary concepts of welfare-based scientific management principles on a comprehensive, uniform and routine basis. This will ensure welfare auditing and ensure tailor-made solutions to support welfare reforms relevant to the current welfare scenario in the shelters.

The welfare issues and risk factors identified in this study have revealed the vulnerabilities in the welfare-based management of shelters that might evoke mass public and societal concerns in the long run, if not addressed. This study should stimulate government to initiate practical welfare assessments in the shelters all over the country through an animal welfare science-based approach. The strengths and weaknesses of sheltering of cows can be identified and the potential risk factors affecting the welfare of cows evaluated to initiate corrective measures and long term Improvement strategies. Furthermore, the impact of improvements done by the shelter managements based on the feedback of the welfare assessments can be reassessed to prove the practical relevance of the assessment protocol.

The direct relationship of the general public with the shelters, being one of the largest sources of donations, their attitudes and perceptions as driving forces for improving welfare of cows cannot be overlooked. This study has shown religious and cultural veneration of cows by the public will continue to exercise influence on the sustainability of the shelters. Improvements through welfare science-based assessment feedback mechanisms can spell more active support from the public for a paradigm change in sheltering of cows. The cultural and attitudinal barriers identified in this study suggest adoption of science-based management of shelters for solution of welfare concerns that may have societal acceptance. The authors of the study also recognize the need for effective strategies for communicating welfare standards to the public in order to raise their awareness about animal welfare and bridge knowledge gaps to enable a critical assessment of the working of shelters. The public and manager surveys reveal that there is a need for an intensified dialogue amongst all stakeholders to have a critical, scientific and practical approach towards management of cow shelters to accommodate societal concerns. These measures can ensure the social sustainability of these traditional institutions.

This study should also facilitate the building of consensus between the stakeholders on welfare issues in the cow shelters. This study aims to achieve basic cow welfare in shelters. Record keeping needs improvement in order to make information accessible in the public domain for transparency, welfare auditing and accountability. Media coverage of compromised welfare of cows in shelters has been intense in recent times and has raised public concerns on cow welfare. The public being a major stakeholder in cow shelters, through their financial support, their perceptions might get influenced by these reports. This demands more transparency in working and continual improvement in the welfare of cows in cow shelters to ensure sustained support to this unique concept of prevention of animal wastage. Providing credible assurance that the cows are well looked after in shelters, through these routine welfare assessments will boost the confidence of the stakeholders to improve the social sustainability of these institutions.

10.1.6 Future work that needs to be done and how can that build on this study

The religious value of the cows is influenced by the culture within the Hindu society. This status of the cow as a mother goddess has to be realized in the true sense by ensuring its welfare in the cow shelters. The welfare of the cows in the shelter can be compared to the social pillar of sustainable development (von Keyserlingk et al. 2013) as it includes human and cultural values. These values are affected by culture (Boogaard et al. 2011). In the context of socio-cultural pillar, the sustainability of cow shelters deserves scientific interventions. The socio-cultural pillar of sustainability has been given importance in scientific discussions especially when societal concerns were raised about the intensively housed animal production systems (Thornton 2010; Mench et al. 2011). The present study can be a benchmark on which further studies on welfare assessments in shelters can be built upon. A standardized methodology for assessing welfare of cows in shelters can be built upon based on this study. This will facilitate reliable and practical on-shelter welfare monitoring system to assess welfare levels in the shelters and evaluate potential risks to welfare. The integration of the most appropriate specialist expertise in India is essential to develop, refine, standardize and intercalibrate welfare monitoring systems and to identify and validate remedial measures. An Indian standard for welfare assessment system of shelters similar to the Welfare

Quality® protocol (*Welfare Quality® assessment protocol for cattle* 2009) can be established in order to facilitate welfare auditing for feedback to stakeholders for initiation of corrective interventions. Then only one can harmonize welfare and welfare monitoring that is informative and relevant to all stakeholders.

The present assessment protocol as mentioned earlier was time consuming. However, being the first such study on welfare assessment using welfare indicators the time spent in each shelter for a comprehensive study is justified. Time and finances might be the constraints for routine welfare assessments of cow shelters in such a big country. Repeating this protocol in more shelters can provide more ideas about its repeatability and practicality. Further on, studies could be based on the identification of potential 'iceberg indicators' (Farm Animal Welfare Council 2009; Heath et al. 2014c) that provide overall assessment of welfare in shelters, reduce the time of assessment and still accurately predict the overall welfare to increase the feasibility of the welfare assessment. This might restrict the assessment of specific welfare indicators and accordingly reduce the assessment time. Behaviour opportunities available to the cows such as access to yards and pastures, interaction with conspecifics, free access to water troughs, presence of trees and shady areas in the yards to lie down and rub bodies, enrichment measures in shelters can be utilized as separate indicators for measuring positive welfare (Farm Animal Welfare Council 2009; Heath et al. 2014c).

A blueprint of an ideal shelter set up for cow keeping in line with the approximate number of cows needs to be provided to all stakeholders, based on the modern scientific principles of cattle husbandry and welfare. This blueprint should encompass the appropriate resource and environment based facilities to be provided as per the contemporary welfare standards that could be uniformly applicable all over the country. Design criteria such as shelter location, space allowance/animal, stocking density/ shed, group size with provision for animal interactions physical structure of shelters sheds, animal loading and unloading ramps, yards, flooring, bedding, lighting and noise mitigation strategies. Biosecurity and animal waste management protocols specifically for shelters need to be formulated and implemented. The development of such an integrated shelter welfare system based on a uniformly standardized assessment protocol would be an invaluable tool for welfare monitoring and assessment of cow shelters. The identification of potential risks through such welfare monitoring will help these assessments play a critical preventative role for the shelters. Welfare auditing based on these assessments will ensure transparency in working these shelters that are vital for all the stakeholders.

This study being a point in time assessment of welfare of cows in shelters, the evidence of causation based on correlations between the various welfare parameters requires confirmation through subsequent longitudinal studies and interventional studies on limited number of parameters.

The assessment parameters used in this study should be subjected to further validation and repeatability through a training format based on the workshops to train assessors in order to promote accuracy. This accuracy can be reassessed through the measurement of inter-observer agreement and reliability based on kappa statistics (Croyle et al. 2018).

A routine systematic welfare assessment program uniformly focused on cow shelters in the country is the destination desired to be built upon this study. Periodic assessments will identify the causes of various risk factors associated with the welfare of cows in shelters. Evaluation of the success of changes effected on the basis of the assessments will lead to an improvement in working of shelters and the cows. Welfare auditing will ensure feedback to all stakeholders and ensure transparency in the management of shelters that will ultimately help in sustainability of these traditional institutions through higher public involvement. Furthermore, training of veterinarians as assessors for carrying out welfare assessments is very important for the sustainability of welfare auditing of cow shelters. An institutional level approach is needed to enable this training as a continual process for robust and dynamic welfare assessments. The AWBI needs to coordinate with the respective state animal welfare boards to introduce welfare assessment protocols in the states, assess the repeatability and practicality of the protocols and monitor feedback for improvement.

Ensuring a uniform and routine record keeping in all shelters in the country will generate more intervention studies on the welfare of cows. Greater scientific participation might be stimulated to work on the data generated through this record keeping, leading to a wider understanding of the welfare, managemental, economic, social and cultural aspects of sheltering of cows. This could serve as a catalyst to bring about a paradigm shift in the management of shelters based on modern scientific animal welfare concepts through innovations and their diffusion to bring desired changes.

10.2 General Conclusions

The welfare indicator-based welfare assessment protocol for cow shelters developed and applied in this study was mainly based on the Welfare Quality® protocol, though some parameters were also based on other welfare assessments carried out in different parts of the world. The relevance of the selected parameters to the welfare measurement of abandoned and unproductive cows in shelters was the basic criterion for their selection. In addition, the feasibility of measurement and feedback from the stakeholders were also taken care of during inclusion of parameters in the protocol. This study presents a holistic view of the welfare situation of cows in the shelters. This comprehensive assessment based on animal, resource and environment-based measures is a snapshot diagnosis of the welfare issues of the sheltered cows. Assessment of flooring, lameness prevalence and human-animal relationship have been included in most of the assessment protocols and these were included in this study also. Association of these parameters with other measures was analyzed and risk factors were identified following multivariable analysis. The additional study done on the analysis of hair cortisol of the cows is a unique work on the assessment of long term stress in the sheltered cows. The associated risk factors leading to this stress were identified through multivariable analysis.

Low space allowance, non-uniform and inappropriate flooring, lack of freedom of movement within and outside the shelter sheds, lack of pasture grazing, lack of bedding, absence of ad libitum access to drinking water, compromised biosecurity and lack of proper animal waste disposal methods were some of the major welfare issues observed in the shelters. An easy, affordable, practical and quick method of assessment of floor friction was developed in this study. The multivariable analysis validated the hypothesis that floor friction affects the welfare of cows. Floor friction revealed significant correlation with floor type, proportion of standing cows in the shelter sheds, the avoidance distance of the cows and dirtiness of the hind limbs. This suggested that floor friction affects comfort levels of the cows. Further studies on the repeatability of this method are recommended for confirming its validity.

The prevalence of lameness in the shelters was comparatively lower than the organized dairy farms in India and abroad. Inadequate cleanliness of shelter premises, improper flooring and lack of a balanced diet were identified as risk factors to lameness. These risk factors were manifested in the form of reduced body condition of cows, dirty udders, dirty limbs, hock and carpal joint lesions, and claw overgrowth. Improvement in these managemental aspects of sheltering might help in reducing the prevalence of lameness. Proper drainage and disposal of slurry stagnating in the lying areas and passages will promote foot hygiene. Appropriate floor gradient, floor friction levels and adequate bedding help in proper effluent drainage, reduces slipperiness induced falls and hock lesions. These corrective measures improve comfort levels and positively affect welfare. Adequate and nutritious feeding management in shelters is essential for improving the body condition of the cows as low BCS renders cows vulnerable to carpal and hock joint lesions and subsequent lameness.

Long term stress levels in cattle in shelters were also evaluated by analyzing their hair cortisol concentrations. The risk factors associated with elevated hair cortisol concentrations were dirtiness of the cows, lesions on the body and limbs, age, lactation and dehydration. Cleanliness of the shelter premises and provision of access to the yards for the cows reduced hair cortisol concentration indicating low stress levels. This study is at the point of time analysis of stress levels in sheltered cows. A longitudinal study to assess the stress levels of cows when it enters the shelters and then after subsequent months can provide information about the well-being of cows during their stay in the shelters. Hair cortisol promises to be an effective biomarker of long term stress in cows especially for conducting field-based studies.

Evaluation of human-animal relationships in cow shelters was important to ascertain whether the compassion for the old, abandoned and unproductive cows existed. This was done by measurement and assessment of avoidance distance (AD) at the feed bunk. The results of this study revealed AD is relative to the state of the animal and is dependent on the animal health and welfare parameters. A cautious approach is recommended to interpret the influence of health parameters on AD as well as being a reflection of stockpersonship. Half of the cows allowed touch by the assessor indicating a cordial human-animal relationship in shelters that helps in guaranteeing good cow welfare.

Survey of the public attitudes towards cows and cow welfare helped to gauge the public sentiment towards cows in the contemporary context where the overpopulation of street cows has led to a situation of human-animal conflict. The results of this study show that attitudes of the public are guided by the concept of sacredness of the cow, revered as mother goddess by the majority Hindu population. Visiting shelters for religious reasons and reverence for the cows irrespective of its breeds confirmed this status of the cow. The utilitarian and religious values of shelters were considered by the older people, while younger generation regarded them as centres for cow welfare and protection. Increasing education levels increased reverence and concern about cows. Higher income levels revealed frequent shelter visits, revealing the status of the cow as a goddess of wealth in Hindu mythology. Neutral views of females on welfare of cows in shelters reflect the typical patriarchal character of Indian society. These key differences in attitudes need to be considered in public driven initiatives towards improvement of welfare of cows in shelters. These demographic variations in attitudes can help in introducing welfare science-based modern techniques for management of shelters by maximizing public support. This will strengthen further these institutions in fulfilling the aspirations of the general public. Further studies on public guided identification of welfare issues in cow shelters can be undertaken with a wider range of respondents and the impact of such interventions in the improvement of shelters.

The engagement of shelter managers, the vital cogs of shelter management, is essential for the improvement in the working of shelters. Work profile and experience of managers' positions them to identify basic problems and issues in shelter management. Greater representation of women is desired in this position. Overcrowding, biosecurity issues, animal waste disposal, indiscriminate breeding, lack of appropriate separation of cows into different groups and erratic record maintenance were the key issues identified in the managers' survey. Mandatory affiliation with the AWBI can bring out uniformity in management, policy and research interventions in the shelters.

Despite high confidence levels of managers about the adequacy of welfare of cows and human-animal relationship in their respective shelters, regular training programs on stress-free handling of animals and welfare science-based modern management concepts are needed for the managers and the workers.

This study has described a snapshot of the contemporary welfare situation in cow shelters. Associations between various welfare indicators were observed and risk factors to various animal-based and management-based welfare issues were identified. Public attitudes towards cows and cow welfare were surveyed and managers' inputs about the constraints in managing shelters and their attitudes towards shelters and cow welfare were also evaluated. Further studies need to be built upon this groundwork to assess its repeatability and validity. Welfare assessment of cow shelters based on a tested protocol should become a routine feature for improving the welfare of cows in shelters. Feedback obtained through such assessment shall ensure accountability and interventions for improvement.

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Appendices

Appendix 1: Animal-based parameters used for the assessment of welfare of cows in Indian shelters

Parameter	Description	Scales and Scores
General temperament (Café et al. 2011)	Visual examination	0-docile, 1-aggressive
Cow Comfort Index (CCI) (Krawczel et al. 2008)	Proportion of cows in a stall or shed that were lying down	
Stall Standing Index (SSI) (Krawczel et al. 2008)	Proportion of cows in a stall or shed that were standing	
Avoidance Distance (AD) (de Vries et al. 2014)	Cows that were standing at the feeding manger were approached at the front at a rate of one step per second, starting at 2 m from the manger. The distance between the assessor's hand and the cow's head was estimated at the moment the cow moved away and turned its head	0- touched 1- 0 to 50 cm 2- 51 to 100 cm 3- >100 cm
Lactation		0- Non-lactating 1- Lactating
Body Condition Score (BCS) (Edmonson et al. 1989; Thomsen & Baadsgaard 2006)	A cow with a score of ≤ 1.25 was considered emaciated, 1.5–2 thin, 2.25–3.75 normal and 4 or more obese Visual examination	1 to 5 with increments of 0.25.
Lameness Score (Flower & Weary 2006; Sprecher et al. 1997)	1 to 5 scale Visual examination	1- not lame (smooth and fluid movement) 2- mildly lame but not observable easily (an imperfect gait but able to freely move with a mildly arched back) 3- moderately lame (able to move but not freely, with an arched back) 4- lame, with inability to move freely with and asymmetrical gait and abnormal head movement 5-severely lame (severely restricted in movement, requiring considerable encouragement to move, and a severely arched back)
Claw overgrowth (Huxley & Whay 2006c)	Visual examination	0- Normal claws 1- Mild claw overgrowth 2- Moderate claw overgrowth 3- Severe claw overgrowth.

Rising behavior (Chaplin & Munksgaard 2016; Rousing et al. 2004))	All cows lying in the shelter were coaxed to get up with use of a minimum amount of force. If the presence of the assessor did not evoke rising they were given one or two gentle slaps on the back, followed by a break of 5 s, then more slaps with slightly more force if required, up to a maximum of 30 s	1- Normal (smooth and a normal sequence of rising behaviour 2- Easy but slightly interfered (smooth movement with slight twisting of the head but with normal sequence of rising process 3- Uneasy with effort (sudden movement and difficulty in rising with awkward twisting of the head and neck but following a normal sequential rising process 4- Abnormal (uncharacteristic sequence of a rising event) 5- refused to get up
Rising restrictions (Huxley & Whay 2006b)	As a result of shelter facilities by visual inspection	0-Unrestricted (cow is able to rise as if it were in a pasture) 1-Mild restrictions (cow is able to modify standing to rise comfortably as it lunges sideways and not forwards) 2- Cow takes time to rise and hits shed fixtures or fittings while rising 3-Dog sitting posture adopted while standing or make multiple attempts before able to rise.
Hock joint swellings (Wechsler et al. 2000; Whay et al. 2003)	Visual examination	1- mild swollen joint 2- medium swollen joint 3- severely swollen joint
Hock joint hair loss and ulceration (Wechsler et al. 2000; Whay et al. 2003)	Visual examination	0- no hair loss or ulceration 1- mild hair loss or ulceration <2 cm^2 2- medium hair loss or ulceration (approx. 2.5 cm^2) 3- severe hair loss or ulceration >2.5 cm^2
Carpal joint injuries (Wechsler et al. 2000)	Visual examination	0- no skin change 1- hairless 2- swollen 3– wound(s)
Dirtiness of the hind limbs, udder and flanks (Whay et al. 2003)	By visual inspection of the cows from both sides (left and right) and from behind	1- no dirtiness 2- mildly dirty (small soiled areas of dirtiness with no thick scabs) 3- medium dirtiness (large soiled areas but with < 1 cm thick scabs of dung) 4- severely dirty (large soiled areas with > 1cm thick dung scabs)
Body hair loss (Whay et al. 2003)	Visual inspection	0—absence of hair loss;1—mild; 2—medium; 3—severe
Body Coat condition (Huxley & Whay 2006a)	Visual examination	1- dull and short 2- shiny and short 3- dull and hairy

Ectoparasitism (Popescu et al. 2010)	Visual examination	1- Absence of ectoparasites 2- Mild infestation – no lesions (not easily visible by naked eye but on tactile perception in the neck region 3-Moderate-mild infestation visually observable ectoparasites or immature forms or eggs in the neck, groin, peri rectal, tail root and switch regions 4- Severe-Visually observation of mature ectoparasites all over the body especially regions mentioned in score 3
Lesions from shelter furniture (Huxley & Whay 2006c)	Visual examination	0- normal (no lesions present) 1- small area of hair loss 2- moderate area of hair loss and/or thickening of the skin 3- severe (a large area of hair loss and /or breakage of the skin
Skin lesions / Integument alterations (Leeb et al. 2004)	Visual examination	0- normal (no apparent lesions) 1- mild hair loss (< 2 cm^2) 2- moderate (> 2 cm^2 hair loss and inflamed skin) 3- severe (a large > 4 cm^2 area of hair loss with extensive skin inflammation and breakage)
Teat and udder condition	Visual inspection	1- Normal teats and udder 2- Dry udder and teats 3- Teat cracks 4- Warts on teats and udder 5- Acute lesions on the teats and udder 6- Chronic lesions on teats and udder
Skin tenting time (Roussel 2014; Constable 2003; Jackson & Cockcroft 2008)	Visual examination by skin pinch of the cervical region of neck	1- ≤ 2 seconds 2- >2 seconds 3- ≥6 seconds
Oral lesions	Visual examination	0- absent, 1-present
Neck lesions (Kielland et al. 2010)	Visual examination	1- no observable skin change 2- hair loss 3- swollen 4- closed wounds (hematomas or closed abscesses) 5- open wounds
Ocular lesions (Coignard et al 2013)	Visual examination	0- absent, 1-present
Nasal discharge (Coignard et al 2013)	Visual examination	0- absent, 1-present
Hampered respiration (Coignard et al 2013)	Visual examination	0- absent, 1-present
Vulvar discharge (Coignard et al 2013)	Visual examination	0- absent, 1-present

Rumen Fill Score (Zaaijer & Noordhuizen 2003)	Visually by standing behind the cow on the left side and observing the left para lumbar fossa between the last rib, the lumbar transverse processes and the hip bone	1- the para lumbar fossa is empty, presenting a rectangular cavity that is more than a hand's width behind the last rib and a hand's width under the lumbar transversal processes 2- the para lumbar fossa forms a triangular cavity with a width about the size of a hand behind the last rib, but less than this under the lumbar transverse processes 3- the para lumbar fossa forms a cavity less than a hand's width behind the last rib and about a hand's width vertically downwards from the lumbar transverse processes and then bulges out 4- the para lumbar fossa skin covers the area behind the last rib and arches immediately outside below the lumbar transverse processes due to a bloated rumen 5- the rumen is distended and almost fills up the para lumbar fossa; the last rib and the lumbar transverse processes are not visible.
Diarrhoea (Coignard et al. 2013)	Visual examination	0—absent, 1—present
Fecal consistency (Zaaijer & Noordhuizen 2003)	Visual inspection	1- thin and watery and not truly recognizable as feces 2- thin custard-like consistency, structurally recognizable as feces, splashing out wide upon falling on the floor 3- thick custard-like consistency, making a plopping sound while falling on the floor and a well-circumscribed pad which spreads out and is about 2 cm thick 4- stiff with a heavy plopping sound while falling on the floor and a proper circumscribed pad with visible rings and minimal spreading out 5- hard fecal balls like horse feces

Appendix 2

Record Sheet for Resource-based measures for cows in Gaushalas

Gaushala Name & Code: ___________________________________

1. **Shed Levels measurements/Recordings**

Parameter	Scale	Recording	Remarks
Type of Housing	Freestall, Tiestall, Loose, Tether, No housing, Other		
Type of Flooring	Brick, Concrete, Bitumen, Earthen, Other		
Type of Roof	Portal, Flat, Sloped, Other		
Number of Stalls			
Inlet/Outlet/Shed Design			
Number of Water Points			
Types of Water Points	Trough, Bowl, Natural water-body, Other		
Type of bedding			
Presence of Dung in Lying Area/Bedding and Percentage	Y/N and %		
Presence of Dung in Passages and Percentage	Y/N and %		
Presence of Standing Urine in Lying Area/Bedding	Y/N		
Presence of Standing Urine in Passages	Y/N		
Presence of Mould in Feed Trough	Y/N		
Dustiness of Feed in the trough	Very dusty, Dusty, Not dusty		

Moisture Level of feed in the Trough	Wet, Moist, Dry		
Dimensions of Each Water Point	- Lth/Br/Dpth Circumference/Diam/Depth		
Appearance of Each Water Point	- Clear - Hazy - Opaque		
Algae/Moss in Each Water Point	- Y/N		
Dimensions of Shed	Meters		
Length of Tether	Meters		
Area of Movement around Tether	m^2		
Height to Eaves	Meters		
6-point thickness of Bedding	Cm		
Moisture of Bedding	Wet, Moist, Dry		
Water Run-off in Bedding/Lying Area	Y/N		
Gradient of Bedding/Lying Area by spirit-level	Lth %, Br %		
Gradient of Passages by spirit-level	Lth %, Br %		
Frictional Force of Passages by spring-balance	N		
6-point Light Intensity using phone-app/ Time of Day	Lumens		

Three Noise Measurements using phone-app	Decibels		
Dry Bulb Temperature/Wet Bulb Temperature and Time of Day	° F/°C Hour: Minutes		

2. **Yard level measurements/Recordings**

Parameter	Scale	Recording	Remarks
Type of Flooring	Brick, Concrete, Bitumen, Earthen, Other		
Number of Water Points			
Types of Water Points	Trough, Bowl, Natural water-body, Other		
Presence of Dung and Percentage	Y/N and %		
Presence of Standing Urine	Y/N		
Dimensions of Each Water Point	- Lth/Br/Depth - Diam/Depth - -		
Appearance of Each Water Point	- Clear - Hazy - Opaque -		
Algae/Moss in Each Water Point	- Y/N		
Dimensions of Yard**	Meters		
Frictional Force of Passages by spring-balance	N		

Three Noise Measurements using phone-app	Decibels		
No. of trees in the yard			
Feed trough Dimensions			
Gradient by spirit level	Longitudinal Horizontal		

3. **<u>Questionnaire to Shelter Manager</u>**

Question	Scale	Answer	Notes
Number of animals in housing area			
Type of water source	Human potable, Tap water, Natural water-body, Other		
Is water given ad lib	Y/N		
Access to pasture	hours/day		
Access to yards	hours/day		
Frequency of scraping housing areas			
Method of scraping housing areas			
Any other area scraped/cleaned?			
Time of feeding or Frequency of feeding each type of feed	- - -		

	- - -		
Quantity given per number of animals of each type of feed	- - - - - -		
Type of Processing of each type of feed	- - - - - -		

Appendix 3

Survey of public perception about cow welfare and gaushalas in India CODE_____________

1. Your gender

- Male
- Female
- Other

2. Your age?

- 18-25 years
- 26-35 years
- 36-45 years
- 46-55 years
- 56-65 years
- 66 years and above

3. Your religion?

- Hinduism
- Islam
- Sikhism
- Christianity
- Zoroastrianism
- Judaism
- Buddhism
- Jainism
- Confucianism
- Shintoism
- Taoism
- Bahai'
- I do not follow any religion
- Atheism
- Any other religion _______________

4. To what extent do you consider yourself religious?

a. Not religious at all…..... □
b. Not very religious........ □
c. Moderately religious.... □
d. Very religious………… □

5. What is your ethnic group?

a. Indo-Aryan…................□
b. Dravidian……………....... □
c. Mongoloid.................... □

d. Others………………… □

6. What is your highest level of education?

- No formal education
- Under 10th standard
- 10th standard pass
- Senior secondary/ 10+2Diplomate
- Graduation
- Post-graduation

7. Your marital status is?

- Single
- Married
- Widowed
- Other
- Divorced

8. How many children do you have?

- One
- Two
- Three
- Four
- Five or more
- No children

9. Do you mind asking what your annual income is?

- 10000 -25000 INR
- 25001- 50000 INR
- 50001-75000 INR
- 75001-100000 INR
- 100001-500000 INR
- 500001-1000000 INR
- 1000001- 5000000 INR
- 5000001-10000000 INR
- Above 10000000 INR

10. How would you describe the place where you live?

- Urban (City)
- Sub-urban (Suburb)
- Country town (Tehsil/Taluka)
- Village

11. As a child did you grow up having contact with cows in your home or nearby?

- Yes
- No

Now, I am going to ask you about gaushala visits.

12. Are you aware of the _________________ gaushala which is located near your home (location?)

a) Yes

b) No

13. How often do you visit your local gaushala?

a. Once a day
b. Once a week
c. Once in 15 days
d. Once a month
e. Once in 6 months
f. Once a year
g. Less than once a year,
h. I've never visited it

14. List the following in order of declining importance for which gaushalas are established (from 1, most important to 6, least important) List here:

i. Welfare.. ☐

ii. Milking.. ☐

iii. Breeding.. ☐

iv. Attract funding from rich .... ☐

v. Profit.. ☐

vi. Religious purpose.. ☐

14. Why do you visit gaushalas?

a) Religious reasons
b) Feed the cows
c) Educational reasons
d) Examine cow welfare standards
e) Leisure, I or my family enjoy seeing the cows
f) Buy cow products
g) Others, please specify ____________________.

Now I am going to ask you questions about your attitude towards gaushalas and cows in them.

15. What do you understand by the term the "welfare of cows"?

Keyword(s) ____

16. Which is best for unwanted cows?

a) Gaushalas
b) On the streets
c) Export to neighbouring state or country
d) Slaughter
e) All equal

18. Circle the following in declining order of cow welfare from 1 -3, where 1 means best for welfare and 3 means worst for welfare of the cows?

a) Housed in gaushalas	1	2	3
b) Roaming in the streets	1	2	3
c) Slaughter	1	2	3

19. On your gaushala visit, which is your favourite type of cow?

a. Local Indian Breeds
b. Cross breeds
c. Jersey
d. Holstein
e. All are favourites
f. Others, please list --

20. To what extent does the community have an equal responsibility to each cow type?

a) Greater responsibility to local Indian breeds
b) Equal responsibility to all cows
c) Greater responsibility to exotic breeds

21. On a scale of 1-5, how important is it for cows to be able to go to gaushalas, where 1 is not important at all and 5 is very important?

1 3 5

I--I

Strongly unimportant 1	Unimportant 2	Nether unimportant or important 3	Important 4	Strongly Important 5

22. To what extent do you agree that cows should be kept in gaushalas?

1) For reasons of tradition/culture,

Strongly agree 1	Agree 2	Nether disagree or agree 3	Disagree 4	Strongly disagree 5

2) For animal welfare reasons,

Strongly agree 1	Agree 2	Nether disagree or agree 3	Disagree 4	Strongly disagree 5

3) For breeding purposes,

Strongly agree 1	Agree 2	Nether disagree or agree 3	Disagree 4	Strongly disagree 5

4) For milk production purposes.

Strongly agree 1	Agree 2	Nether disagree or agree 3	Disagree 4	Strongly disagree 5

Please provide a level of agreement (1=strongly agree, 2=agree, 3 neither agree nor disagree, 4= disagree, 5=strongly disagree) for each

23. What is the maximum number of cows that *should* be housed together in your local gaushala for acceptable animal welfare?

a) Less than 50
b) 50-100
c) 100-150
d) 150-200
e) Above 200
f) Above 500
g) Above 1000
h) As per the space available

24. On a scale of 1-5, do you feel the gaushala near here gives adequate shelter to the cows?

Strongly disagree 1	Disagree 2	Nether disagree or agree 3	Agree 4	Strongly agree 5

25. On a scale of 1-5, do you feel the gaushala around your place gives adequate food and water to the cows?

Strongly disagree 1	Disagree 2	Nether disagree or agree 3	Agree 4	Strongly agree 5

26. On a scale of 1-5, do you feel the gaushala near here gives adequate freedom to move about and socialize with other cows?

Strongly disagree 1	Disagree 2	Nether disagree or agree 3	Agree 4	Strongly agree 5

27. On a scale of 1-5, do you feel the gaushala near here giving adequate provision of bedding, flooring and lying down to the cows?

Strongly disagree 1	Disagree 2	Nether disagree or agree 3	Agree 4	Strongly agree 5

28. On a scale of 1-5, do you feel the gaushala near here treating the sheltered cows humanely?

Strongly disagree 1	Disagree 2	Nether disagree or agree 3	Agree 4	Strongly agree 5

29. On a scale of 1-5, do you feel the gaushala near here giving adequate veterinary care to the cows?

Strongly disagree 1	Disagree 2	Nether disagree or agree 3	Agree 4	Strongly agree 5

31. How do you support this gaushala? Please circle all that apply

a) Financially
b) Morally
c) Donating food/ supplies
d) Volunteering my time to assist
e) All of these

32. Do you have any issues with the gaushala?

- Yes
- No

33. If Yes: What are the most important issues are you experiencing? Please list in order of declining importance.

a) Offensive odours
b) Flies and mosquitos
c) Noise
d) Traffic
e) Waste management
f) Conflicts with staff
g) Other

Appendix 4

Survey of the Managers on welfare of cattle in shelters (gaushalas) in India

Gaushala Name & Code:

Screening questions

1. Does this gaushala have a minimum of 30 animals?

a. Yes
b. No

2. Which of the following are admitted to this gaushala?

a) Infertile
b) abandoned
c) infirm
d) old cows
e) Stray cows
f) All of these
g) Other

3. What religious connection does it have?

a) Jain
b) Hindu
c) Sikh
d) Other

4. When was this gaushala established? ___________________________________

PART 1- Demographics

1. Please indicate your gender

a. Male……….... □
b. Female……....□

2. In what type of area have you lived for most of your life?

a. Urban (city)…......... □
b. Sub – Urban (Suburb)……........ □
c. Country town (Tehsil/Taluka) .... □
d. Village □

3. Please indicate your age range

a. 18-25……......... □
b. 26-35……......... □
c. 36-45…….... …. □
d. 46-55…….... …. □
e. 56-65…….... …. □
f. Over 65……...... □

4. Please indicate your education level

a. No formal education……... □
b. Below 10th class…….…..... □
c. 10th class (Higher secondary) □
d. 10 +2 (senior secondary) … □
e. Diplomate…………………...□
f. Graduand……... …. □
g. Post-graduand……...…. □
h. Other, if any □

5. Which religion do you follow?

a. Bahai' Faith……....... □
b. Buddhism……......... □
c. Caodaism……......... □
d. Chinese folk religion □
e. Chondogyo……....... □
f. Christianity……....... □
g. Confuciansim……...... □
h. Hinduism…….............. □
i. Islam……...................□
j. Jainism……................ □
k. Judaism……............... □
l. Shinto……...................□
m. Sikhism……..................□
n. Taoism……...................□
o. I don't follow a religion□
p. Atheism □
q. Other (please specify) ____________________________________

6. To what extent do you consider yourself religious?

e. Not religious at all…..... □
f. Not very religious........ □
g. Moderately religious.... □
h. Very religious……........□

7. Please indicate which job role best describes your involvement in the gaushala

a. Work directly with the animals…………………………………………… □
b. Team Leader: Supervise people who work directly with the animals. □
c. Business owner………………………………………………………….. □
d. Business Manager………………………………………………………… □
e. Farmer………………………………………………………………………□
f. Veterinarian who treats animals' hands on……………………………… □
g. Veterinarian working for the Government as an advisor……………… □
h. Other, if any…………………………………………………………… □

8. **Please indicate your level of understanding of gaushalas**
 a. Expert …………………………………………………………………… □
 b. Good knowledge………………………………………………………. □
 c. Some knowledge………………………………………………………. □
 d. Little knowledge……………………………………………………… □
 e. No knowledge…………………………………………………………… □

9. **How did you gain your knowledge about cow welfare in gaushalas?**
 a. Formal qualifications – relevant degree, training course…………..……. □
 b. Farm employment – hands on experience……………………………… □
 c. Personal interest – internet, journals, newspaper articles, television programmes……………………………………………………………… □
 d. Friends and acquaintances………………………………………………. □
 e. Other …….………………………………………………………………. □

10. **Please indicate the type of animal welfare organisation you have been involved with other than this gaushala**
 a. Gaushala………………………………………. □
 b. Dairy industry ……………………………… □
 c. Animal Welfare organisation………………………… □
 d. Other…………………………………………………. □
 e. None…………………………………………………□

11. **Please indicate the type of animal welfare activity you have been involved with in addition to managing this gaushala**
 a) Activism………………………….……………. □
 b) Advocacy ………………………………..………. □
 c) Administration ………………………………. □
 d) Policy making………………………………………. □
 f. Feeding street/stray animals………………………..…□
 g. Humane Education…………………………………□
 h. None…………………………………………... □

12. **Please indicate how long you have been working in the field of animal welfare**
 a. Less than 1 year……………………………………………………… □
 b. 2 – 3 Years…………………………………………………………….□
 c. 3 – 5 Years…………………………………………………………….□
 d. 5 – 9 Years…………………………………………………………….□
 e. 10 – 15 Years………………………………………………………… □
 f. More than 15 Years……………………………………………………. □

13. **Please indicate how long you have been working in this gaushala**
 a) Less than 1 year……………………………………………………… □
 b) 2 – 3 Years…………………………………………………………. □
 c) 3 – 5 Years…………………………………………………………. □
 d) 5 – 9 Years…………………………………………………………. □
 e) 10 – 15 Years……………………………………………………… □
 f) More than 15 Years…………………………………………………. □

PART 3 – Complementary data

1. **No. of cattle entering the gaushala**

a) In last 3 months ____________________
b) In last 6 months ____________________
c) In last 1 year ____________________
d) No records kept ____________________

2. **Total milk yield of the gaushala/ day**
   a) _______________ litres/day
   b) No records kept

3. **No. of lactating cows in the gaushala**
   a) ____________ cows
   b) No records kept

4. **Approximate proportion of horned animals**
   ___________%

5. **No. of males and female animals in the gaushala**

a) Bulls
b) Cows
c) Heifers
d) Bullocks
e) Male calves (6 month or less)
f) Female calves (6 month or less)

6. **If calves are born in the gaushala, what do you do with the calves?**
   a) Male calves
      i) Sell
      ii) Donate
      iii) Rear
   b) Female calves
      i) Sell
      ii) Donate
      iii) Rear

7. **Vaccination status of the animals**
   a) Vaccinated
   b) Non-vaccinated
   c) Some vaccinated, some not

8. **If vaccinated, vaccinated against which diseases –**

9. If vaccinated how many times vaccination done

a) one a year

b) twice a year

c) thrice a year

d) four times a year

e) No regular schedule followed

f) Never done

10. Deworming status of the animals

a) Dewormed

b) Non-dewormed

c) Some dewormed, some not

11. If dewormed how many times deworming done

a) one a year

b) twice a year

c) thrice a year

d) four times a year

e) No regular schedule followed

f) Never done

12. If ectoparasiticidal treatment given?

a) one a year

b) twice a year

c) thrice a year

d) four times a year

e) No regular schedule followed

f) Never done

13. Veterinarian in the gaushala: In house / Visiting (If visiting how frequent)

a) Daily
b) Weekly
c) Fortnightly
d) Monthly
e) On call

14. No. of workers in the gaushala: Male ______________ Female _______________

15. Training of animal workers is done

a) Induction training done
b) Not done at all
c) Trained workers inducted

16. Maintenance of records in the gaushala: List of records

i) Milk yield

ii) Calving/Reproduction

iii) Health Records

iv) Veterinary provisions/inventory

v) Mortality

vi) Feeding

vii) Sales

17. Sale of livestock products

a) Milk: Yes / No
b) Dung: Yes / No
c) Urine: Yes / No
d) Carcass: Yes/No

18. Do you have a biogas production system?

a) Yes

b) No

19. Who runs the administration of the gaushala? ______________________________

20. Rank any of the following which are funding sources, in declining order of importance

a) State Government □
b) Central Government □
c) Both the central and state government □
d) Trust □
e) Philanthropy □
f) Temple Trust □
g) Foreign Funding □
h) Others, if any □

21. Is the gaushala affiliated to AWBI?

a) Yes
b) No

22. Mortality rate in the gaushala ___________ deaths/year

23. Rank any of the following which are the causes of death?

a) Old age □
b) Debility □
c) Malnutrition □
d) Disease □
e) Brought in moribund state □
f) Others □

24. What does 'cow welfare' mean to you?

Key words

____

25. Do you feed colostrum to the calves? Yes / No. If Yes, then

i) To male calves
ii) To female calves

iii) To both

26. When do you feed colostrum to the calves?

i) Immediately after birth
ii) After 6 hours of birth
iii) After 12 hours
iv) After 24 hours
v) After 48 hours

27. Do you separate the calf from the mother after birth?

i) Yes
ii) No

28. What is the feeding regime of your gaushala? (Schedule and formulation)

29. How do you manage the male calves born in the gaushala?

i) Maintain them in the gaushala for rearing as breeding bulls
ii) Sell them
iii) Donate them
iv) Castrate other than those kept for breeding

30. How much time is spent by the animals outdoors in the yard or in the grazing land in a day?

i) Not sent out at all
ii) 1-2 hours
iii) 2-4 hours
iv) 4-6 hours
v) More than 6 hours

31. Is breeding of cows done in the gaushala?

i) Yes
ii) No

32. If yes to Q.31, then what type of breeding?

i) Indiscriminate
ii) Natural breeding from a bull present in gaushala
iii) Artificial insemination

33. What is the purpose this breeding?

i) Breed improvement/improvement
ii) Improve productivity
iii) No purpose

34. Are the funds received by the gaushala audited regularly?

i) Yes, always
ii) Sometimes
iii) No

35. How long the workers are working in the gaushala?

i) 6 months
ii) 1 year

iii) 2 years
iv) 3 years
v) More than 3 years
vi) Keep on leaving frequently

36. How long you are working in the gaushala (manager)?

i) Less than 1 year
ii) 1-2 years
iii) 3-5 years
iv) More than 5 years

37. Do people come for volunteering in the gaushala?

i) Yes, regularly
ii) No
iii) Occasionally

38. What type of voluntary work is done?

39. Are there any animal enrichment measures in place in the gaushala?

40. Are there any biosecurity measures in place in the gaushala?

Introduction of new animals

Disposal of carcasses

Isolation room for animals suffering from infectious diseases

41. Was there any disease outbreak in 5 years in the gaushala? If yes, what was it?

42. Is there any hierarchy of animals in the animal groups and how is it controlled?

43. Is there any public relation or outreach activity done by the gaushala involving the local community?

44. Is the gaushala located in a drought prone or flood prone area/ disaster prone area?

i) Yes
ii) No

45. Are there any disaster preparedness plans in place?

46. Are the records of visitors maintained?

47. What is the purpose of visit of the visitors?

48. Is the the feeding of animals by the visitors monitored by the management?

49. How is the Disposal of dung carried out?

50. How is the Handling/disposal of urine done?

51. Are dung/urine utilized as value-added resources?

52. Are there loading and unloading ramps for cows in the gaushala?

53. Is animal experimentation allowed in the gaushala?

54. Part -3 Attitudes

	Strongly Disagree	Disagree	Neither Disagree or Agree	Agree	Strongly Agree
1. The welfare of the cattle in this gaushala is satisfactory.					
2. The welfare of the cattle in the gaushala is important to me.					
3. I feel that my knowledge of animal welfare is adequate.					
4. The feed the cattle receive at this gaushala is adequate.					
5. I am willing to adopt measures that will improve the welfare of the cattle, if it was provided to me.					
6. The local community financially supports this gaushala.					
7. The local community morally supports this gaushala.					
8. The government financially supports this gaushala.					
9. The government morally supports this gaushala.					
10. I intend to make improvements to the welfare of the cattle in my care.					
11. In the past I have tried to make improvements to the welfare of the animals in my care.					
12. The staff at this gaushala have a close relationship with the cattle.					

Appendix 5

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

UQ Research and Innovation
Director, Research Management Office
Nicole Thompson

Animal Ethics Approval Certificate

04-Aug-2016

Please check all details below and inform the Animal Welfare Unit within 10 working days if anything is incorrect.

Activity Details

Chief Investigator:	Professor Clive Phillips, Animal Welfare and Ethics
Title:	Development and validation of welfare indices for Indian cattle in shelters
AEC Approval Number:	SVS/CAWE/314/16/INDIA
Previous AEC Number:	SVS/CAWE/214/16/
Approval Duration:	04-Aug-2016 to 04-Aug-2017
Funding Body:	
Group:	Production and Companion Animal
Other Staff/Students:	Arvind Sharma, Uttara Kennedy Kennedy, Catherine Schuetze
Location(s):	Other International Location

Summary

Subspecies	Strain	Class	Gender	Source	Approved	Remaining
Cattle		Adults	Mix	Pound/Refuge	1620	1620

Permits

Provisos

The AEC has directed that the CI nominate a person to provide reports and monitor the project on behalf of the Committee. This person must have sufficient knowledge of the proposed work to be undertaken to enable monitoring as per The Code (Section 2.6.11 & 2.6.12).

Approval Details

Description	Amount	Balance
Cattle (Mix, Adults, Pound/Refuge)		
4 Aug 2016 Initial approval	1620	1620

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Appendix 6

THE UNIVERSITY OF QUEENSLAND

Institutional Human Research Ethics Approval

Project Title:	Public and Stakeholder Opinion on the Welfare of Indian Cattle in Shelters (Gaushalas)
Chief Investigator:	Prof Clive Phillips
Supervisor:	None
Co-Investigator(s):	Dr Arvind Sharma, Dr Catherine Schuetze
School(s):	School of Veterinary Science
Approval Number:	2016001243
Granting Agency/Degree:	UQ PhD student grant; Humane Society International, Australia; Universities Fund for Animal Welfare, UK
Duration:	30th September 2017

Comments/Conditions:

Note: if this approval is for amendments to an already approved protocol for which a UQ Clinical Trials Protection/Insurance Form was originally submitted, then the researchers must directly notify the UQ Insurance Office of any changes to that Form and Participant Information Sheets & Consent Forms as a result of the amendments, before action.

Name of responsible Committee:
University of Queensland Human Research Ethics Committee B
This project complies with the provisions contained in the *National Statement on Ethical Conduct in Human Research* and complies with the regulations governing experimentation on humans.

Name of Ethics Committee representative:
Dr. Frederick Khafagi
Chairperson
University of Queensland Human Research Ethics Committee
Registration: EC00457

Signature ______________________ Date 07/10/2016

Appendix 7

ANIMAL WELFARE BOARD OF INDIA
Ministry of Environment, Forests and Climate Change, Govt. of India
भारतीय जीव जन्तु कल्याण बोर्ड
(पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार)

सत्यमेव जयते

MAJ. GEN. (Retd.) Dr. R. M. KHARB, AVSM
CHAIRMAN

To whom it may concern

This is to confirm the support of the Animal Welfare Board of India (AWBI) for the research project titled **"Development and validation of welfare indices for Indian cattle in shelters (Gaushalas) to improve cattle welfare".** This project is very much relevant for the improvement of the welfare of abandoned / stray cattle sheltered in the Gaushalas in India as such AWBI is pleased to confirm its involvement and support for this innovative research study. The recommendations arising from this study be communicated to the Board for the furtherance of the goal of improvement of cattle welfare in Indian Gaushalas.

This is to confirm that the Animal Welfare Board of India hereby accords permission to Dr Arvind Sharma, Veterinary Officer, Department of Animal Husbandry, Government of Himachal Pradesh presently pursuing his PhD at the School of Veterinary Science, The University of Queensland, Australia, under the supervision of Prof. Clive Phillips and Dr Catherine Schuetze, and Dr Uttara Kennedy to visit the cattle shelters (Gaushalas / Gosadans / Pinjarapoles) located in India for undertaking his field research for his PhD.

All concerned Gaushala managers, trustees and caretakers in various States which are being visited by the research team are requested to give every assistance and cooperation for this research project by allowing the team access while visiting their Gaushalas in gathering information being requested by the visiting team.

Dated: 22nd April, 2016

MAJ. GEN.(Dr.)R.M.KHARB, AVSM (Retd.)
Chairman, AWBI

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