STUDIES ON BEHAVIOUR AND WELFARE OF MIGRATORY FLOCKS OF GADDI GOATS IN NORTH-WESTERN HIMALAYAN REGION

THESIS SUBMITTED TO THE
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
(DEEMED UNIVERSITY)
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

LIVESTOCK PRODUCTION MANAGEMENT

BY

Dr. ANKAJ THAKUR
M.V.Sc (LPM)

LIVESTOCK PRODUCTION MANAGEMENT DIVISION
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE
(DEEMED UNIVERSITY)
KARNAL-132001 (HARYANA), INDIA

2022

Regn. No: 15-P-LP-08

STUDIES ON BEHAVIOUR AND WELFARE OF MIGRATORY FLOCKS OF GADDI GOATS IN NORTH-WESTERN HIMALAYAN REGION

BY

DR. ANKAJ THAKUR

THESIS SUBMITTED TO THE
ICAR - NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
(DEEMED UNIVERSITY)
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY
IN
LIVESTOCK PRODUCTION AND MANAGEMENT

Approved By:

19.12.2022

Dr. M.L. KAMBOJ
Principal Scientist, LPM
(Major Advisor)

External Examiner

Members of Advisory Committee

1. **Dr. P.K. Dogra**
   Head of Department, LPM, CSKHPKV
2. **Dr A.K. Misra**
   Head and Principal Scientist, LPM Division
3. **Dr. Pawan Singh**
   Principal Scientist, LPM Division
4. **Dr. Ashutosh**
   Principal Scientist, DCP Division
5. **Dr. Vikas Vohra**
   Principal Scientist, AGB Division
6. **Dr.K. Ponnusamy**
   Principal Scientist, DE Division
   (Director's Nominee)

K. Pon 19.12.2022

LIVESTOCK PRODUCTION MANAGEMENT
ICAR-NATIONAL DAIRY RESEARCH INSTITUTE
(DEEMED UNIVERSITY)
KARNAL-132 001 (HARYANA), INDIA

Dr. M. L. KAMBOJ
Principal Scientist,
E-mail: kamboj66@rediffmail.com

CERTIFICATE

This is certified that the thesis entitled **"Studies on behavior and welfare of migratory flocks of Gaddi goats in North-Western Himalayan region"** submitted by **Dr. Ankaj Thakur** towards the partial fulfillment of the award of the degree of **"DOCTOR OF PHILOSOPHY"** in **Livestock Production Management** of the National Dairy Research Institute (Deemed University), Karnal, Haryana is a bonafied research work carried out by him under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

Date:

Dr. M. L. KAMBOJ
MAJOR ADVISOR & CHAIRMAN

Dedicated

to my Father

Late Sh. Balbir Thakur

And

My beloved daughter

Kaira Thakur

ACKNOWLEDGEMENT

First and foremost, I would like to thank God Almighty for giving me strength, knowledge, ability and opportunity to understand this research study and to preserve and complete it satisfactorily. I also remain indebted to all the innocent animals both sick and healthy troubled by me directly or indirectly during my research study.

At this moment of accomplishment, I am greatly indebted to my research guide and advisor ***Dr. M.L Kamboj****, Principal Scientist, ICAR-NDRI who accepted me as his Ph.D. student and offered me his mentorship. This work would not have been possible without his guidance, involvement, his support and encouragement on daily bases. Under his guidance I successfully overcame many difficulties and learnt a lot. His own zeal for perfection, passion, unflinching courage and convection has always inspired me to do more. For all these, I sincerely thank him from bottom of my heart. I will be truly indebted to him throughout my life time.*

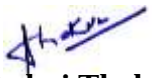
I would also like to thank ***Dr. PK Dogra****, Head, Department of Livestock Production Management, CSKHPKV for his persistent motivation and ever extending hands of help not only for completion of this research work, but also for my overall improvement during the entire period and homely touch.*

I wish to express my deep sense of gratitude to ***Dr. Pawan Singh****, Principal Scientist, and Livestock Production Management Division for his impeccable guidance, immaculate suggestions and encouragement.I thank* ***Dr. K. Ponnusamy****, Principal Scientist, Dairy Extension Division for his valuable guidance, timely suggestions and support whenever needed.*

I am enormously thankful to ***Dr. Ashutosh****, Principal Scientist, Dairy Cattle Physiology Division and* ***Dr. Vikas Vohra****, Principal Scientist, Animal Genetics and Breeding Division. As my teacher and mentor they have taught me more than I could ever give them credit here. They inspired me to choose the right path at the time of dilemma and rest went smoothly as predicted by them. I am grateful for their valuable advice, constructive criticism, positive appreciation and counselling which led to the successful completion of research work. I extend my sincere thanks to Dr. M.S. Chauhan, Director, NDRI, Karnal and Dr. Harinder Kumar Chaudhary, Vice Chancellor, CSKHPKV for their valuable and immense support and for providing necessary facilities during my study*

I would also like to extend my gratitude to Dr. Shivani Katoch,Dr. Rakesh Thakur, Dr. Nishant Verma, Dr. Madhu Suman, Dr. Anjali Rana, Dr. Narender Langyan, Dr. Meesam Raza and Dr. Rohit Kumar for providing their valuable time, help, motivation and moral support extended to me during my thesis writing.

My heartfelt gratitude to Rajesh Sharma, Abhishek Thakur, Anurag Sharma, Sappy Thakur for helping me throughout my research tenure for their endless support and help during my research.



Ankaj Thakur

CONTENTS

LIST OF TABLES

LIST OF FIGURES

PLATES

LIST OF ABBREVIATIONS

ABM	-	Animal Based Measures
ADG	-	Average Daily Gain
AICRP	-	All India Coordinated Research Project
ANI	-	Animal Need Index
ANOVA	-	Analysis Of Variance
ASL	-	Above sea level
AWIN	-	Animal Welfare Indicators Project
BCS	-	Body Condition Score
BCSK	-	Body Condition Score at Kidding
BWAP	-	Bristol Welfare Animal Programme
CAEV	-	Caprine Arthritis Encephalitis Virus
CIRG	-	Central Institute for Research on Goats
CP	-	Crude Protein
CSWRI	-	Central Sheep & Wool Research Institute
DISCO	-	Diarrhoea Score
EFSA	-	European Food Safety Food Authority
EPG	-	Eggs per gram
EU	-	European Union
FAMACHA	-	FAffaMAlanCHArt
FAWC	-	Farm Animal Welfare Council
FHAT	-	Familiar Human Approach Test
FMD	-	Foot and Mouth Disease
GI	-	Gastro Intestinal
GIN	-	Gastrointestinal Nematodiasis
HAR	-	Human Animal Relationship
HH	-	High hills
IUCN	-	International Union Conservation of Nature
KMO-MSA	-	Kaiser-Meyer-Olkin Measure of Sampling Adequacy
LGD	-	Livestock Guard Dog
LH	-	Low Hills
LS	-	Lameness Score
MBM	-	Management Based Measures

ME	–	Metabolic Energy
MH	-	Mid Hills
ML	-	Mid Lactation
MP	-	Mid Pregnancy
MSL	-	Mean Sea Level
NAD	-	Nothing abnormal Detected
NDF	-	Neutral Detergent Fiber
OBM	-	Output Based Measures
OIE	-	World Organisation for Animal Health
PC	-	Principal Component
PCA	-	Principal Component Analysis
PK	-	Post Kidding
PPR	-	Peste-des-petits ruminant
QBA	-	Qualitative Behavioural Assessment
RBM	-	Resource Based Measures
SCC	-	Somatic Cell Count
SD	-	Standard Deviation
SE	-	Standard Error
SPSS	-	Statistical Package for the Social Sciences
WAI	-	Weighted Average Index

ABSTRACT

The present study was carried out to investigate the behaviour and welfare of Gaddi goats in the north-western Himalyan region. Behaviours were recorded for 15 min/hour for 8 hours of grazing daily for four consecutive days using focal sampling by video cameras on four flocks at key stages of production cycle during post-kidding (PK) at low-hills, mid-lactation (ML) at mid-hills and mid-pregnancy (MP) at high-hills. The assessment protocol was adapted from AWIN framework for goats (AWIN, 2015). It was categorized into five welfare domains (feeding, environment/facility around camping, health, behaviour and performance) with 32 welfare indicators (5, 6, 9, 5 and 7 from each domain respectively) and domains were assigned a welfare score (WS) of 25,15,30,15 and 15 respectively aggregating into 100. The adapted protocol was tested for its validity (by expert judgment) and reliability by Cronbach's alpha. It was found valid (91.3 percent of experts agreement) and reliable with the value of Cronbach's α as 0.90. Welfare assessment was performed at low hills on two migratory routes on 24 flocks categorized into small (S<100 goats), medium (M=100-200 goats) and large (L>200 goats) with eight flocks each.Data was analyzed using one-way analysis of variance (ANOVA) in SSPS. Total daily feeding time (browsing plus grazing) was higher (P<0.05) at ML (282.15±2.8 min; 58.77±0.5%) as compared to PK (270.37±5.6 min; 56.33±1.1%) and MP (261.98±2.7 min; 54.58±0.4%). Time devoted to browsing was higher (P<0.05) at ML (220.18±2.6 min; 45.87±0.5%) as compared to PK (173.08±3.8 min; 36.06±0.7%) and MP (40.32±0.9 min; 8.40±0.1%) while daily grazing time was greatest at MP (221.66±3.6 min) followed by PK (97.29±4.8 min) and ML (61.97±3.3 min). Standing time was greater (P<0.05) at MP (46.83±3.7 min) and PK (39.83±1.9 min) as compared to ML (24.01±2.1 min). Daily times spent on walking, rumination and lying were similar at three stages. Frequency of bipedal stance was higher (P<0.05) at ML (28.50±2.1) as compared to PK (12.50±1.7) and MP (4.17±0.6). Frequency of self-grooming was higher (P<0.05) at PK (14.00±2.1) than at ML (5.83±1.5) and MP (1.0±0.6) while frequencies of allogrooming was similar at three stages. Frequency of object grooming was greater (P<0.05) at ML (2.16±0.6) as compared to PK (1.0±0.3) and MP (0.00±0.0).S flocks scored higher (*P*<0.05) than M and L flocks in feeding (14.25±0.8 vs. 11.00±1.3 and 10.12±0.8), health (26.25±1.1 vs. 24.25±.9 and 21.37±0.8) and environmental domains (12.3±0.2 vs. 8.37±0.5 and 9.00±0.8). Welfare scores of behavioural domain in S flocks (14.75±0.2) were higher (*P*<0.05) than L (12.75±0.4) but were not different from M flocks (13.62±0.5) whereas scores of performance were higher (*P*<0.05) in S (12.75±0.7) and M (9.75±1.0) than L flocks (8.62±1.0). Overall welfare scores in S (80.62±2.4) were higher (*P*<0.05) than in L (62.87±3.3) and M (69.00±3.7) flocks. Results showed that Gaddi goats spent most of day time in feeding and walking with little time spent on standing, lying and rumination. Feeding was undertaken through grazing predominantly at high-hills and through browsing in bipedal stance during lactation at low and mid-hills. Grooming activities were most evident at post-kidding and during lactation at low and mid-hills. Welfare was found acceptable (welfare score >60) at all small flocks, 75% of medium flocks, 50% of large flocks and 75% of all studied flocks. Body condition score, environmental protection to kids, animal losses, hair coat condition, healthcare practices, familiar human approach test and abortions were most compromised welfare indicators at large and medium flocks. In conclusion, welfare of most of Gaddi goat flocks was acceptable (75 per cent) and small flocks performed better than medium and large flocks.

सारांश

वर्तमान अध्ययन उत्तर पश्चिमी हिमाचली क्षेत्र में गद्दी बकरियों के व्यव्हार और कल्याण का अध्ययन करने के लिए किया गया था| उत्पादन चक्र के प्रमुख चरणों, निचली-पहाड़ियों पर मध्य-ब्यांत (एमएल) के दौरान, मध्य-पहाड़ियों पर प्रसव के बाद (पीके) एवं मध्य-गर्भावस्था (एमपी) में उच्च-पहाड़ियों पर में चार झुंडों पर विडियो कैमरों द्वारा फोकल सैंपलिंग का उपयोग करके लगातार चार दिनों तक रोजाना 8 घंटें चरने के लिए 15 मिनट/घंटे के लिए व्यव्हार दर्ज किये गए थे | मूल्यांकन प्रोटोकॉल को बकरियों के लिए AWIN ढांचे से अनुकूलित किया गया था (AWIN, 2015)।इसे 32 कल्याण संकेतकों (क्रमशः प्रत्येक डोमेन से 5, 6, 9, 5 और 7) के साथ पांच कल्याणकारी डोमेन (फीडिंग, पर्यावरण / शिविर, स्वास्थ्य, व्यवहार और प्रदर्शन के आसपास की सुविधा) में वर्गीकृत किया गया था और डोमेन को एक कल्याण स्कोर (WS) सौंपा गया था (25,15,30,15 और 15 का क्रमशः100 में एकत्रित किया गया था)। क्रोनबैक के अल्फा द्वारा इसकी वैधता (विशेषज्ञ निर्णय द्वारा) और विश्वसनीयता के लिए अनुकूलित प्रोटोकॉल का परीक्षण किया गया था। यह मान्य पाया गया (91.3 प्रतिशत विशेषज्ञ समझौते) और क्रोनबैक के α के मूल्य के साथ 0.90 के रूप में विश्वसनीय था। छोटे (एस<100), मध्यम (एम = 100-200) और बड़े (एल>200) में वर्गीकृत 24 झुंडों पर दो प्रवासी मार्गों पर निचली पहाड़ियों पर कल्याण मूल्यांकन किया गया था, जिनमें से प्रत्येक में आठ झुंड थे। एसएसपीएस (एनोवा) में विचरण के एकतरफा विश्लेषण का उपयोग करके डेटा का विश्लेषण किया गया था । पीके (270.37 ± 5.6 मिनट; 56.33 ± 1.1%) और एमपी (261.98 ± 2.7) की तुलना में एमएल (282.15 ± 2.8 मिनट; 58.77 ± 0.5%) पर कुल दैनिक भोजन समय (ब्राउज़िंग प्लस चराई) अधिक (पी <0.05) था। पीके (173.08 ± 3.8 मिनट; 36.06 ± 0.7%) और एमपी (40.32 ± 0.9 मिनट; 8.40 ± 0.1) की तुलना में ब्राउज़िंग के लिए समर्पित समय एमएल (220.18 ± 2.6 मिनट; 45.87 ± 0.5%) पर अधिक (पी <0.05) था। %) जबकि दैनिक चराई का समय एमपी (221.66 ± 3.6 मिनट) में सबसे बड़ा था, इसके बाद पीके (97.29 ± 4.8 मिनट) और एमएल (61.97 ± 3.3 मिनट) का स्थान आता है। एमएल (24.01 ± 2.1 मिनट) की तुलना में एमपी (46.83 ± 3.7 मिनट) और पीके (39.83± 1.9 मिनट) पर खड़े होने का समय अधिक (पी <0.05) था। चलने, जुगाली करने और लेटने में बिताया गया दैनिक समय तीन चरणों में समान था। पीके (12.50 ± 1.7) और एमपी (4.17 ± 0.6) की तुलना में एमएल (28.50 ± 2.1) पर द्विपक्षीय रुख की आवृत्ति अधिक थी (पी <0.05)। पीके (14.00 ± 2.1) पर सेल्फ-ग्रूमिंग की आवृत्ति एमएल (5.83 ± 1.5) और एमपी (1.0 ± 0.6) की तुलना में अधिक थी (पी <0.05) जबकि एलोग्रूमिंग की आवृत्ति तीन चरणों में समान थी। पीके (1.0 ± 0.3) और एमपी (0.00 ± 0.0) की तुलना में एमएल (2.16 ± 0.6) पर ऑब्जेक्ट ग्रूमिंग की आवृत्ति अधिक (पी <0.05) थी। पोषण में (14.25 ±0.8 बनाम 11.00 ±1.3 और 10.12 ± 0.8), स्वास्थ्य (26.25±1.1 बनाम 24.25±.9 और 21.37±0.8) और पर्यावरण डोमेन (14.25 ± 0.8 बनाम 11.00 ± 1.3 और 10.12 ± 0.8) की तुलना में एस झुंडों ने उच्च (पी<0.05) स्कोर किया। 12.3±0.2 बनाम 8.37±0.5 और 9.00±0.8)। S झुंड (14.75±0.2) में स्कोर्स व्यवहारिक डोमेन L (12.75±0.4) की तुलना में अधिक (P<0.05) थे, लेकिन M झुंड (13.62±0.5) से अलग नहीं थे, जबकि प्रदर्शन के स्कोर अधिक थे (P<0.05) में एल झुंड (8.62±1.0) की तुलना में एस (12.75±0.7) और एम (9.75±1.0) । एस (80.62 ± 2.4) में समग्र कल्याण स्कोर एल (62.87 ± 3.3) और एम (69.00 ± 3.7) झुंडों की तुलना में अधिक (पी<0.05) थे। परिणामों से पता चला कि गद्दी बकरियां दिन का अधिकांश समय भोजन करने और चलने में व्यतीत करती हैं और खड़े होने, लेटने और जुगाली करने में कम समय व्यती तकरती हैं। भोजन मुख्य रूप से ऊंची पहाड़ियों पर चराई के माध्यम से और निचली और मध्य पहाड़ियों पर ब्यांत के दौरान द्विपादरुख में ब्राउज़िंग के माध्यम से की जाती थी। प्रसव के बाद और ब्यांत के दौरान निचली और मध्य-पहाड़ियों पर ग्रूमिंग की गतिविधियाँ सबसे अधिक स्पष्ट थीं। सभी छोटे झुंडों में कल्याण स्वीकार्य (कल्याण स्कोर>60), मध्यम झुंडों का 75%, बड़े झुंडों का 50% और सभी अध्ययन किए गए झुंडों का 75% कल्याण पाया गया। शरीर की स्थिति का स्कोर, बच्चों के लिए पर्यावरण संरक्षण, जानवरों के नुकसान, बालों के कोट की स्थिति, स्वास्थ्य देखभाल के तरीके, परिचित मानव दृष्टिकोण परीक्षण और गर्भपात बड़े और मध्यम झुंडों में सबसे अधिक समझौता कल्याण संकेतक थे। अंत में, गद्दी बकरियों के अधिकांश झुंडों का कल्याण स्वीकार्य (75 प्रतिशत) था और छोटे झुंडों ने मध्यम और बड़े झुंडों की तुलना में बेहतर प्रदर्शन किया।

CHAPTER –1

Introduction

INTRODUCTION

Goat, the most adaptable and geographically widespread livestock species, serves as livelihood, nutritional and financial security to the local tribes of the state of Himachal Pradesh. The total goat population of Himachal Pradesh is 11.08 Lakh (Livestock Census, 2019). Migratory goat and sheep population constitutes 70% of the total population of sheep and goat of the state (Misri, 1998). Gaddi goat (White Himalyan goat) is the predominant breed of goat of high altitude, mainly reared by a distinct tribe of nomadic pastoralists leading to its nomenclature as "Gaddi" breed. Gaddi goat has its true home tract in H.P., but distribution extends to the neighbouring hilly areas of Jammu and Kashmir and Uttarakhand (Acharya 1982). The name 'Gaddis' is derived from the name of the land they live in—Gadheran. The Gaddis live around Himachal Pradesh's Dhauladhar range, mainly in the Bharmour region of Chamba district and Riva and Budhil valleys.

The unrestricted aspect of the extensive system does not automatically guarantee high standards of welfare and these systems often pose unique and complex problems for the animals (Goddard *et al*., 2006; Matthews, 1996; Waterhouse, 1996). In particular, the extensive rearing production system faces welfare problems related to large seasonal fluctuations (food availability, climate), predation and limited monitoring (Waterhouse, 1996, Patherick, 2005). Goats are less vulnerable to pests and infectious diseases in zero-grazing environments relative to those in free-range ones. The behavioural needs of animals may also be compromised in some extensive environments which may lead to suboptimal welfare. Despite being free to exhibit normal behaviour, if environmental problems override its developed coping mechanisms, an animal can undergo unpleasant emotional states and altered biological functioning (Dwyer, 2009), for example, in poor pastures, animals can suffer starvation and exhibit changes in biological functioning associated with starvation. Because of seasonal variations in herbage quantity and quality, pasture may also have a detrimental effect on animal welfare; thus, grazing animals are generally subjected to transient nutritional stress. If there is nutritional stress during the breeding season, it may decrease the reproduction efficiency of sheep (Rassu *et al*., 2004). Underfed ewes have demonstrated a higher milk somatic cell count, suggesting the metabolic stress of the ewes and their mammary gland. In extensive system, lameness can

also pose a serious challenge for small ruminants (Goddard, 2006). Sheep with moderate to extreme foot rot exhibit elevated levels of plasma adrenaline and noradrenaline (Ley *et al*., 1992). A slightly decreased tolerance for nociceptive effects relative to healthy animals is also associated with considerable foot rot, which suggests a greatly improved susceptibility to acute pain. Therefore, the welfare of pastoral goats despite offering more opportunities than other production systems to exhibit natural behaviour may be compromised.

Concerns about how animals are raised are growing among consumers, and they are having a significant impact on their purchase decisions (Verbeke and Viaene, 2000). Customers' positive opinions about giving animal's access to the outdoors can be interpreted as proof that naturalness should be promoted (Wolf and Tonsor, 2017). To provide the ideal conditions for the zootechnical development of herds and to maintain an eco-friendly management strategy, knowledge of goat behaviour in its environment is crucial (Furtado *et al*., 2015). It is critical to understand how livestock behave in response to a variety of environmental factors and forage dynamics when evaluating management techniques for pastoral livestock production (Hejcmanova *et al*., 2009). Understanding of behavior is crucial to make informed choices for migratory goat's welfare (Kilgour and Dalton, 1984). Feeding behavior also plays an important role in the mathematical model that predicts the roughage intake of ruminants because diet and roughage may affect the quality of feeding behavior which in turn affects feed intake (Sauvant *et al*., 1996). Awareness and understanding of animal behaviour would also raise yield levels and serve as proof of the encouragement of goat's natural behaviour (Tuncer *et al*., 2016).

The publication *Animal Machines by* Ruth Harrison (1964) helped in raising public concern for the welfare of the intensively housed animals or factory-style production system. This has led to a fundamental shift in the scientific understanding of farm animal welfare and paved the way for its marketability. The higher adaptability of goats and thier ability to cope with prohibitive environmental conditions has led to very less research in the welfare field. A substantial proportion of the world's domestic animal population, occupying a wide part of the globe, is often made up of livestock produced in an extensive environment. However, the welfare concerns of the migratory or extensive animals have received much less attention in comparison to the intensively housed ones, perhaps due to naïve public perception of the extensively reared animals (Dwyer and Lawrence, 2008).

There are two schools of thought on extensive production of animals one which believes an animal has freedom of natural behaviour and well-being while the other thought question psychological and physiological well-being that may be compromised by natural factors, environment and malnutrition among others. Fraser *et al*., (1997) reported that animal well-being requires the physical environment of an animal (e.g., fitness and production), the affective state (e.g., the experiences), and the potential to execute normal behaviour. The well-being of widely controlled animals has been widely ignored; the assumption that health in these systems is fine is not founded on empirical evaluation (Turner and Dwyer, 2007). The lack of behavioural constraints encountered by extensively controlled animals has been considered to be significant positive for animal welfare, at least in the eyes of the general population (Matthews 1996). The problems faced by extensively reared livestock are also perceived to be natural and animals have adapted to deal with these challenges (Appleby, 2011). In their communication of discomfort, illness or anxiety, the animals that are reared in the extensive production appear to be discreet since they have formed as a predated species (Romeyer and Bouissou 1992, Dwyer 2004). Healthy animal welfare, however, requires more than the lack of constraints on behaviour.

Assessment of farm animal welfare has been increasing worldwide as farm animals are sentient (Blokhuis *et al*., 2010). Animal welfare is concerned about the ability of an individual to adapt to the challenges imposed by the environment and sometimes failure of which will result in animal mortality, reduction in growth rate and an increase in emergence of diseases (Broom, 1986). Animal welfare assessment is a multidimensional concept covering physical, physiological and psychological components. Less emphasis has been given to developing techniques for assessing animal welfare in migratory production systems due to the belief that these animals live a more natural life. Welfare assessment of intensive livestock production systems is mainly concerned with the compliance of buildings and floor space requirements, behavioural observations and health records tracking. However, in extensive systems, the usage of these indicators is inappropriate, impossible and insufficient. Environments are always heterogeneous; livestock can be impossible to observe and there may be no proper maintenance of health records. Assessment of animals in an extensive production system can involve assessing key environmental features, such as handling facilities, assessing the stockperson skills, expertise and planning, and evaluating the animal at vital stages in the production cycle (Turner and Dwyer, 2007).

Comprehensive on-farm welfare assessment protocols have been developed for the dairy goats reared under intensive and semi-intensive production systems. The five freedoms are used as a framework for identifying elements that may compromise animal welfare. Five domains model (nutrition, health, environment, behaviour and mental state) give detailed comprehension of the external state of the animals and the external circumstances that affect the animal welfare (Mellor, 2017). Animal Welfare Indicators (AWIN) protocol was also developed for adult dairy goats reared under intensive or semi-intensive husbandry systems under the European Welfare Quality program (Battini *et al*., 2014). Muri *et al*. (2013) also developed a welfare assessment protocol for dairy goats using animal, resource and management-based indicators. Liete Olivera *et al*. (2020) used the AWIN indicators to study the welfare of goats reared under extensive farm conditions. However, no welfare assessment protocol exists for the migratory goat production system which is low-input low-output production system relying on natural resources, limited supplements and no or limited access to housing.

The welfare assessment helps in improvement of the migratory goat production system in terms of production, economic performance, efficiency and sustainability. It will help farmers in guiding the areas of weakness in their units and also on the area of good welfare that should be maintained. It will act as a tool to gauge whether the amount of welfare issues or problems is increasing (or decreasing) then this can be used as a barometer against which to judge the practical steps the farmer can make to reduce the problem. This will also help in developing the epidemiological database and identification of welfare problems of migratory goat production. Thresholds may be developed through benchmarking the management practices to improve the pastoral animal's welfare. On-farm, welfare assessments may be used to measure the effect on livestock of various husbandry practices, but it may also be used for regulatory criteria, as a testing framework and as farmers' guidance and management tool (Main *et al*., 2003). It is necessary to evaluate the welfare of goat farms to boost the quality and hygienic conditions of food production (Battini *et al*., 2013). Most of the studies have been focused on the health and productivity of goats, but the studies on the natural behavior and welfare of migratory goats are lacking. Therefore, in this backdrop, the present study was planned with the following objectives.

1. To study the natural behaviour of Gaddi goats at different altitudes
2. To develop a protocol for welfare assessment in migratory goats
3. To assess the level of welfare of Gaddi goats in different flock size

CHAPTER –2

Review of Literature

REVIEW OF LITERATURE

2.1 AN OVERVIEW OF HIMACHAL PRADESH AND PASTORALISM

Himachal Pradesh, a Northern Indian state, lies in the western part of the Himalayan range with typical temperate climate. Average elevation above mean sea level of Himachal Pradesh varies from 350-7000 m ASL and have alpine and sub alpine pastures which are used for rearing the livestock. In the hilly areas of Himachal Pradesh, crop production alone is not sufficient to meet the household requirements owing to small land holdings (that too fragmented) and unhostile climate, not so productive for viable agriculture. A substantial number of families retain large flocks of goats and sheep due to the restrictions on arable farming imposed by the mountainous terrain.

The geographical location of Himachal Pradesh is 30˚22 to 33˚12 north latitude and 75˚47 to 79˚4 east longitude. Himachal Pradesh constitutes 1.69 % of India's area and 10.54 % of the Himalayas (55673 sq. km). An overwhelming population (89.96%) lives in rural areas and practice agriculture as their main occupation and the major source of employment in the state. Gaddi is a nomadic pastoralist clan in Himachal Pradesh that raises Gaddi sheep and goats. Centuries ago, they settled in various regions of the Dhauladhar range in modern-day Kangra district with high concentrations around Palampur and Baijnath tehsils and neighboring Chamba district. Gaddis regard livestock as community assets, as their livelihood is dependent on the sale or exchange of animals and their products in order to obtain food and other essentials. Their flocks are entirely handled through a large-scale (migratory) production technique.The breeding tract of the gaddi goat covers Chamba, Kangra, Kullu, Bilaspur, Mandi, and Lahual Spiti in Himachal Pradesh.

2.1.1 Location and boundaries

The Indian state of Himachal Pradesh is located in the far north of the Asian continent. It is bordered on the northwest by Jammu and Kashmir union territory and on the northeast by Ladakh union territory, on the east by the Tibet Autonomous Region of China, and on the southeast by Uttarakhand, Haryana, and Punjab (Fig. 2.1). Several parallel physiographic zones corresponding to the northwest-southeast-trending ranges of the Himalayan mountain system exist within the diversified terrain of Himachal Pradesh.

Two portions of the Siwalik (Shiwalik) Range (the Outer Himalayas) are divided by long, narrow valleys near to the plains of Punjab and Haryana. The region's southern tract has an average elevation of 1,600 feet (500 metres), whereas the northern tract has elevations ranging from 3,000 to 5,000 feet (900 and 1,500 meters). The lesser (or lower) Himalayas rise to around 15,000 feet to the north of the Siwaliks (4,500 meters). The beautiful snow-capped Dhaola Dhar and Pir Panjal peaks are located inside this region. The Zaskar Range, which reaches elevations of over 22,000 feet (6,700 metres) and towers over the other ranges in the region, is located to the north. This region is home to a number of active mountain glaciers. In addition to four major watercourses, Himachal Pradesh features additional perennial snow-fed rivers and streams. The Sutlej River, which originates in Tibet, drains the eastern portion of the state. The Chenab (Chandra-Bhaga), Ravi, and Beas rivers, which have their source in the Great Himalayas, drain the western half of Himachal Pradesh.

Fig 2.1 Geographical map of Himachal Pradesh

2.1.2 Climate

There are three well-defined seasons- summer, the monsoon and winter. Spring acts as a transition period between winter and summer, with autumn as an intermediary

between the monsoons and winter. The mean annual maximum temperature in Himachal Pradesh is 25.9°C with a range varying from 24.5°C to 27.1°C. The highest value attained for maximum temperature (30.7°C) is in the monsoon season while its lowest maximum value (16.9°C) is attained in the winter season. The mean annual minimum temperature is 13.4°C with a range varying from 12.5°C to 14.5°C.

2.1.3 Rainfall

Himachal Pradesh gets maximum rainfall in July (33% of monsoon rainfall) followed by August (28 % of monsoon rainfall). The annual average number of rainy days (when daily rain >=2.5 mm) in Himachal Pradesh State is 101 days and varies from 74 days to 125 days. The light to rather heavy rainfall events is 100 on average and ranges from 74 to 124 days. Himachal Pradesh has an average annual rainfall of 1284.2 mm, with a range of 704.7 mm to 2062.8 mm. Amongst all the districts, Kangra and Chamba receive the maximum average annual rainfall. The monsoon (June, July, August, and September) rainfall contributes the maximum annual rainfall amounting to approximately 66% for Himachal Pradesh State.

2.1.4 Milk and meat production

Livestock sub-sector plays a vital role in the Himachal's economy and also in the socio-economic development of rural households. India has seen steady growth in meat production over the past decade. According to Livestock Census (2019), the total livestock population in the State was 44,12,846. The cattle, buffalo and goat population in were estimated to be around 18.28, 6.47 and 11.08 lacs. The milk production in state of Himachal Pradesh has been reported to be 1,576.44 tonnes in year 2021 with per captita availability of 565g/day. Milk production potential of Gaddi goat breed remains unexplored and therefore, no data is available regarding milk from the said breed. The goat breeds found in Himachal Pradesh are predominantly raised for the meat production. The total meat production rose by 6% as per animal husbandry statistics, 2019. Goat meat accounted for 13.53 percent of India's total meat production. Estimated meat production in Himachal Pradesh for the years 2018-19 was found to be 4600 tonnes. Goat husbandry sector of the state contributed 2.32 tonnes with a slaughter of 123740 goats. The meat production through the goat sector rose by 3 percent as compared to the previous year. The lack of proper marketing channel has been a major constraint in establishment of full-

fledged marketing channels in the Himachal Pradesh where most of the goat population rests with Gaddi nomads.

2.2 Pastoralism

Pastoralism is the main occupation of the weaker sections of society and tribal areas of Himachal Pradesh. Pastoralists are described as the "Caste or ethnic group members with a strong traditional affiliation with livestock keeping, where a large percentage of the group derives more than 50 percent of household consumption from or sales of livestock or livestock products, and where more than 90 percent of animal consumption comes from natural pasture or browsing, and where households are responsible for the entire livestock breeding period" (Sharma *et al.*, 2003). Pastoralism lets the populations of Gaddi deal with local environmental restrictions and makes maximum use of grazing and water supplies for seasonal availability. This production system is potentially less damaging than sedentary because they exploit the herbage at fixed seasons, leaving it to recover for the remainder season. Pastoralists and their livestock also function as custodians of grasslands and biodiverse ecosystems, conserve soils capable of carbon sequestration, control water cycles correctly, restore natural vegetation, and avoid natural hazards (IUCN, 20011; Reuff *et al.*, 2004). During the summer months, Gaddi nomads migrate with their flocks from the foothills of the Himalayas (Shivalik foothills of the Himalya on the border between Himachal Pradesh and Punjab) to high altitude alpine ranges (high Himalayan summer pasture of Lahul and Spiti) and then descend back to the foothills and plains during the winter season (CSWRI, 2001; Pandey *et al.*, 2002). Shepherds travel from high hills to mid hills in the month of July and eventually enter low hills and plains by September-October, where they temporarily settle until March, and begin their return journey to high hills again.

2.3 Pattern of migration

Shepherds move from high hills to mid hills in the month of July, then eventually to low hills and plains in the months of September and October, where they temporarily dwell until the beginning of March before beginning their return trek to high hills (Fig. 2.2). In general, Gaddis prefers to take just one kidding per year. Their traditional migratory practices, which favour mating and kid harvesting in the winter, allow for the sale of a small number of young kids on the way back to lower and mid hill settlements during migration and the rearing of the remainder for about three to four months in upper

hills so that they can reach marketing weight (15 to 18 kg) and be sold while migrating downhill in the summer.

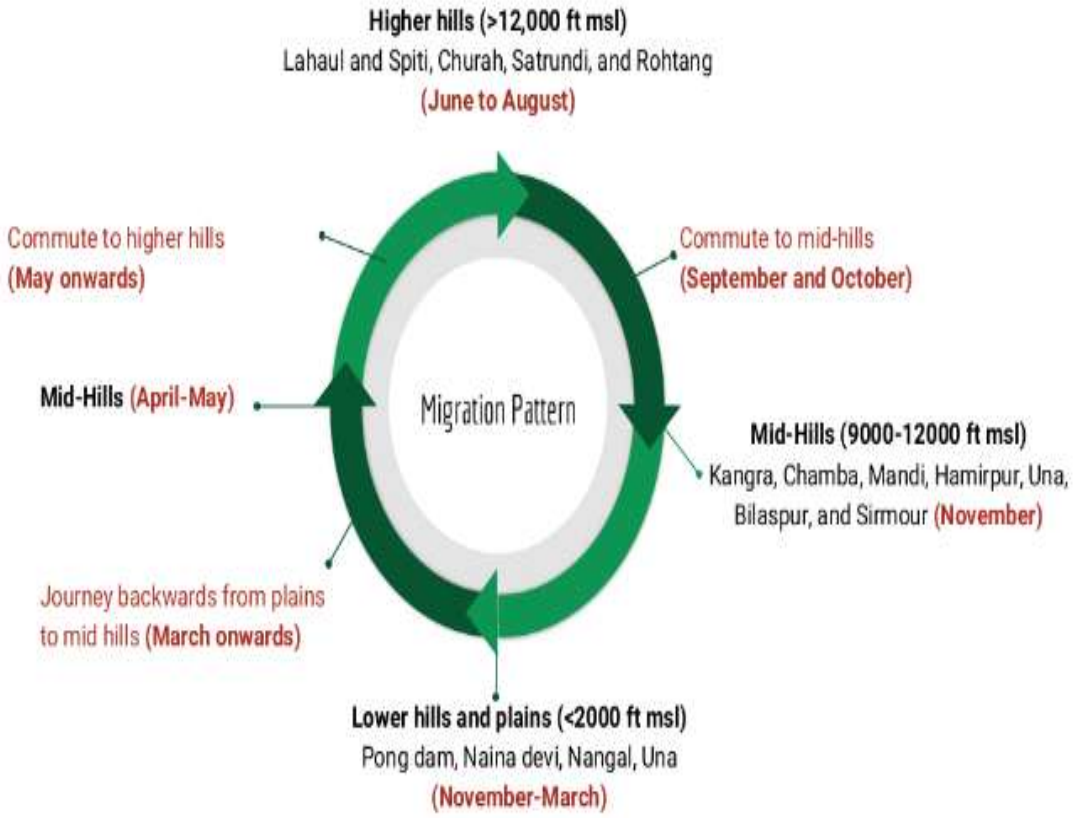


Fig 2.2 Migation pattern of Gaddi nomads

2.4 Migratory routes and camping sites

The breeding tract of gaddi goat covers Chamba, Kangra, Kullu, Bilaspur, Mandi and LahualSpiti in Himachal Pradesh and parts of Jammu Hills. The goats of tribal region of the state entirely depend upon grazing. During winter, the herds graze in the valleys, while in summer they move to higher altitudes. The main reason for their migration to the lower hills during winter is the absence of grazing pastures due to heavy snow fall in the high altitude areas. The animals that are reared through grazing grow at comparative faster rate, well strong and are seldom sick. The shepherds migrate from middle hills to plains in the month of November and return back to same place in month of April. From April on wards they migrate to high altitudes (8500-9000 feet) and remain there upto May and from June to August in higher hills (10000- 12000 feet) of Lahaul and Spiti, Churah, Satrundi and Rohtang. During winters (November to March) they migrate around Paonta Sahib, Sataun and Sarahan areas of Sirmour district and Arki in Solan district. The migrants of

Bharmour area move their flock to lower hills of Kangra, Chamba, Mandi, Hamirpur, Una, Bilaspur and Sirmour in Himachal Pradesh and Gurdaspur in Punjab.

Saberwal, (1996) reported that the Gaddi pastoralist migrate semi-annually with their livestock between Himalayan alpine meadows in summer and the Shivalik scrub forest in wintertime. The migration is of 300 km distance and takes place at an altitude of over 13.000 feet. Himachal Pradesh Gaddi's (Pbillimore 1982; Tucker 1985), Jammu and Kashmir Bakrwals (Caisimir& Rao 1985), Uttar Pradesh Bhotia's and the Gujjars are popularly known for practicing the transhumance in the western Himalayas

Dogra *et al*. (2011) reported that the migrants of the Bharmour region move with their flocks in the Himachal Pradesh (Chamba, Kangra, Hamirpur, Mandi, Una, Bilaspur, Sirmour) and to the Lower Hills (Gurdaspur in Punjab), while moving a distance of about 15 to 20 km daily. The animals usually graze for 7-8 hours every day.

2.5 Gaddi goat

The colour of Gaddi goat hair is predominantly white, but it is also seen in black and brown and variations of these (Acharya, 1982). It has long horns (long spiral upward and backward directed horns with pointed tips), long drooping ears, long hair (20-25 cm) and convex nose line (Plate 1.). It is primarily used for chevon production, besides little quantity of milk produced which rear their own kids and also accompanying lambs (as Gaddi sheep are very poor in milk production). It is primarily a meat breed with a robust structure and is suited for migratory production system.

A. B.

Plate 1. Gaddi goat of Himachal Pradesh A. Typical adult female B. Typical adult male

2.5.1 Breed Utility

Misri (2003) reported that Gaddi's consider the selling of goat milk as unethical. The milk of the goat is used by the pastoralist for consumption and for producing cheese. At the start of upward and at end of downward movement stock was sold, female goats were kept for eight years. Young ones were sold at three to six months of age fetching a price of Rs 350 (US$ 7.6) and Rs 700 (US$ 15.2) respectively. At this age the body weight of lambs and kids is 9-12 kg. The next sale is in September, at the beginning of downward migration, weight of goats were between 20 and 22 kg at this time. To buy the animals, the traders go up to the higher hills. Each sheep gets 650 rupee (US$ 14.13), and each goat gets 750-850 rupee (US$ 16.30-18.47). In a year, herders sell 40% of their sheep and 70% of their goats.

Dogra *et al*. (2010) reported that the Gaddi goat is mainly reared for meat, milk, fiber, skin, manure and transport facility especially in high altitude as in Himalayan region. Gaddi goat hairs are used in making blankets, shoe laces etc. On a very steep slope, a Gaddi goat can bear up to 10 kg load that can be negotiated by mules.

Somvanshi (2006) reported that in the Higher Himalayan region of India, Gaddi goats (especially males) are still used for transportation purposes.

Dogra *et al.* (2019) reported that Gaddi breed is mainly reared for meat purpose only and milk yield is sufficient enough for the kids only. The lactating does are rarely milked. If required, a number of does are being milked simultaneously and very small quantity of milk is extracted after suckling which is utilized for the daily requirements of caretakers. Daily milk yiled of 50 does were recorded and its average was 27.53, 50.66 and 64.78 litres at 30, 60 and 90 days, respectively.

2.5.2 Flock Sizes

The overall average flock size (both Goat and Sheep) of the Gaddi's flock is 136.9 with small flock of 61.9, medium of 153.7 and large of 379.6 (Sankhyan *et al*., 2016).

2.5.3 Productive and reproductive parameters

Acharya (1982) reported body weight of adult males was 27.45 kg and 24.72 kg in adult females in Gaddi goats. Under farm conditions the milk yield of Gaddi goat was 308 gm. Gupta *et al*. (2005) studied growth pattern of Gaddi goat in cold arid zone of Himanchal Pradesh. The morphological characteristics and growth pattern of 3869 Gaddi

goats (26.9 percent male and 73.1 percent females) from Kangra (27.6 percent males and 30.5 percent females), Chamba (42.7 percent males and 33.6 percent females) and Kullu (29.7 percent males and 35.9 percent females) districts, Himachal Pradesh, India were investigated. The average body weight of male Gaddi goat at birth, three, six and twelve months of age were 4.3 ± 0.8, 14.7 ± 0.7, 19.1 ± 0.6 and 27.13 ± 1.6 kg, respectively, while 4.06 ± 0.3, 14.3 ± 0.5, 18.5 ± 0.7 and 25.3± 0.8 kg, respectively for female goat. The average body girth for male and female were 34.5 ± 0.5, 53.3 ± 1.0, 60.0 ± 0.8 and 67.8 ± 1.1 cm, and 35.3 ± 1.0, 52.0 ± 0.9, 59.0 ± 1.0 and 66.1 ± 0.5 cm, respectively. The height at withers were 36.0 ± 0.8, 51.4± 0.2, 56.5 ± 1.1 and 63.42 ± 1.0 cm, respectively for male and 34.9 ± 1.0, 49.9 ± 0.9, 54.8 ± 0.5 and 62.7 ± 0.9 cm, respectively for female goat. In terms of morphometric traits studied, a substantial sex difference was observed.

Sankhyan *et al*. (2016) conducted survey on migratory Gaddi goats to generate baseline data on various productive and reproductive traits. Data collected on four flocks each from different migratory route showed percentage of twin birth 18.32, percent of abortion or still birth 7.32% and pre-weaning mortality 15.70%. Body weight at different ages for the enroute migratory flock was 2.70 kg at birth, 14.91 kg at 3 months, 18.18 kg at 6 months, 21.16 kg at 9 months and 26.21 at 12 months.

2.5.4 Feeding management

Singh *et al*. (2006) conducted survey on the twenty-six migratory sheep and goat owners and found that the feeding practices were poor among the Gaddi nomads. The owners do not provide concentrate supplements and minerals to their flocks. In addition, when the availability of fodder is low, especially during the winter, they do not feed roughage to their flocks. However, salt was regularly fed to the flock.

Acharya (1982) reported that migratory flocks are primarily grazed on alpine pasture during summer and on the harvested fields, forest areas and other uncultivated fallow and barren lands during winter. During winter and early spring, when the flocks are in the foothills and the plains, the tree leaves and pods of fodder trees constitute an important source of feed for the sheep and goat.

Misri (2003) documented that in addition to grazing, salt (at 3 kg/100 animals) is the only supplement provided to the animals and is distributed by scattering it across the rocks at stopovers once a week.

2.5.5 Breeding management

Acharya (1982) reported that nomads practice nautral breeding in the flocks and animals have evolved through natural selection. Twinning occurs only in 15-20% of kidding.

Dogra *et al*. (2011) reported that only one buck was kept for 50-75 breedable does and only natural service was followed. The major breeding season begins and lasts until June from April onwards. Kidding starts from the month of October in open only. No special treatment or management practices (concentrate feeding, navel cord treatment etc.) were followed after kidding. For their herd, the farmers practiced very primitive health practices and only 62.19 percent of the farmers were mindful of the symptoms of the most frequently encountered diseases.

Sankhyan *et al*. (2015) reported that the Gaddi farmers' own flock is the primary source of breeding buck followed by buck purchased from middleman while in few cases the buck is purchased from fellow farmer's flock. Regardless of the flock size, the number of breeding bucks used in flock at a given time typically varied from 1-3 with most of the flock typically holding 2 bucks. The breeding bucks were used continuously for upto 4–5 breeding seasons and this practice is common in flocks of all sizes. Almost all the farmers mentioned that they practice selection of male buck either from their own flock or neighboring flock, although mostly it is based on indigenous know how, traditional system and certain myth which are passed on as inheritance with flock but few criteria fits well on the scientific breeding male

Sankhyan *et al*. (2015) reported that the most common breeding season in case of migratory goat is summer (March–May), with occasional breeding occurring during winter (Sept-Oct). The season of mating and harvesting of only single kid crop/year was mainly because of their traditional migratory practices in which kidding are more suited in winter so that while migrating up on hills. During the migration, a few small kids can be sold on the way back to lower and mid hill settlements, while others were reared on the upper hills for 3–4 months until they reach selling weight (15–18 kg) and can be sold when migrating downhill in the summer. Prolificacy was less and twinning hardly 10-15 percent.

2.5.6 Health management

Singh and Misri (2006) studied traditional health management practices followed by the Gaddi's of Himachal Pradesh in Chamba district. They reported that the farmers

have sufficient indigenous knowledge of the diseases and their treatment. Rural people have experience of interactions with plant animals such as poisonous and medicinal plants. Gaddi nomads were well equipped with knowledge of preventing illnesses and keeping animals in good health. Indigenous knowledge was reported to be cost-effective, easily usable, commercially affordable and socially beneficial.

Sankhyan *et al*. (2014) documented that traditionally reared goats by the Gaddi tribe is major limiting factors such as high mortality, low survivability and slower growth rates.The frequency of weaning mortality on the predisposing factors and causes of mortality in 3 field units under separate migratory routes over a span of three years was studied. In order to gather data on field units, participatory rural assessment and regular flock visits were introduced. It was found that weaning at 4-5 months and sub-optimal management practices have been adopted for the flocks. The overall kid mortality and survival rates were 11.5 percent and 88.5 percent, respectively.

Nagal *et al*. (2014) recorded an outbreak of plant nitrate poisoning in a flock of 300 migratory Gaddi goats during February in the Khundia district region due to *Salvia coccinea* (Kali phool). Of the 300 Gaddi goats, 20 per cent (60/300) died within 48–72 hours, with suckling kids suffered a mortality rate of 40 per cent. A subnormal body temperature (100.2 to 101.8°F), elevated pulse rate (115–129/min), increased respiration rate (35–37/min), acute ruminal impaction, stumbling gait, anorexia, and congested conjunctivae showing tissue oxygen deficiency were among the clinical symptoms.

Pathania and Inder (2015) studied rearing practices of migratory sheep and goat. They rerported that foot and mouth disease (FMD) was prevalent on the plains.Compared to migration to valleys; both infection and mortality were higher in the plains. Laborer charges followed by veterinary expenses and shearing were the key components of rearing costs. As the whole flock was grazed on common (forest / pasture) land on hills and plains, there was no cost incurred on fodder. Owing to lack of market facilities in higher hills, production from sheep as well as goats was more in plains compared to hills.

Sankhayn *et al*. (2016) reported that although the state department of animal husbandry ensures proper health care and has several dedicated institutions for the purpose, because the flock migrates from lower hills (350 metres above MSL) to the inner Himalayan ranges (up to 5000 metres above MSL), these facilities are usually limited in low hills to middle hills.In addition, flocks migrate to alpine pastures in the summer, which

are far from human settlements, and it is very hard to have health care services in those areas.

2.6 Behaviour of goats under extensive system

Natural behaviour expression, described as that which is not subject to human control, can show how we fulfill this aspect of welfare in our production system (Yeates, 2018). Goats are rarely found alone in natural environment and isolation can be stressful in such conditions (Kannan *et al*., 2002). Impairments in maternal behaviour of the pregnant ewes can be due to undernutrition. Dwyer *et al*. (2003) also documented that undernutrition ewes take longer to interact with their lambs, spend less grooming time or licking and bleating at their lambs after birth and weakly bonded to their lambs as compared to well-fed ewes.

Lynch *et al*. (1992) reported that the mean grazing time of goat and sheep was eight to nine hours with maximum length of around 13 hours when feed supply was limited.

Grova and Bjelland (1997) reported diurnal variation (morning vs. afternoon) to be vital factor that influences browsing and grazing activities. Browsing is dominated in the morning, while grazing dominates the afternoon activity. Goat spent almost twice (1.8:1) on browsing as much they spend on grazing in morning, while in afternoon the ratio was (0.7:1). On abundant pasture, the morning browsing time was four times more than that of grazing (4.2:1) and becomes equal when forage is restricted. The ratio in the afternoon becomes 1.7:1 to 0.5:1 with limited forage. They also reported that browsing was 2.5 times higher than grazing with abundant forage in winter.

Mitohner *et al*. (2001) documented that one could reliably record behaviours of animals group by watching 1 animal out of 10. Drinking and walking behaviour were less reliable when observed for brief period intervals (one, five, ten or fifteen min.), while lying, feeding and standing behaviours were reliable and consistent

Shrader *et al*. (2006) had demonstrated that in order to find high quality of pasture patches goats used the social information. Feeding dynamics of the goats gets modified in the presence of other group members. May be in reaction to the more competitors, the foraging animals increases their consumption rate in the current patch and thereby lost personal vigilance levels in the phase.

El Aich *et al*. (2007) reported that overall grazing time represent on an average 70% of the total time grazing (higher in winter) with bipedal stance never exceeding 10%,

walking activity 24%, resting behaviour less than 6% when feeding of the goats were based on Argan tree and pasture. They also described diurnal behaviour of goats as they grazed in three different sequences during the day. Limited grazing time in the morning in which goat's grazed while moving, mid-day grazing in which goat slowed down and took short rest in between and last grazing period in which goats increased its pace for grazing.

Goetsch *et al*. (2009) reviewed the feeding behaviour of goats and reported that there are various connections between nutrition and behaviour in goats. These can have effect on production and reproductive efficiencies. While observation methods are still useful, technical advancements have led to the success in observing range of animal behaviour

Pakhreti and Pirta (2010) studied the behaviour of sheep and goat in transhumance Gaddis and found that the frequency of shoulder level and hind leg grazing in goats were higher than in sheep.

Safari *et al*. (2011) found thar due to decline in proteins and digestive elements after the rains, goats increase their grazing time in the late dry season as compared to rainy season which may have contributed to their need to eat more selectively to meet their nutritional needs.

Solanki (2010) documented that indigenous goat of Zalabadi breed spent 7.8, 10.6, 19.2 and 62.4 per cent of time in walking, standing, sitting and grazing respectively. Diurnal activity was observed in the forage selectivity pattern of goats. Grazing was done in two peaks, one in morning and other one in evening. In the morning more plant varieties were pastured than in the evening hours.

Bojkovski *et al*. (2014) found that there are different grazing patterns in sheep and goat which depend on the period of daylight. Grazing is done in the evenings for a longer period of time and during the day for a shorter period of time. At sunrise and sunset the sheep and goats have major grazing period.

Moyo *et al*. (2019) investigated effect of diet and roughage quality on feeding behavior of small ruminants. They found that ruminants spend more time in ruminating than eating or grazing at night and spend more time eating or grazing during the day. Also the time stand idling is more during the day than at night to compensate for the reduced vigilance on the threat of predation.

Mohammed *et al*. (2020) reported that goats spent 94 % of their standing time during daylight for feed consumption (i.e. grazing or browsing). Time spent for feed consumption by the grazing animals ranged 78-85 % of day light (7.8-8.5 hrs).

2.7 Welfare

Brambell report (1965) also known as the "Five Freedoms"/FAWC (Farm Animal Welfare Council,2009) defined animal welfare as being composed of both physical and mental aspects of quality of life and extending beyond the absence of disease. Animal's welfare state can be defined by biological functioning (freedom from disease and injury), naturalness (freedom to perform most normal behaviour) and feelings (freedom from hunger, pain and fear)

Animal welfare includes the physical environment of the animal (e.g. fitness, production), the mental state (e.g. experience) and the capacity to conduct normal behaviours (Fraser *et al*., 1997); however, there is a different perspective on all three elements among stakeholders. Three separate approaches to animal welfare have been developed: one based on affective status, one on biological function and one that relies on natural living as a fundamental measure (Fraser, 2003).

The definition of animal welfare adopted by the Panel on Animal Health and Welfare of the European Food Safety Authority is "Welfare refers to the state of an individual as it attempts to cope with its environment. Effects on welfare include changes in health, mental functioning, positive and negative feelings, physiological and behavioural responses and injuries." The term covers the spectrum of animal states typically assumed to be synonymous with their welfare. An apparent shortcoming of this form of definition is the lack of an explicit context for interpreting data that fits beyond the boundaries set out in the definition. Three interpretive structures are widely followed and, even when used in conjunction, they tend to be weighted accordingly based on the viewpoint of the assessor, the evaluation process or the reason for which the evaluation is being carried out. The three structures are as follows:

Biological functioning – normality as shown from measures of behaviour, physiology, health and productivity

Affective states – as shown by the measures of abnormal behaviours, affective states (positive and negative feelings) and cognitive function, and

Naturalness – As evident by the characteristics of the animal or telos, in particular the usual behavioural repertoires and the characteristics of its environment, in particular the congruence between the current development environment and the often notional, preconceived optimal environment for the species of the animal.

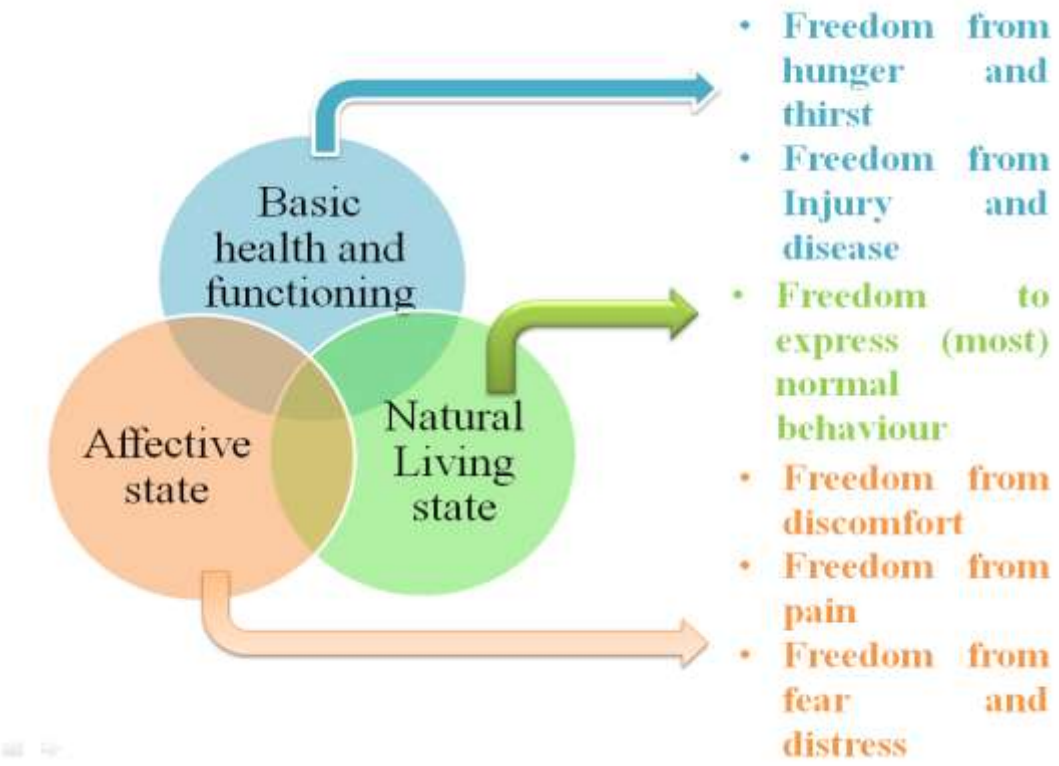


Fig. 2.3 Animal Welfare (Fraser *et al*., 1997; Farm Animal Welfare Council, 2009)

A scientific definition of animal welfare would be: the ability of an animal to cope up physically, behaviourally, cognitively and emotionally with its physiochemical and social environment, including animal's subjective experience of its condition (Scott, 2004).

World Organisation for Animal Health (OIE) (2012) defined animal welfare as mean show an animal is coping with the conditions in which it lives without pain, fear, and distress. An animal is in a good state of wellbeing if it is stable, relaxed, well-nourished, safe, able to communicate intrinsic behaviour, and if it does not suffer from adverse states such as pain, fear, and distress, as demonstrated by clinical evidence. The effective animal care includes the prevention of diseases and proper veterinary care, housing, supervision and feeding, safe handling and fair killing or slaughter. Animal health applies to the animal's state; other words such as animal control, animal husbandry and fair treatment include the attention that an animal gets.

2.8 Welfare issues in migratory goat production

2.8.1 Husbandry practices

Phillips and Phillips (2010) reported that the biggest welfare issues faced by extensively managed sheep were disease and pain caused by the husbandry practices.

2.8.2 Diarrhoea

Pati and Kurande (2008) reported *Enterococcus fecalis* in migratory flocks during downward migration causing 2-7% and 2-15% mortality in sheep and goats, respectively.

2.8.3 Abortions

Sharma *et al.* (1996) studied abortions due to Listeria species amongst the migratory flocks of Gaddi sheep and goats in Himachal Pradesh. *Listeria monocytogenes* was isolated from sheep and goat, whilst *Listeria ivanovii* was isolated from sheep only. Sharma *et al*. (2008) documented abortion outbreaks in 51 flock and sporadic abortions in 114 flocks. *Brucella melitensis*, *Listeria moncytogenes* and *Salmonella dublin* from four, eight and one flocks were suspected of causing abortions, while *Chlamydia psittaci* was suspected in 17 flocks abortion outbreaks. Batta *et al*. (2011) also reported in isolations from samples of 149 sheep and goat migratory flocks with different disease syndromes like abortions, metritis, enteritis and pneumonia.

2.8.4 Endoparasitic infestation

Jithenran and Bhat (1996) documented that helmninths are a significant obstacle for the growth of livestock in Himachal Pradesh and Indian hilly regions. *Dicrocoeliosis* were found in 8.1 per cent Sheep (1488 fecal samples) and 4.1 per cent goats (1552 fecal samples). Infection was also reported to be higher in autumn and summer months than in spring and winter

Jithendran (1998) studied gastrointestinal nematode epidemiology in migratory sheep and goats in the humid northwestern Himalayan area reported that 94% of the infections were gastrointestinal nematodes. In July-September, the severity of infection in terms of monthly mean eggs per gramme of feces (EPG) was revealed, with a high intensity of overall EPG infection ranging from 236 to 3400 in sheep and 325 to 5908 in goats, primarily due to certain parasite species such as *Strongyloides, Trichostrongylus, Haemonchus, Oesophagostomum, Bunostomum and Chabertia*, in a decreasing order of occurance.

Jithendran (2000) found that the main constraints for the profitable small ruminant production in the Himachal Pradesh were the parasitic infections. The most significant flukes reported from the state were Fasciola (liver fluke), Amphistome (stomach fluke), Dicrocoelium (lancet fluke) and Schistosoma (blood fluke), which were problematic mainly during the monsoon and post-monsoon seasons.

Bath and Wyk (2009) reported that gastro-intestinal worms were serious cause of concern for the migratory goats as the animal experiences severe anemia, diarrhea, dehydration and if left untreated the animal may die.

Moudgil *et al*. (2017) performed the detailed copro-parasitological examination and copro-culture of the fecal samples of the Gaddi bucks and found the presence of *Moniezia expansa* and larvae of *Haemonchus* species in the fecal samples of both clinically and sub clinically infected individuals.

2.8.5 Ectoparastic infestation

Ectoparasites in the extensive production system may also pose and potentially cause lethal problems for sheep causing pain and chronic stress (Colebrook and Wall, 2004, Dwyer and Bornett, 2004; Pete Goddard *et al*., 2008)

2.8.6 Nasal and ocular discharge

In three migratory flocks of Gaddi sheep and goats in Himachal Pradesh, Joshi *et al*. (1996) reported PPR outbreaks showed 82.9 percent, 64.6 percent and 57.9 percent of morbidity and mortality ranging from 53.5 percent, 26.7 percent and 17.1 percent respectively. Madhu *et al*. (2014) found nasal discharge in goat due to *Oestrus ovis*. Singh *et al*. (2004) suggested that the disease outbreaks due to *peste des petits ruminants* virus infection was reported to be more severe in goats than sheep. Asrani *et al*. (1999) also reported 5 outbreaks of verminous bronchopulmonitis in peak winter among migratory sheep and goats of Himachal Pradesh having symptoms of coughing, moist rales and chronic diarrhea. Verma *et al*. (2010) found Capri pox virus was to be associated with the morbidity and mortalities in migratory herds in Himachal Pradesh, mainly outbreaks occurring in winters and probably associated with cold stress and fodder scarcity.

2.8.7 Lameness

Lameness in migratory herd is mainly due to foot rot and foot abscess. Foot rot is one of the widespread foot diseases in goats and sheep (Kaler and Green, 2008) that cause

major losses in welfare and production due to lameness. Due to lower forage consumption, lower body weight gains and milk production, reduced reproductive rates and premature culling, it is responsible for economic losses (Pugh, 2004; Tadich and Hernandez, 2000).

Sharma *et al.* (2002) studied the diseases of Himachal Pradesh migratory sheep and reported that the highest percentage (23.8 percent) was muscle skeletal diseases. Of these, the conditions most often encountered were foot disorders. The causes of these disorders were repetitive walking on irregular, undulating, difficult rough and steep rocky slopes. In 22.7 percent of cases, enteritis was the second most frequently observed problem due to heavy rains, lush green grasses in pastures in July and August and non-selective grazing of young flocks. Around 15.2 percent of young ones developed pneumonia at high altitudes due to insufficient partial oxygen pressure.

Wani *et al*. (2015) analysed 216 samples of foot lesion in 15,006 sheep and 12,580 goats of Himchal Pradesh. A total of 6.48 percent (14/216) samples were found positive for *Dichelobacter nodosus,* 20.83 percent (45/216) for *Fusobacterium necrophorum* and 20.37% (44/216) *Trueperella pyogenes*. These play a possible role in aggravating the Footrot-induced infection.

2.8.8 Environmental extremes, accidental deaths and theft

Dogra *et al*. (2018) reported that under migratory production system, the animals were not provided any shelter at all; therefore, they became vulnerable to environmental extremes such as heavy rainfall rendering animals susceptible to diseases. Sometimes, the animals had to cross high passes and long glaciers covered with snow resulting in foot affections and associated problems. Accidental deaths are very common during migration to upper hills and back through narrow and treacherous path making animals prone to accidental slip from cliffs resulting either in death or sometime serious locomotive injuries which rendered the animal unfit for further migration and forced the farmers to dispose it off at throw away prices. Theft is more frequent during migration in lower hills. Many farmers reported that almost every year substantial livestock losses occurred due to theft by antisocial elements and farmers were not in a position to report it immediately to local authorities

Dogra *et al.* (2011) reported that the causes of mortality in migratory flocks were wild attack (48.42%), diarrhea (31.57%), consumption of poisonous grasses (9.47%), sudden accidents (1.07%) and diseases (9.47%). As high as 65.26% of mortality was

observed in Gaddi kids (0-3 months), out of which 66.12% died due to the wild animal attack.

Dogra *et al*. (2019) reported year wise mortality of 10.92% in 2014-2015, 7.49% in 2016-2017, 7.11% in 2016-2017, 6.78% in 2017-2018, and 8.10% in 2018-2019 among Gaddi goat flocks and the causes of mortality reported in 2018-2019 were colibacillosis (diarrhoea) (23.80%), Pneumonia (27.21%), NAD/ general weakness (10.20%), toxemia / acidosis (plant poisoning) (10.20%), predation (12.24%), coccidiosis (9.52%) and liver abscess (6.80%). The major causes of morbidity in Gaddi flocks were diarrhea (22.05%) and cough (18.25 %).

2.8.9 Other welfare issues

Singh *et al.* (2006) reported that the main constraints in Himachal Pradesh's migratory sheep and goat production system are the scarcity of fodder in the foothills and plains during the winter, while the other constraints were the lack of facilities for marketing and processing, low output rates, wild animal attack and high morbidity rate.

Grant (2004) recorded that many repetitive husbandry activities that induce pain and discomfort (ear marking, tail docking, castration and vaccination) are concurrently subjected to lambs in extensive production, which may have a negative effect on their welfare.

In Kangra district of Himachal Pradesh, Singh *et al*. (2006) conducted a report on the migratory sheep and goat development system and reported that feeding practices were poor; they did not feed their animals with concentrate, supplements and vitamins, but vaccination practices was satisfactory adopted

Munoz *et al*. (2018) identified welfare issues in 32 commercially extensive sheep farms of Australia. Study was conducted on 6200 ewes using six animal based indicators: body condition score (BCS), fleece condition, skin lesions, tail length, dag score and lameness. Moderate/extreme lameness or foot-related conditions, poor body condition (BCS ≤2) and active dermatophilosis were reported to be the main reasons for further care. Moreover, short tail length (85.7 %) was prevalent welfare issue found in all farms. Less common, other welfare issues were also reported, such as ear lesions due to sunburn, bad condition of fleece, cuts of shearing and obese ewes. Overall, the problems found in this study emerged from management strategies and can be handled or alleviated by them.

Munoz *et al*. (2018) examined animal-based parameters on 100 adult Merino ewes reared under extensilvey management system of Australia during mid-pregnancy, mid-lactation and weaning. Eight welfare measures viz. flight distance, body condition score, fleece condition, skin lesions, tail length, dag score, lameness and mastitis were used for welfare assessment. Overfreeding, ewe mortality, lamness, ectoparasites (flystrike) and mastitis were the main welfare issues.

2.9 Welfare indicators

Each welfare criterion contains specific indicators that can be used to determine each welfare component (Rushen *et al*., 2011). At farm level indicators may be broadly divided in to animal based indicator and resource based indicators (Main *et al*., 2003; Johnsen *et al*., 2001). Indicators used for assessment of the welfare should be associated with the physical and mental well-being of the animals. Some of these indicators refer to only one criteria, while others include detail on many topics pertaining to welfare. For example, details on disease incidence (e.g. paratuberculosis or caprine arthritis encephalitis virus (CAEV), long-term dietary restriction, unbalanced diet, parasitism, etc. can be given by the body condition score (BCS)

Indicators should be quick to apply and interpret welfare for inclusion in on-farm welfare assessment (Farm Animal Welfare Council, 2005). It is possible to break farm animal indicators into behavioural, physiological, health and zootechnical indicators (Broom; Fraser, 2010; Appleby *et al*., 2011). In addition, the indicators must be valid (important in terms of animal welfare), reliable (the tendency of two or more observers to provide the same results) and feasible (they can be calculated with realistic cost and time criteria at the farm level) (Napolitano *et al*., 2009). Most valid assessment of welfare is obtained by combining both the animal-based measures and resource based measures (Johnsen *et al*., 2001). The single-mined pursuit of any one criterion for welfare assessment may lead to poor judging of welfare. Welfare assessment necessitated a multifaceted method, matching to a multi-criteria evaluation issue, with the goal of determining true animal welfare, comprising both physical and mental health (EFSA, 2012).

Varieties of animal-based interventions are available and can be seen together as a 'toolbox' where the most applicable interventions for a specific disease or species are selected (EFSA Panel on Animal Health and Welfare, 2012). Resource-based (e.g.,

airflow, housing size, paddock surface quality) and management-based (e.g. feed regime, feed intervals) interventions are often used in welfare appraisal guidelines, but they are mainly risk factors and thus cannot indicate much about the animal's current welfare status.

It is possible to narrowly categorize welfare assessment into resource (input) and animal (output) dependent assessments (Main *et al*., 2003). Those that provide both input and output indicators are likely to be the most successful measurement protocols (Johnsen *et al*., 2001). ABMs / OBMs (Animal Based Measure / Output Based Measures) backed by RBMs (Resource Based Measures) and management-based measures to determine risk factors may be based on welfare evaluation, which are those factors used to help diagnose the actual causes of welfare problems. Once the causes are identified, strategies can then be put in to place to reduce and eliminate the problems. The combination of animal, resource and management related measures may be suitable for the assessment of farm welfare (Capdeville and Veissier, 2001; Waiblnger *et al*., 2001).

2.9.1 Resource based (Input)

The physical situation of the animal is determined by the resources given. These are also necessary for providing advice on how to avoid welfare problems and how to assess the risk of insufficient welfare. Because measurements are usually quick and easy (e.g., the Animal Need Index TGI 35 L created by Bartuseek (1999) for numerous species), resource-based indicators have become more popular in welfare evaluation methods.Several resource-based indicators have been used to estimate animal welfare status at farm level, since they are less arbitrary, sometimes easier to audit (requiring very little assessor training), very convenient (a brief farm visit is generally adequate for all metrics to be assessed) and highly repeatable, often with high inter- and intra-observer repeatability.

2.9.2 Animal based indicators (Output)

Good management and environmental resource management may not always equate to high welfare standards (Sejian *et al*., 2011). Assessments based on resource-based indicators do not fully address concerns about the animals' real welfare situation on a specific farm (Rushen *et al*., 2011; Main *et al*., 2003). The European Union (EU) has also recently highlighted the need for welfare schemes focused on animal-based measures rather than resource-based or management-based ones. Animal-based indicators have increasingly been a preferred approach and have been found to be more valid in the

wellbeing appraisal as it offers the most clear input into how animals deal with their own environment (Capdeville and Veissier, 2001; Whay *et al*., 2003). Better animal welfare metrics could be given by ABS (Animal Based Measures), since welfare is a function of the actual animal, not just the system in which animals are housed.

As evidenced by the shifting of schemes that measured environmental aspects (which may show high variation from country to country due to different housing and management conditions) towards one that measures the way in which the animal itself responds to such environment, Animal based measures are more appropriate indicator when compared to non-ABM indicators /Resource based and environmental based (FSA, 2012; Whay *et al*., 2003; World Organisation for Animal Health OIE 2012). The measurement of the dietary status (e.g. body condition score), environmental factors (e.g. fleece factors) and diseases (e.g. lameness, mastitis) are animal-based indicators (Munoz *et al*., 2018).

2.9.3 Management based indicators

The key management decisions about the life of the animal are how and where they are handled, transported and combined with other animals and repetitive procedures such as beak trimming, tail docking or dehorning (Blokhuis *et al*., 2013). This consists of a more indirect component of animal health, based on the premise that if we have the right habitat and treatment for the animal, it would have a high quality. They are often commonly the type of indicators used for legislation, and where well-chosen resource-based measures can avoid the occurrence of welfare issues, the risk factors or dangers that can influence animal health can be calculated (Rushen *et al*., 2011).

2.9.4 Human-animal indicators

Strong human-animal interaction (HAR) characterised by animals with low human fear, can enhance animal health and help prevent issues with their care. Negative beliefs about goats and aversive handling by the stockperson will cause physiological stress on goats reducing their welfare through classical conditioning. Gentle handling includes stroking, patting, resting the hands on the animals while aversive handling includes slapping, hitting with stick. Stockmanship competence can also be used as an indicator to assess the welfare of goats in migratory system. It denotes the systematic and balanced approach to livestock handling (Hibbard, 2013). Animals that are handled positively were more relaxed in presence of humans (Waiblinger *et al*., 2006). Stockperson can affect the

welfare by directly interacting with the animals and indirectly through management decisions. Muri *et al*. (2013) reported that fear level is of particular concern in some herds

Behaviour of a stockperson can be influenced by the gender, work motivation and overall trust in his or her position. Stockperson behavioural attitudes can be recorded on the basis of attitudinal statements whose response can be recorded on seven-point rating scales with descriptors (Hemsworth*et al*., 2000; Lensink *et al*., 2000, Muri *et al*., 2013).

Chin contact test

A chin test was used to measure the goat's fear of the unfamiliar human. Standing in front of each goat, the observer reach out with an arm pointed upward and slowly move the hand towards the goat's chin. On a three-point scale, the goat's reaction to the approaching hand was recorded as full acceptance, brief touch or full avoidance (Muri *et al*., 2013).

Latency to first contact test (AWIN 2015)

The time between the assessor standing at a pre-determined starting location in the pen and the first goat nuzzling or touching some part of the assessor's body was recorded (maximum time: 300s). The assessor exits the pen after analysing the latency for the first touch test before returning to execute the Avoidance distance test.

Avoidance distance test (Mattiello *et al*., 2010)

The number of contacts (the goat withdraws after a touch of 3s) and acceptance (the goat accepts a mild stroke of the head for > 3s) were used to determine how each goat reacts to the approaching assessor. The approach to the goats was standardised: the assessor stands at a distance of 200 cm from the goat and approaches slowly (one step / s) towards it with the arm outstretched and palm directed downwards.In the avoidance test, the same test person moved around the pen attempting to touch as many individual goats as possible within 2 min (AvTouch=number of goats touched). As the migratory goats have larger flight distance than the intensively reared goat therefore, avoidance distance test can be replaced with the withdrawal distance.

2.10. Welfare assessment protocol for goats

Welfare assessment on the rationale of the Five Freedoms was used in the Bristol Welfare Programme (BWAP) (Main *et al*., 2004, 2007). BWAP seeks to implement

current animal-based welfare assessment methods into the qualification framework for traditional and organic farming.

Napolitano *et al*. (2009) used the Animal Need Index (ANI) 35 L of cattle to determine the health of sheep on organic and traditional farms. With a lack of animal-based indicators, ANI is mostly based on infrastructure requirements.

The Welfare Quality ® initiative extended the 'Five Freedoms' (Brambell Committee, 1965) structure for the understanding and appraisal of animal welfare, providing a comprehensive philosophy spanning the numerous areas of animal welfare (Blokhuis *et al*., 2013). Twelve standards based on four welfare principles (Blokhuis, Veissier, Miele & Jones , 2010; Rushen *et al*., 2011) were based on welfare quality protocols, each formulated to communicate an important welfare problem and branched into separate criteria (Welfare Quality, 2009). The aims of the four principles are very similar to the concept of animal welfare of the Five Freedoms (FAWC, 2009) and the OIE (World Organization for Animal Protection, OIE, 2012) and can thus be viewed as a valuable framework for ensuring good welfare (Rushen *et al*., 2011).

The use of animal-based measures (ABMs/Outcome based measures) to estimate the current welfare status of the animals in terms of their actions, health or physical condition was the focus of their work. While management-based measures (MBMs) and resource-based measures (RBMs) (or input factors) are more objective and repeatable, they simply suggest the possibility of welfare problems rather than providing an actual assessment of wellbeing (Rousing *et al*., 2000). In compliance with the 4 principles and 12 standards defined by the standard of welfare, Botreau *et al*. (2007) classified twenty-five animal based indicators. The 12 criteria were used to identify indicators when assessing the farm. Exhaustive (no incomplete item), minimum (only required items), decided by stakeholders and legible (limited number of parameters) are the collection of parameters. Moreover, the interpretation of one standard does not rely on the interpretation of another.

The Muri Goat Protocol has been shown to be accurate, efficient and to have certain standard requirements for consumer understanding of animal welfare (Muri *et al*., 2013). According to the Muri Protocol, measures for the measurement of animal welfare can be classified into five points of view: animal-based measures, Human- animal based

indicators, management indicators, resource-based indicators and environmental indicators.

The Animal Welfare Indicators Project (AWIN) was established in 2011 with the title "Development, integration and dissemination of animal-based welfare indicators, including pain, in commercially important husbandry species, with special emphasis on small ruminants, Equidae and turkeys" in commercially important husbandry species, with a specific focus on small ruminants, equines and turkeys.' It was funded by the EU VII Framework Programme and was expected in May 2015 to present its final findings. Protocol was published in 2015 to determine milk goat welfare using animal-based indicators in Europe (AWIN, 2015). Project AWIN has created indices for animals not regarded in terms of standard of welfare.

Stilwell *et al*. (2016) have reported that veterinarians and farmers can routinely use a good welfare assessment protocol as a powerful tool for approval schemes and for health tracking. It will serve as a method for rational measurement of welfare and to recognize issues in health and production at the farm level.

2.11 AWIN protocol for dairy goats

The Animal Welfare Indicator (AWIN) project was created to develop animal-based protocols for assessing welfare in different animal species, including goats. AWIN protocol for dairy goats is applicable for goats reared in intensive or semi-intesive (occasional access to pasture) production systems. The AWIN project followed the Welfare Quality standards and criteria and had these indicators tabulated in the Welfare Quality Format. Four principles and twelve parameters describe welfare quality, most of which are described in the protocols of AWIN (Animal Welfare Indicators Project) (Welfare Quality, 2009; AWIN Project, 2015).

Each criteria has welfare indicators which can be observed under more than one principle. The AWIN prototype incorporates 14 group-level indicators and 11 individual-level indicators, which are analyzed to generate the prevalence of each indicator (Table 2.1). It is a welfare appraisal approach focused on research, founded on animal-based indicators, including pain.

Table 2.1 Indicators of AWIN protocol for dairy goats

Welfare Principles	**Welfare Criteria**	**Welfare Indicators**
Good feeding	Appropriate nutrition	Body condition score Hair coat condition Queuing at feeding
	Absence of prolonged thirst	Queuing at drinking
Good housing	Comfort around resting	Bedding
	Thermal comfort	Thermal stress
	Ease of movement	Kneeling at feed rack
Good health	Absence of Injuries	Severe lameness
	Absence of disease	Abscesses Body condition Score fecal soiling Hair coat condition Nasal discharge Oblivion Occular discharge Overgrown claws Udder asymmetry
	Absence of pain and pain induced by management procedure	Improper disbudding
Appropriate behaviour	Expression of social behaviour	Queuing a drinking Queuing at feeding
	Expression of other behaviour	Oblivion
	Good human-animal relationship	Latency to the first contact test
	Positive emotional state	Qualitative behaviour assessment

2.11.1 Procedure for welfare assessment according to AWIN protocol

AWIN protocol is applied in two separate phases. Phase one consist of group level assemnet using certain set of indicators, which are quick and easy to assess. Phase two is only carried out if the welfare violations are encountered or if the farm has 5 % lowest score for any indicator. In phase two, set of different welfare indicators are applied to individual animal

2.11.2 Group level assessment

Pythian *et al*. (2012) assessed the used eight indicators that were animal based (irritation of skin, loss of wool, demeanour, lameness, excessive panting, coughing, and ventral abdominal cleanliness and 'breech' areas and suggested that Welfare findings based on behavioural observations and the physical appearance of individual animals in a group can provide a valid and feasible instrument for assessing sheep well-being at farm level.

Qualitative behavioural assessment (QBA) helps in providing social interactions observations for assessment of stress and social tension on farms animals in a shorter period of time. The Qualitative Behaviour Evaluation (QBA) is a whole-animal technique, using words such as stressed, nervous or comfortable to add subjective details of the verbal demeanour of the animals. Dr. Françoise Wemelsfelder developed it; it has been included in many farm species since then and has been used in the protocols of Welfare Standard. Waiblinger *et al*. (2017) reported that the quick QBA findings are relevant for assessing the degree of social stress in dairy goat herds (assessed by the occurrence of social encounters and injuries), but also represent other facets of welfare. Muri *et al*., 2013 reported significant associations were found between qualitative behavioural assessments and measures of health and stockmanship. Kooring (2017) reported that the size of the farm was associated with the QBA's negative emotions (cor=0.68) and the larger the farm, the more goats displayed negative emotions. He also concluded that instead of horn presence, injuries and social stress was caused by group stability, condition of housing, management of feeding and Human-animal relationship

2.11.3 Individual assessment

Body condition scoring can be a used as a good instrument for tracking nutritionally status of flocks in extensively production system (Morgan-Davies *et al*., 2008). Palpation was stated as an infeasible indicator for welfare assessment as the main

thing is to distinguish the very fat and fat thin animals only (Vieira *et al*., 2015). To easily test BCS in dairy goats, the Portuguese team created a pictorial body image scale. Each goat should be examined in a standing posture from behind; ensuring a good view of the rump area. BCS, using a 3-level scoring methodology, is visually scored on individual goats. The goats may be categorized as fit, fat or thin.

Morgan-Davies *et al*. (2007) reported that mid-pregnancy body condition score is a very important animal welfare indicator, which can be used to predict subsequent ewe survival across a wide range of winter management, nutrition and body condition changes. Preventing ewes falling to lower scores, by culling or transferring out those with very low body condition in the autumn and by good nutrition in early and mid-pregnancy, is confirmed as sound advice. Condition affecting the integumentary system, injuries, lameness, and body condition score have also been recommended as significant health metrics in the assessment of goat welfare by Caroprese *et al.* (2009).

Stubsjøen *et al*. (2011) reported lower BCS 2.6 (± 0.6) in sheep across all the farms. A comparatively significant proportion of ewes had a 2 (41%) BCS was reprted to be linked to increased nutritional stress, disease incidence and poor productivity.

2.12 Welfare assessment of goat

Before the development of the AWIN protocol fewer studies were also reported to use different animal or resource based measures for welfare assessment of goats. Anzuino *et al*. (2010) assessed twenty four commercial dairy goat farms of England for health and welfare in England based on direct observations and identified the welfare issues viz. claw overgrowth, lameness, skin lesions, udder lesions, teat lesions, and pruritus.Muri *et al*. (2013) also tested a comprehensive welfare assessment protocol {derived from dairy cow protocols developed by BWAP (Main *et al*., 2004, 2007) and the Welfare Quality Project 2009} on 30 commercial dairy goat farms in Norway and concluded ocular discharge (93.3%), skin lesions (96.7%), udder asymmetry (100%), calluses on knees (100%) and hocks (90%), and overgrown claws (100%) most prevalent conditions in farms.

Can *et al*. (2016) conducted on-farm welfare of three size categories (small, medium and large) of 30 commercial goat farms of Portugal using animal based indicators (AWIN protocol prototype including eleven indicators and individual level and fourteen indicators at group level and) and found that the main welfare areas of concern were overgrown claws (35.5%), poor condition of hair coat (22.9%) feed queening (22.8%) and

dirtiness in hindquarters (18%). Larger farms have higher prevalence (48.5%) of claw overgrowth when compared to smaller ones (11.4%)

Battinin *et al*. (2016) tested the AWIN welfare assessment protocol for goats in thirty intensive farms (N=30) of Italy. The farms were classified as small, medium and large with the flck size of <50, 51-100 and >101 lactating goats respectively. He concluded that the larger farms have worse welfare than the smaller farms. Overgrown claws and prevalence of the dirt goats were statistically lower in the smaller flock size. The most common issue at individual level was overgrowing claws (47.2% ±6.0), faecal soiling (16.7% ±4.9%), too thin (14.5% ±2.5%) and excess obese goats (5.1% ±1.3%).

Leite *et al*. (2017) designed a welfare assessment protocol for meat goats using AWIN protocol. Some of the AWIN indicators were excluded such as udder asymmetry, improper disbudding, queuing at drinking as they are more focused towards intensively reared goats (AWIN, 2015a). It also included indicators (body and head lesions, leg injuries, familiar approach test, panting and lameness and water availability) from the AWIN protocol of sheep as they are more concerned with the goats reared in the Brazilian conditions(AWIN, 2015b). Cleanliness of the facilities was also added as a new indicator for the welfare assessment of goats

Kooring (2017) developed a summary protocol derived from Muri Protocol (Muri protocol which was further improved by comparing it with Welfare Quality and AWIN protocol to make it short and easy to use. He tested this protocol on 10 farms in Netherlands and found the specific health issues such as vaccination bulbs, claw conformation, disbudded horns regrowth, and pathologies of pinnae.

2.13 Effect of Flock size on welfare

Waterhouse (1996) reported that if decreased labour has been introduced by more intensive grazing and practises, it is possible that lower livestock care and higher lamb mortality will result.Phillips and Phillips (2002) reported that the management and housing conditions of larger size herds threat the animal welfare in a different way (not necessarily better or worse) than small or medium herds. Stott *et al*. (2005) reported labor availability and quality as the biggest threat for providing good welfare to the British sheep farms.

Goddard *et al*. (2006) reported that there is an increasing awareness of the need to consider the effect on the sheep of human: animal relationship. The key human animal interactions occur at the time of zootechnical operations such as during sale, lambing

etc.Vosough Ahmadi *et al*. (2010) reported that to ensure optimal animal welfare by farm labourers and for sustainability, trade-off between animal welfare and profitability of farm is required. Larrondo *et al*. (2018) found that the understanding of animal care and suffering associated with husbandry activities in large flocks by certain sheep farmers could be impaired, specifically due to reduced human: animal contact, a condition that was different in smaller flocks.

Flock size was reported to influence the perception of animal's pain among farmers. Perception of pain due to husbandry practices was reported to be less in large sheep farms than those of smaller farms, perhaps because the animals were regularly gathered and observed under extensive production and are also exposed to a vast majority of painful practices at the same time (Sutherland, 2011). When the size of the flock is very large, the task of husbandry must be done more rapidly, thereby restricting the detection of any pain-related activity that is often intense and happens within the first 30 to 60 minutes after painful procedures. (Kent *et al*., 2001; Molony *et al*., 2002)

CHAPTER –3

Materials & Methods

MATERIALS AND METHODS

The following methodology and procedure were employed to study behaviour and welfare of migratory flocks of Gaddi goats in North-Western Himalayan region.

OBJECTIVE: 1

3.1 Study of natural behaviour of Gaddi goats at different altitudes

3.1.1 Selection of migratory routes

The behavioural study of goats was done on the two migratory routes M1 and M2 out of the 4 routes of the flocks adopted by the AICRP Gaddi field unit, Palampur (Fig. 3.1). The altitude is divided in to three hills as high hills (>1800 m above mean sea level), mid hills (651-1800 m amsl) and low hills (350-650 m amsl) (Anonymous, 2009). Following are the migratory routes of the adopted flocks depicting the starting and endpoint.

Table 3.1 Migratory routes of the flocks adopted under AICRP (Gaddi unit) project

<table>
<tr><th rowspan="2">Altitude</th><th colspan="4">Migratory routes</th></tr>
<tr><th>M1</th><th>M2</th><th>M3</th><th>M4</th></tr>
<tr><td rowspan="2">High hills (>1800 m amsl) Humid Temperate</td><td>Batal (Lahaul and Spiti)</td><td>Rohtang (Lahaul and Spiti)</td><td>Khuthi Dhar (Chamba)</td><td>Bara Bhangal (Kangra)</td></tr>
<tr><td>Rohtang (Lahaul and Spiti)</td><td>Manali</td><td>Nayagran</td><td>Manjuari</td></tr>
<tr><td rowspan="2">Mid Hills (651-1800 m amsl) Sub Temperate</td><td>Gumma (Mandi)</td><td>Jogindernagar (Mandi)</td><td>Sujanpur</td><td>Barot</td></tr>
<tr><td>Palampur (Kangra)</td><td>Palampur (Kangra)</td><td>Naina Devi (Bilaspur)</td><td>Katindi (Mnadi)</td></tr>
<tr><td rowspan="2">Low Hills (350-650 m amsl) Sub Tropical</td><td>Majhin</td><td rowspan="2">Nadaun (Hamirpur)</td><td rowspan="2">Anantpur Sahib (Una/ Bilaspur)</td><td>Ghagus</td></tr>
<tr><td>Kundiyan (Kangra)</td><td>Solan</td></tr>
</table>

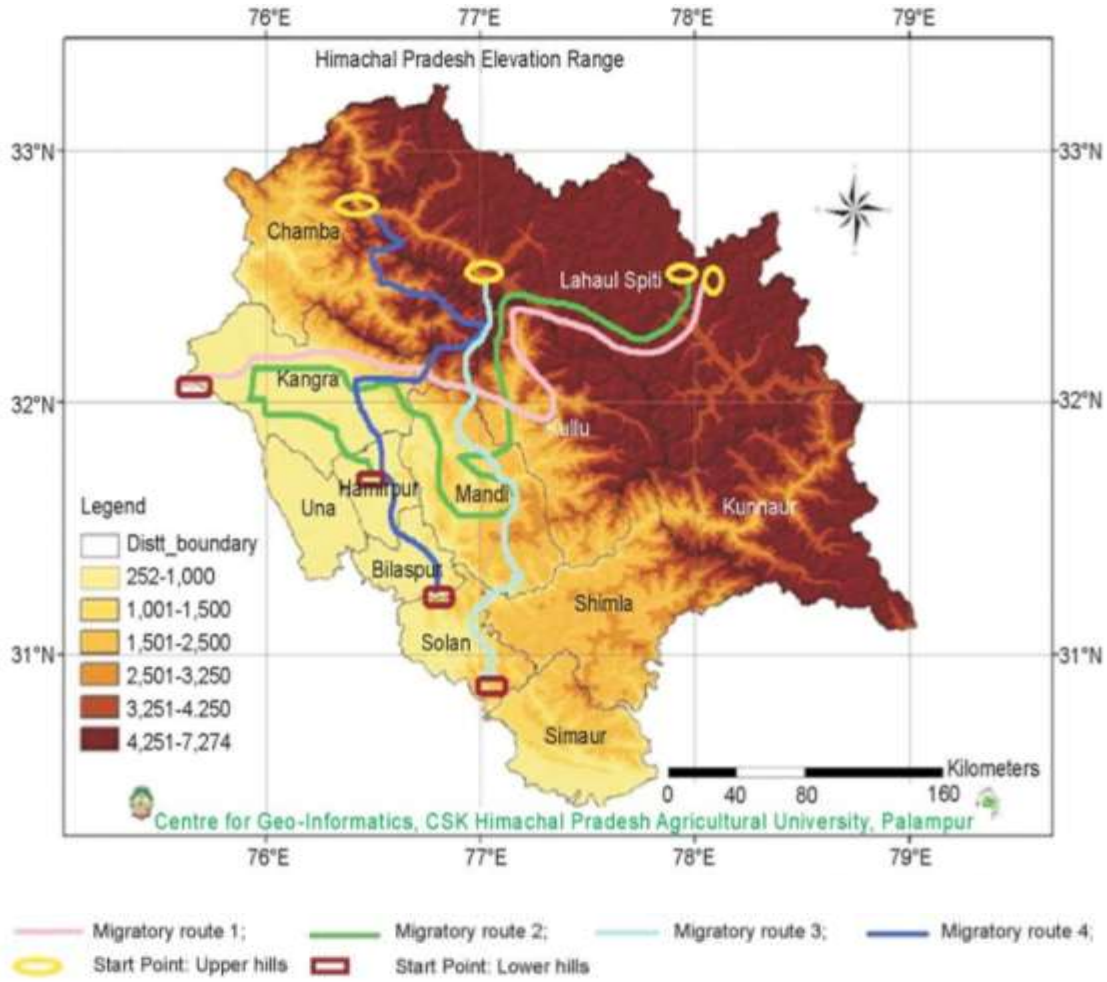


Fig.3.1 Picture showing migratory routes of selected flocks

The altitude is divided in to three categories based on the key stages of reproductive cycle of Gaddi goats as

1. High hills (>1800 m above mean sea level)/Mid-pregnancy (MP)
2. Mid hills (651-1800 m a Msl)/Post-kidding (PK, 7-14 days after kidding)
3. Low hills (350-650 m a Msl)/ Mid-lactation (ML)

3.1.2 Selection of flocks and sample size

From each migratory route M1 and M2, two flocks were selected. 10 per cent of the animals were randomly selected from each flock for behavioral observations. Selected goats were marked for identification and recording was done for behavioural observations using (Sony handycam HDR XR150).

Plate 2. Recording of behavioral parameter of goats during grazing using camera

3.1.3 Behavioural parameters

Behavioral traits of the Gaddi goat that were recorded are elaborated in Table 3.2.

Table 3.2 Behaviour parameters recorded at different altitudes

S.No.	Behaviour	Descriptiom
1.	Grazing	Animal eating grass, fruits or seeds with its head in downward position
2.	Browsing	Animal standing or walking with its head in tress or shrub
3.	Walking	Animal walking, without performing any other visible activity
4.	Idle standing	Animal standing, without performing any other visible activity
5.	Idle lying	Animal lying, without performing any other visible activity
6.	Rumination	Animal chewing without any visible foodstuff in mouth both when lying, standing and moving. It includes rumination + standing and rumination + lying
7.	Bipedal stance	Animal standing on their hindlimbs and eating offshoots, buds, and leaves
8.	Auto-grooming bouts	Animal licking, grabbling the body, skincare or scatching with hind leg or horn
9.	Allogrooming bouts	Animal performed licking or grooming behaviors between the pairs
10.	Object grooming bouts	Animal scratching the body parts by rubbing tress, bushes etc

3.1.4 Behavioural observations

Behavioural observations were done by using the following methodology. Behaviours were recorded at key stages of production cycle during post-kidding (PK) at low-hills, during mid-lactation (ML) at mid-hills and at mid-pregnancy (MP) at hill-hills (Fig. 3.2). Behaviours were recorded for 15 min/hour for 8 hours of grazing daily for four consecutive days using focal sampling by video cameras on four flocks. Grazing time (8 hours) of Gaddi goats differ during summer and winter. In summer the grazing time was from 6:00 AM to 10:00 AM and 2:00 PM to 6:00 PM during winters, while winter grazing time was 9:00 AM to 5: 00 PM.

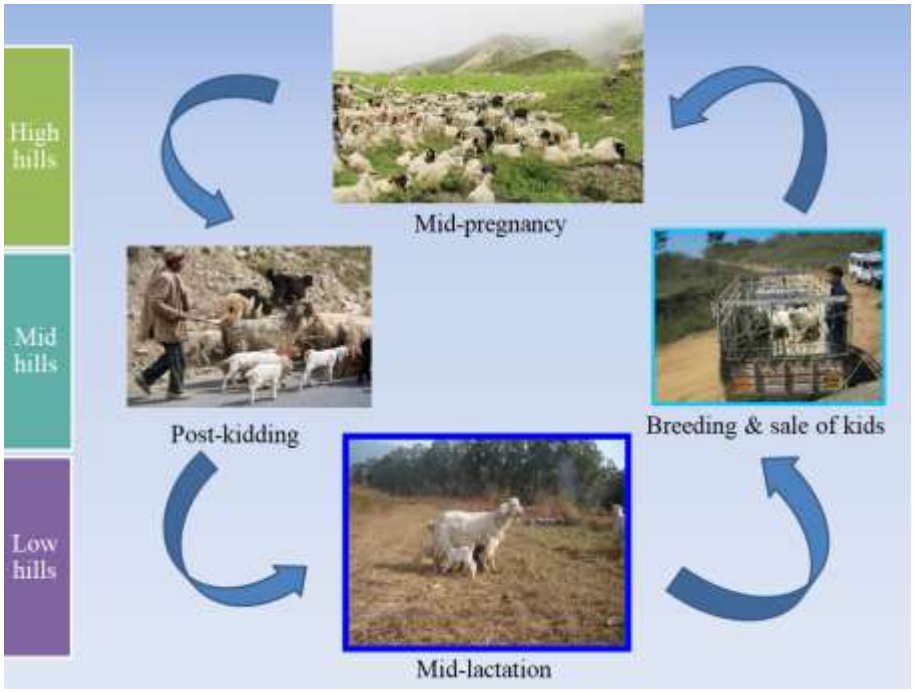


Fig. 3.2 Different reproductive stages of Gaddi goats during migration

OBJECTIVE: 2

3.2 Development of welfare assessment protocol for migratory goats

Development of the welfare assessment protocol were carried out in the following five stages

Stage 1. Reviewing existing welfare measures

Parameters to be considered for the development of welfare assessment protocol for the goats under migratory system on the basis of literature were proposed. Proposal of potential welfare indicators to be used for welfare assessment protocol in migratory goats were based on the following broad categories.

1. Resource base
2. Animal based
3. Stockmanship
4. Management based
5. Productive and reproductive performance

The Feasibility, validity and reliability of each welfare indicator was also assessed from literature review. The 4 principles and 12 criteria of the AWIN welfare protocol were used to develop the list of potential welfare indicators for welfare assessment of migratory goats. The principle of "Good Housing" was broadened and renamed "Good Environment/ Facility around camping".

Stage 2. Consulting experts

The list of these indicators was verified by an expert panel which comprised 46 members having experience of more than 5 years in goat welfare, health and production from various institutes, CIRG (Central Institute for Research on Goats), veterinarians. Each selected indicator was discussed with the expert panel through personal meeting or email consultation. Indicators suited for welfare assessment in migratory conditions was accepted, rejected or selected for further evaluation.

Potential welfare indicators were selected on the basis of their WAI (Weighted Average Index) values. WAI of each indicator was calculated by adding up the response numbers of each indicator multiplied by a weighted value between 0.2 and 1 dividing by the number of responses. The median has been considered as the cut-off point for the selection of the indicators.

$$\mathbf{WAI=\Sigma\, f_{i}w_{i} / \Sigma\, f_{i}}$$

f_i = frequency of the respondents

w_i = The weight each of the likert score values assigned as follows

Not important (1)	:	0.2
Slightly important (2)	:	0.4
Moderately important (3)	:	0.6
Important (4)	:	0.8
Very important (5)	:	1

Stage 3. Developing welfare assessment scale

The proposed welfare assessment welfare scale was developed based on five freedoms given by Farm Animal Welfare Council (1993) and four principles of animal welfare (Botreau *et al*., 2007).

The Five freedoms of animal welfare as per Farm Animal Welfare Council (1993) are

1. *Freedom from hunger and thirst* -by ready access to fresh water and a diet to maintain full health and vigor
2. *Freedom from discomfort*-by providing an appropriate environment including shelter and a comfortable resting area
3. *Freedom from pain, injury, and diseases* -by prevention or rapid diagnosis and treatment
4. *Freedom to express normal behaviour*-by providing sufficient space, proper facilities and company of the animals and own kind and
5. *Freedom from fear and distress* -by ensuring conditions and treatment which avoid mental suffering

Four principles of animal welfare

The principle of good housing was broadened and renamed as Good Environment as the pastoral/migratory goats are neither tethered nor housed

Table 3.3 Four principles of animal welfare

Four principles of animal welfare	**Welfare criteria**
Good feeding	Appropriate nutrition
	Absence of prolonged thirst
Good environment	Comfort around resting
	Thermal comfort
	Ease of movement
Good health	Absence of injuries
	Absence of disease
	Absence of pain and pain induced by management procedure

Appropriate behavior	Expression of social behaviour
	Expression of other behaviour
	Good human-animal relationship
	Positive emotional state

Welfare principles, criteria and indicators were further weighted and modified as per suggestion of the expert panel. The scoring system was also designed for indicators to be used for welfare assessment.

Stage 4. Testing reliability and validity of the scale

Reliability of scale

The reliability of the scale was calculated in terms of internal consistency by computing Cronbach's alpha. The computation of Cronbach's alpha is based on the number of items on the survey (k) and the ratio of the average inter-item covariance to the average item variance.

Cronbach's alpha $\alpha = k\,(cov/var)1+(k-1)(cov/var)$

Under the assumption that the item variances are all equal, this ratio simplifies to the average inter-item correlation, and the result is known as the Standardized item alpha (or Spearman-Brown stepped-up reliability coefficient).

Validity of scale

- Content validity of scale was done by consulting the experts
- Threshold level for scale to be valid was 80%

Finally, the score obtained from the welfare assessment of the flocks was then used to place it in one of the four following categories and percentage of flocks that fall in these categories was determined such as excellent, enhanced, acceptable and unclassified

Satge 5. Testing feasibility of the validated indicators during key stages of Gaddi goat reproduction cycle

To test the feasibility of the prototype, 50 goats were randomly selected from each of four migratory flocks (N=150). Welfare indicators were tested on all the selected flocks during following key stages of Gaddi goat reproduction cycle

- Low hills (Mid-Lactation)
- Mid hills- (Post-Kidding)
- High hills (Mid-Pregnancy)

OBJECTIVE: 3

3.3 Level of welfare of Gaddi goats in different flock sizes

For fulfilling this objective the assessment schedule (Guide Book) was developed for collecting data pertaining to each indicator and for each components of scale as described in annexure 1.

3.3.1 Selection of goat flocks and sampling design

Enroute Welfare assessment of the selected flock sizes was done at low hills during mid-lactation using the proposed final welfare assessment protocol for migratory goats. Welfare assessment was performed at low hills on two migratory routes on 24 flocks categorized into small (S<100), medium (M=100-200) and large (L>200) with eight flocks each (Sankhyan *et al*., 2016). Flocks were ranked according to the welfare ranking criteria presented in Table 4.3

Table 3.4 Welfare ranking criteria

Total Welfare Score	**Welfare category**
The flocks obtaining a total score of more than 80	Excellent
The flocks obtaining a total score between 60-79	Very Good
The flocks obtaining a total score between 40-59	Average
The flocks obtaining a total score of less than 40	Poor

3.3.2 Farmer selection

The list of farmers from different categories of flock sizes are presented in Table 3.5, 3.6 and 3.7

Table 3.5 List of selected small flocks owners

Sr.No.	Name of flock owner	Village	District	Flock size	Sample flock size
S1	Vikram	Lanj	Kangra	95	47
S2	Ranbir Singh	Nagri	Kangra	89	44
S3	Balya Ram	Kugti	Chamba	70	41
S4	Balwant	Kugti	Chamba	40	29
S5	Shankar Ram	Holi	Chamba	60	37
S6	Ram Singh	Bhawarna	Kangra	72	41
S7	Kunju Lal	Bindravan fata	Kangra	85	44
S8	Chaitar Singh	Bindravan fata	Kangra	75	41

Table 3.6 List of selected medium flocks owners

Sr.No.	Name of flock owner	Village	District	Flock size	Sample flock size
M1	Angrez	Bandla	Kangra	150	59
M2	Angrez	Kugti	Chamba	120	49
M3	Suresh Kumar	Bhagotta	Kangra	200	63
M4	Jaspal Singh	Phrer, Palampur	Kangra	130	55
M5	Ghellar Ram	Holi	Chamba	108	49
M6	Subash Chand	Bharmour	Chamba	175	63
M7	Sardari Ram	Chaupati	Kangra	145	55
M8	Paras Ram	Kandi	Kangra	165	59

Table 3.7 List of selected large flocks owners

Sr.No.	Name of flock owner	Village	District	Flock size	Sample flock size
L1	Lal Chand	Bhawarna	Kangra	205	65
L2	Hoshiar Singh	Bhawarna	Kangra	210	65
L3	Suresh	Guga Saloh	Kangra	225	68
L4	Bhani Ram	NagrotaBagwan	Kangra	250	70
L5	Jai Singh	Bhagotla	Kangra	270	70
L6	Karam Chand	Bhagotla	Kangra	350	73
L7	Mehar Singh	Uarna Kandi	Kangra	290	70
L8	Pawan Kumar	Bandla	Kangra	240	68

3.4 Welfare indicators description

A. Feeding

1. Body condition score (BCS): Actual scoring of the body condition of lactating goats using Body condition scoring scale as suggested by Villaquiran *et al.*, (2005).

Table 3.8 Body condition scoring scale chart

BCS	Condition	Backbone	Ribs and intercostal space	Lumbar area	Sternum
1	Emaciated	Emaciated and weak animal, the backbone is highly visible and forms a continuous ridge. The flank is hollow.	Ribs are clearly visible. There is no fat cover and fingers easily penetrate into intercostal spaces (between ribs).	The spinous processes of the lumbar vertebrae can be grasped easily between the thumb and forefinger; the spinous processes are rough, prominent, and distinct giving a saw-tooth appearance. Very little muscle and no fat can be felt between the skin and the spinous process. There is a deep depression in the transition from spinous to transverse processes	Sternal fat can be easily grasped between thumb and fingers and moved from side to side. The cartilage and joints joining ribs and sternum are easily felt.
2	Thin	Slightly raw-boned: the backbone is still visible with a continuous ridge.	Some ribs can be seen and there is a small amount of fat cover. Ribs are still felt. Intercostal spaces are smooth but can still be penetrated.	The spinous processes of the lumbar vertebrae are evident and can still be grasped between the thumb and forefinger; however, a muscle mass can be felt between the skin and the spinous process. There is an obvious depression in the transition from spinous to transverse processes.	Sternal fat is wider and thicker but can still be grasped and lifted by the thumb and forefinger. The fat layer can still be moved slightly from side to side. Joints are less evident.

				The hand can grasp the transverse processes but the outlines of the transverse processes are difficult to see. About one-third to one-half of the length of the transverse processes is discernible.	
3	Normal	The backbone is not prominent.	Ribs are barely discernible; an even layer of fat covers them. Intercostal spaces are felt using pressure.	The spinous processes of the lumbar vertebrae cannot be easily grasped because the tissue layer covering the vertebrae is thick. When running a finger over the spinous processes, a slight hollow is felt. There is a smooth slope in the transition from spinous to transverse processes. The outline of the transverse processes of the lumbar vertebrae is slightly discernible. Less than one-quarter of the length of the transverse processes is discernible.	Sternal fat is wide and thick. It can still be grasped but has very little movement. Joints joining cartilage and ribs are barely felt.
4	Fatty	The backbone cannot be seen.	Ribs are not seen. The side of the animal is sleek in appearance.	It is impossible to grasp the spinous processes of the lumbar vertebrae, which are wrapped in a thick layer of muscle and fat. The	Sternal fat is difficult to grasp because of its width

				spinous processes form a continuous line. There is a rounded transition from spinous to transverse processes. The outline of the transverse processes of the lumbar vertebrae is no longer discernible. The transverse process forms a smooth, rounded edge, with no individual processes discernible.	and depth. It cannot be moved from side to side.
5	Obese	The backbone is buried in fat.	Ribs are not visible. The rib cage is covered with excessive fat	The thickness of the muscle and fat is so great that reference marks on the spinous process are lost. The spinous process forms a depression along the backbone and there is a bulging transition from spinous to transverse process. The thickness of the muscle and fat is so great that reference marks on the transverse process are also lost. It is impossible to grasp the transverse process.	The sternal fat now extends and covers the sternum, joining fat covering cartilage and ribs. It cannot be grasped.

Note- 0.5 increments is done when the animal being evaluated is intermediate to the BCS description above

2. Forage availability

   Availability of the forage at the camping site was recorded as per owner declaration

3. Quality of water

   Quality of water at the camping site was visually assessed

4. Distance to water points

   Distance to the water points from the camping site was recorded

5. Supplementary feeding

   Supplementary feeding practiced in the flock was recorded by asking open-end question from the flock owner

B. Environment/Facility around camping

1. Environmental protection to kids

   Environmental protection given to the kids was visually assessed at the camping

2. Migration Distance

   Average migration distance travelled by the farmers with flock during camp shifting was recorded using an open-end question

3. Livestock Losses

   Livestock losses to the flock in the last 12 months were recorded using open-end question

4. Livestock Guard Dog

   Presence of the livestock guard dog at the camping site was recorded

5. Cold Stress Score (Battini *et al*., 2016)

   Visual assessment of the flock was done to record the number of goats suffering from the cold stress

Table 3.9 Cold stress scoring chart

Score	Defination	Description
0	No signs	The hair coat is flat on the back, no signs of cold stress are visible, the posture is relaxed
1	Hair horripilation	The hair coat is bristling on the back, the posture is not a distinguishing trait
2	Shivering	The goat is shivering. The posture may help to reduce the heat loss, e.g. the back is arched,the head is held downward, the whole body is stiff

6. Integument cleanliness

Integument cleanliness was assessed by way of visual assessment**.** Goats were categorized as per (Tiezzi *et al*., 2019)

Table 3.10 Integument cleanliness scale

Category	Description
Optimum	The body is clean, any dirt under the hock
Medium	The body is clean, any dirt on one or more limbs covering part of the area distal to the knee or hock
Poor	Dirt covering the majority of the area below the knee or hock of one or more limbs and some areas of the body

C. Health

1. Lameness Score

Lameness indicator was applied to the goat flock using 5 point locomotion scoring scale (Deeming *et al.*, 2018)

Table 3.11 Lameness scoring chart

Category	5 point	Limp	Moving forward	Weight bearing	Head nod	Identify affected leg (s)	Other descriptors
Normal Gait	1	No	Yes	Yes	No	-	Even stride on all 4 legs, tracking up, walks with a fluid motion.
Uneven Gait	2	No	Yes	Yes	No	No	Shorter stride, not tracking up, joints slightly stiff, inward or outward swinging of a hoof at each stride.
Mildly lame	3	Yes	Yes	Yes	No	Possibly	One or more legs may be affected. Observer may not be able to determine affected leg(s). Mild limp.
Moderately lame	4	Yes	Reluctant	Reluctant	Possibly	Yes	One or more legs may be affected. Moderate limp or slight goose stepping
Severely lame	5	Yes	Unwilling or unable	Unable	Yes	Yes	One or more legs may be affected. Severe limp or walking on knees, or pronounced high goose-stepping

2. Hair Quality:

Hair coat condition was visually assessed and the goats with the poor coat condition were recorded

3. FAMACHA© anemia Chart

Mucosa color was assessed using 5 point color scoring chart given by Vatta *et al*., 2001 to assess the prevalence of the anemia in the flock (Fig 3.3)

Table 3.12 FAMACHA© anemia Chart

Score	Colour	Description
1	Red	Non-anemic
2	Red Pink	Non-anemic
3	Pink	Mildly-anemic
4	Pink-White	Anemic
5	White	Severely anemic

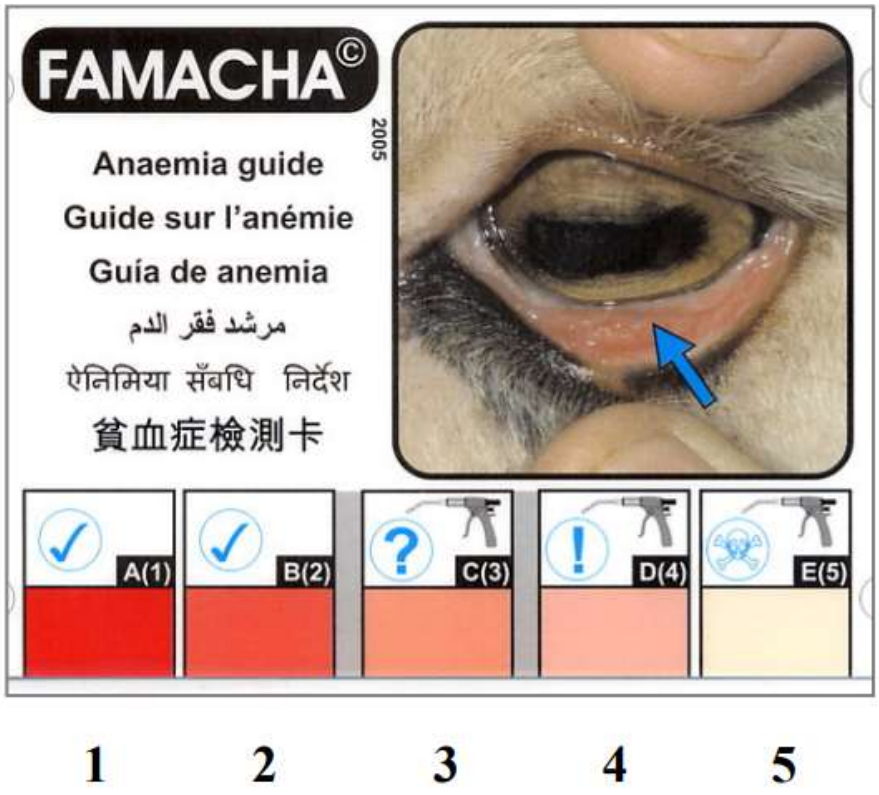


Fig. 3.3 FAMACHA© card

4. Dag score

Prevalence of diarrhea in the flock were recorded using 5 scale scoring given by Bath and Wyk, 2009

Table 3.13 Dag scoring scale chart

Score	Description
0	No fecal soiling at all
1	Very slight fecal soiling on edge of tail /No treatment/action needed
2	Slight soiling on the edge of tail/on each side/Usually no treatment/action needed
3	Moderate soiling of tail, dag formation/ consider treatment/action
4	Severe soiling, severe dag formation/Treatment
5	Very severed, watery diarrhea, extending up to hock/Treatment

5. Veterinary facility

Availability of veterinary facilities during migration was recorded by asking an open-end question from the flock owner

6. Vaccination

Vaccination of the goat flocks during the last 12 months were recorded by asking an open-end question from the flock owner

7. Deworming

Need based deworming practiced by the flock owner in the last 12 months was recorded by asking open-end question

8. Dipping

Need based dipping practiced by the flock owner in the last 12 months was recorded by asking open-end question to the flock owner

9. Pain Management Practices

Flock owner were asked an open end question regarding the pain management practices during management procedures like castration, identification

D. Behaviour

1. Familiar Human approach test (FHAT)/Handling test

Quality of human-animal relationship was assessed by using simplified Familiar Human Approach Test (FHAT) in which reaction of the goats and the farmer was assessed

2. Qualitative behavioural assessment (QBA)

It was performed from one observation point for 60 seconds on the whole group of goats. The assessment was done during activity period of goats, when different behaivioral expression may be exhibited

3. Vocalizations

The number of goats performing vocalizations/2 min. was recorded

4. Oblivion

The number of goats physically or mentally isolated from the group was recorded

5. Behaviour Synchrony

The number of goats performing the behaviour and posture in a social group were counted

E. Performance

1. Kid Birth Weight

Average kid birth weight of the 10% of the total kidding (0-5 days post-kidding) of the flock were taken using electronic weighing balance on the leveled ground

2. Survivability of kids

Survivability of the kids until weaning in the last kidding season were recorded

3. Weight at 9months

Average body weight of the goats at 9 months ± 10 days of age were recorded using the morphometric measurements (Body length and body girth)

Plate 3. Recording of body weight of kids

Plate 4. Morphometric measurements of doe for estimation of body weight

4. Kidding percentage

   Kidding percentage of the goats in the last kidding season were recorded

5. Abortion

   The incidences of number of abortions in the last 12 months were recorded

6. Milkyield

   Milk Yield (ml per milking at 21 ± 5 days) of the 10% of the goats from the flock were recorded

7. Twinning percentage

   Twinning percentage of the flocks in the last kidding season were recorded

Plate 5. Interaction and information collection from Gaddi nomads

3.4.1 Procedure for collection of data from goat flocks

A total of 1325 goats were evaluated in the study. The number of goats evaluated was determined following a sample size calculation based on total number of goats at the farm as suggested by AWIN protocol (AWIN, 2015). Adult lactating goats aged 2-10 years were observed for welfare assessment. The same observer applied the welfare assessment protocol to all the flocks. A first evaluation was performed when the flocks were at camping site at grazing and second welfare assessment was done at grazing. The welfare

score of the flock was obtained after summing the scores of all the individual welfare indicators.

3.4.2 Collection of data and their timing

Goats were managed under migratory goat production system and evaluated from 10:00 to 14:00. Qualitative Behaviour Assessment was the first thing performed on the flock during grazing and without any prior contact. The observer wore blue color coverall without any perfume and accessories to avoid any alteration in the natural behaviour of goat

3.5 Statistical analysis

The collected data was scored, compiled, tabulated and subjected to various appropriate statistical tools to draw meaningful results and logical conclusion.

The statistical tools were used: -

- Mean
- Standard deviation/ Standard Error
- T test
- ANOVA

3.5.1 Software packages used for data analysis

All the data were analyzed using SPSS Software version and XLSTAT software package was used for analysis of data and interpretation

3.5.2 Principal component analysis

Principal component analysis (PCA) was used in order to highlight the relationship among different indicators of goat's welfare in migratory flocks and to know the correlation between them along with welfare of goats. Principal component analysis is considered as a suitable method to treat this data set (animal-based indicators) as it presents a number of advantages: -

i. It is a chemo-metric statistical method which condenses information into few lateral variables.

ii. It offers the possibility of using discrete variables as well as continuous variables, as it is absolutely independent of data distribution.

The data set was used to analyze the 24 goat flocks set using 32 welfare indicators

1. Body condition score
2. Availability of forage at camping site(according to owner declaration)
3. Supplementary feeding
4. Quality of water at camping site
5. Distance to water points from camping site
6. Integument cleanliness
7. Cold stress score
8. Environmental protection to kids
9. Migration distance
10. Livestock losses due to depredation, rustling and accidental misadventures
11. Presence of Livestock Guard Dog with flock
12. Lameness score
13. FAMACHA anemia chart
14. Dag score/Fecal score
15. Hair coat condition
16. Pain management during management procedures (castration, identification)
17. Availability of veterinary facilities
18. Vaccination against diseases (PPR, FMD)
19. Deworming
20. Dipping
21. Behaviour synchrony
22. Vocalization
23. Oblivion (goats physically or mentally isolated from group)
24. QBA (Demeanour)
25. Familiar human approach test (FHAT)/Handling test

26. Average kid birth weight
27. Kid survival until weaning(in last 12 months)
28. Milk yield (ml per milking at 21 ± 5 days)
29. Average body weight at 9 months ± 10 days of age
30. Kidding percentage (in last 12 months)
31. Abortions/still birth (last 12 months)
32. Twinning percentage (in last 12 months)

CHAPTER –4

Results and Discussion

RESULTS AND DISCUSSION

Commensurate with the objectives, the present study on behavior and welfare of migratory flocks of Gaddi goats in North-western Himalayan region was carried out by methodology as detailed in the previous chapter. The data generated were analyzed using suitable statistical techniques and presented in the current chapter. The tabulation and analysis have been done in the light of stated objectives. The main findings of the study and discussion thereon are presented in this chapter under following broad categories.

4.1 Demographic and socio-economic characteristics of Gaddi farmers

4.2 Climatic variable and vegetation cover at different altitudes in study area

4.3 Natural behaviour of Gaddi goat at different altitudes

4.4 Development of welfare assessment protocol for migratory goats

4.5 Testing the reliability and validity of the scale

4.6 Testing the feasibility of the validated indicators

4.7 Mean value of welfare scores in different flock sizes.

4.8 Overall assessment of Gaddi goat welfare

4.9 Principal Component Analysis

OBJECTIVE: 1

4.1. Demographic and socio-economic characteristics of Gaddi farmers

The data on the demographic profile of the different categories of flock sizes owners has been represented in Table 4.1. All the flock owners were male and having mean age of 50.54±10.95 years. Respondent's age ranged from 35-76 years with an average of 50.54±10.95 years. This showed decreasing interest of the younger youth for the migratory goat rearing. Age and experience of the small sized flock owners was significantly ($P<0.05$) higher as compared to medium and large flock owners. Overall, 33.33 per cent of the flock owners were illiterate, while 66.66 per cent were educated.Mishara and Pandey (2019) also reported that 50 per cent of the respondents in their study on Gaddi tribe were illiterate. Secondary education was received by 45.83 per cent of the flock owners. The average flock size observed in the present study was 158.96±16.86. In terms of work satisfaction, small flock owners were showing

significantly (P<0.05) higher score as compared to the medium and large flock owners. Small flocks were also looked after by significantly higher (P<0.05) no. of persons/100 goats.

Table 4.1 Demographic profile of different categories of flock owners

Parameters	**Flock size categories**			**Overall**
	Small	**Medium**	**Large**	
Age of respondent	61.00 [b] [8.45]	44.63 [a] [7.36]	46.00 [a] [8.96]	50.54[10.95] *
<40 years	-	1(12.50)	2(25.00)	3(12.50)
40-50 years	4 (50.00)	4(50.00)	3(37.50)	11 (45.83)
50-60 years	2 (25.00)	3(37.50)	3(37.50)	8 (33.33)
>70 years	2 (25.00)	-	-	2 (8.33)
Experience of respondent	48.00 [b][11.37]	25.75 [a][10.98]	31.63 [a][13.90]	35.13[15.08] *
<30 years	-	6 (75.00)	4 (50.00)	10 (41.66)
30-50 years	5 (62.50)	2 (25.00)	4 (50.00)	11 (45.83)
50-70 years	2 (25.00)	-	-	2 (8.33)
>70 years	1 (12.50)	-	-	1 (4.16)
Education of respondent				
Illiterate	3 (37.50)	2 (25)	3 (37.50)	8 (33.33)
Primary	4 (50.00)	-	1 (12.50)	5 (20.83)
Secondary	1 (12.50)	6 (75.00)	4 (50.00)	11 (45.83)
Work satisfaction (Liker Scale 1-10)	6.75 [b] ±0.45	4.63 [a] ±0.53	4.50 [a]±0.19	5.29±0.36
Flock size	73.38±6.25	148.50±9.77	255±16.98	158.96±16.86
No. of persons/100 goats	1.87 [b]±0.47	1.16 [a]± 0.22	0.95 [a]± 0.13	1.33±0.50

Values within a row with different superscript are significantly different (p < 0.05)
Values in parenthesis [].are Standard error
Values in parenthesis () are percentage

4.2 Climatic variable and vegetation cover at different altitudes in study area

Data on environmental variables recorded at differet altitudes have been presented in Table 4.2. Breeding of goats takes place when the flocks were at mid-hills during upward migration. Flocks were in mid-pregancy at high hills and in mid-lactation at low hills. High hills have more percentage of vegetation cover as pasture while shrubs were predominant at low hills. Most of the environmental parameters are same at all altitudes which helps the Gaddi goats to take advantage of seasonal utlilization of resources. Gaddi's camp in winters at foothills of Shivalik where their livestock graze and browse on vegetation in the tropical broadleaved forests, while in summer and rainy season they camp in alpine meadows (Sharma *et al*., 2022). Lamoot *et al*. (2005) also reported that the animal use dietary shift as a strategy to meet its dietary requirements. Grazing geounds with a greater variety of forages would enable wider range of dietary selection and better sustains the animals. Safari *et al*. (2011) also found that goats ingested more browses and forbs when season changed from rainy to dry, whereas grasses made up considerably smaller portions of their diet.

Table 4.2. Environmental variables at different altitudes

Parameters	**High hills**	**Mid hills**	**Low hills**
Physiological stage of goat	Mid-pregnancy	Post-kidding	Mid-lactation
Altitude (m asl)	420.00±48.51	1294±109.82	3638.00±229.96
Vegetation cover/diet composition			
Shrub (%)	5	85	90
Herbaceous species/forbs (%)	15	10	5
Pasture (%)	80	5	5
Maximum temperature (^{0}C)	20.70±1.41	22.00±0.59	22.23±1.78
Minimum temperature (^{0}C)	14.15±1.54	11.05±0.65	13.17±3.96
Humidity (%)	85.75±0.85	64.75±0.47	85.25±0.48
Rainfall (mm)	11.85±1.39	25.07±3.04	14.6±1.67

4.3 Natural behaviour of Gaddi goats at different altitudes

The mean values of different natural behaviour of Gaddi goats at different altitudes during key stages of reproductive cycle viz. mid-pregnancy (MP), post-kidding (PK) and mid-lactation (ML) are presented in Table 4.3 and 4.4.Browsing time was found significantly ($P<0.05$) higher in ML as compared to both PK and MP, also the browsing during PK was significantly ($P<0.05$) higher than in ML. Grazing time was significantly higher during MP as compared during PK and ML. A significant ($P<0.05$) difference was recorded in terms of standing behaviour as the significantly ($P<0.05$) lower standing time was observed in ML as compared to MP and PK. There was no significant difference in the rumination, lying time and walking time during different physiological stages of Gaddi goats.

The mean values of frequency data of behaviour is presented in Table 4.5. The frequency of bipedal stance was significantly ($P<0.05$) higher in ML as compared to both PK and MP, Self-grooming was significantly ($P<0.05$) higher during PK as compared to ML and MP. Frequency of object grooming was significantly ($P<0.05$) higher during ML as compared to PK and MP. There was no significant difference in the frequency data of allo grooming behaviour in all the three groups.

Several variables determine the intensity and distribution of these activities, including the availability and nutritive value of the pasture and its management, as well as the region's main climatic conditions (Silva *et al.*, 2008). Zalabadi goats have been reported to spend 62.4, 19.2, 10.6 and 78% time on grazing, sitting, Standing and walking respectively in the grazing land of semi-arid region of Guajrat, when behaviour was recorded during day from 08 to 18 hours in different seasons (Solanki GS, 2000). The behavioural activities of goats on natural pasture of sub humid zone of West Africa has been reported during dry season and cool season, browsing, grazing, walking, resting, drinking, rumination and other activities were 24.9, 16.2, 12.0, 26.9, 1.8, 16.1 and 2.1 % during dry season and 16.4, 32.2, 10.5, 21.2, 1.5, 16.6 and 1.6 % during cool season respectively (Kone *et al*., 2006).

Table 4.3 Average time (% of total) spent on expressing different beahviours by goats during grazing period in different physiological stages

Behaviour	Mid-pregnancy/ High hills	Post-kidding/ Mid hills	Mid-lactation/ Low hills
Browsing time	8.40 [a] ±0.19	36.06 [b] ±0.79	45.87 [c] ±0.53
Grazing time	46.18 [c] ±0.66	20.27 [b] ±1.0	12.91 [a] ±0.70
Total feeding time (Browsing plus grazing)	54.58 [a] ±0.48	56.33 [a] ±1.18	58.77 [b] ±0.59
Walking time	32.82±0.87	31.52±1.18	33.93±0.65
Idle standing time	9.75 [b] ±0.78	8.30 [b] ±0.41	5.02 [a] ±0.45
Ruminating time	2.67±0.75	3.34±0.31	2.07±0.22
Idle lying time	0.18±0.12	0.52±0.17	0.21±0.13

Means bearing different superscript in a row differ significantly P<0.05

Table 4.4 Average time (min) spent on expressing different beahviours by goats during grazing period in different physiological stages

Behaviour	Mid-pregnancy/ High hills	Post-kidding/ Mid hills	Mid-lactation/ Low hills
Browsing time	$40.32^{a} \pm 0.92$	$173.08^{b} \pm 3.81$	$220.18^{c} \pm 2.64$
Grazing time	$221.66^{c} \pm 3.66$	$97.29^{b} \pm 4.85$	$61.97^{a} \pm 3.38$
Total feeding time (Browsing plus grazing)	$261.98^{a} \pm 2.78$	$270.37^{a} \pm 5.64$	$282.15^{b} \pm 2.89$
Walking time	157.54 ± 4.17	151.30 ± 5.67	162.86 ± 3.12
Idle standing time	$46.84^{b} \pm 3.74$	$39.83^{b} \pm 1.97$	$24.10^{a} \pm 2.15$
Ruminating time	12.80 ± 3.63	16.05 ± 1.51	9.93 ± 1.05
Idle lying time	0.86 ± 0.56	2.50±0.80	1.0 ± 0.63

Means bearing different superscript in a row differ significantly P<0.05

Table 4.5 Frequency expression of behaviour during grazing period in physiological stages

Behaviour	Mid-pregnancy/ High hills	Post-kidding/ Mid hills	Mid-lactation/ Low hills
Bipedal stance bouts	4.17 [a] ± 0.65	12.50 [b] ± 1.78	28.50 [c] ± 2.13
Self grooming bouts	1.0 [a] ± 0.68	14.00 [b] ± 2.13	5.83 [a] ± 1.56
Object grooming bouts	0.00 [a] ± 0.00	1.0 [ab] ± 0.37	2.16 [b] ± 0.63
Allo grooming bouts	0.00 ± 0.00	0.67 ± 0.42	0.17 ± 0.18

Means bearing different superscript in a row differ significantly P<0.05

4.3.1 Browsing time

Average time devoted to browsing was significantly (P<0.05) higher during ML (220.18 ± 2.6min; 45.87±0.5%) as compared to PK (173.08 ± 3.8 min; 36.06±0.7%), whereas during MP (40.32 ± 0.9 min.; 8.40±0.19%) it was significantly (P<0.05) lower as compared to PK. Increase in the browsing at the low hills during post-kidding may be due to higher presence of browse species, when most of the grasses have senesced. Grasses and forbs are normally more susceptible to reduction in the dry season than browses (Ahmed *et al.*, 2003). Sanon *et al*. (2007) also found that during the dry season, when forage resources are scarce, goats spend more time browsing. In the mornings, goats spent nearly twice as much time browsing as grazing (1.8:1), while in the afternoons, the ratio is reversed (0.7:1). More browses and forbs were consumed in the dry season, while grasses were the least consumed (Saffari *et al.*, 2011).

4.3.2 Grazing time

Daily grazing time was significantly (P<0.05) higher at MP (221.66 ± 3.7 min; 46.18±0.6%) followed by PK (97.29 ± 4.85min; 20.27±1.0) and ML (61.97 ± 3.4 min; 12.91±0.7). During MP at high hills availability of good quality pasture with higher nutritive value might have increased the grazing time in goat drastically. Grazing in the low hills during ML has also been observed in Gaddi goats, this is due to time devoted to the consumption of seeds on the ground.

Higher proportion of grazing in the present study during high hill migration also correlate with study by Odo *et al*. (2001) who observed more grazing time (32.3%) in goats during cool season, when there is scarcity of tree leaves and there is availability of good quality pasture. Dietary changes are a strategy used by animals to meet their

nutritional needs. Grazing grounds with a wider diversity of forage types would allow for more dietary variety and better animal sustainability (Lamoot *et al.,* 2005).

4.3.3 Total feeding time (browsing plus grazing)

Total daily feeding time (browsing plus grazing) out of the total grazing period was significantly ($P<0.05$) higher at ML (282.15 ± 2.9 min; 58.77±0.5%) as compared to PK (270.37 ± 5.6 min; 56.33±1.1%) and MP (261.98 ± 2.8 min; 54.58±0.4%). According to Araújo *et al*. (2009), grazing time is related to pasture quality, i.e., the higher the forage quality, the shorter the grazing time. Lowest feeding time was observed at the high hills during mid-pregnancy while highest was observed at low hills during mid lactation, which indicates good forage availability at high hills and poor forage availability at low hills. El Aich *et al*. (2006) reported grazing time in goats averaged 387 minutes per day and accounted for 70% of total time.

4.3.4 Walking time

Average walking time during grazing period was non-significantly higher in ML (162.86 ± 3.1 min, 33.93±0.6%) as compared to MP (157.54 ± 4.2 min, 32.82±0.8%) and PK (151.30 ± 5.7 min, 31.52±1.1%). Walking activity has been reported to 42.0 per cent in goats reared under range conditions (Lachica *et al*., 1999). Higher time spent walking at low hills during mid-lactation may be due to scarcity of feed which is in accordance with the observations of Ouedraogo-Kone *et al.* (2006) and Sanjabi *et al*. (2014). Due to higher availability of the shrubs and trees in the area and goat perceive browse plants as a discrete food source (a "patch"), and animals do not leave that area until it is depleted.

These findings are consistent with those of Pakorna *et al*. (2013) who observed that there is less walking in goats as compared to sheep in dry grassland of Czech Republic. Cisse *et al*. (2002) also reported that goat spent more time walking in dry season (5-15%) as compared to rainy season (0.6 to 2.6%). Sheep reared in extensive system have greater energy requirements than confined sheep, mostly attributable to increased muscular efforts for walking and grazing, whereas other behaviours such as ruminating and standing, on the other hand, are viewed as modest or insignificant contributors (Lachica and Aguilera, 2005). According to Aich *et al*. (2007), goats increased their grazing time and decreased their walking time throughout the winter, indicating a shift in their food searching approach and behaviour to lower energy expenditure. However, Safari *et al*. (2011) reported that in all three seasons (rainy, mid dry and late dry), goats spent about the same amount of time walking and lying while ruminating.

Plate 6. Browsing behaviour of goats

Plate 7. Grazing behaviour of goats

4.3.5 Idle standing time

Standing time was significantly greater (P<0.05) at MP (46.83±3.7 min; 9.75±0.7%) and ML (39.80±1.9 min; 8.30±0.4%) as compared to PK (24.01±2.1 min; 5.02±0.4%). Less standing observed in low hills might be due to forage shortage at low hills accompanied with poor nutritional quality. Idleness was also found to be increased after 10:00 h, precisely after temperature begins to rise (Furtado, 2008). Paulo and Lopes (2014) reported that in the afternoon, idle behaviour while standing was more common than walking or ruminating while standing or lying down. Higher incidences of idleness while standing than lying down has been reported by Barros *et al*. (2007) and suggested that the goat's senses of sight and smell are sharpened as a result of this behaviour, which facilitates their search for food and water. The increased standing hours is due to more vigilance of the goats from the external threats and predation, later the confidence of grazing may have increased during the noon hours. Present findings were in accordance with Dada *et al*. (2021) who observed that in both sheep and lambs tendency to remain standing was greater when kept in open pasture to those reared in silvopastoral system. Pan *et al.* (2020) also observed similar findings in the lambs kept in open pasture. Solanki (2000) reported that goats have uniform standing activity throughout the day, except during the morning hours (12 min/hour). Also, the animals showed less standing time in the mid and low hills as compared to the high hills, which might have reduced heat production (Johnson, 1991).

4.3.6 Rumination time

Ruminating behaviour in this study includes rumination during both lying and standing during day time grazing period of 8 hours. Goat spent higher time ruminating in PK (16.05±1.5 min, 3.34±0.3 %) as compared to ML (9.93±1.0 min, 2.07±0.2 %). Gaddi goats were penned during the night time which might have given them more opportunity for rumination. However, the present study do not include objective of night recording as it is difficult to do in free range conditions. Rumination on an average was found to be only 1.5-3.0% of the total time goat spent on pasture (Jonsson, 2011). Chances of animal displaying rumination during the day are very less (Dada *et al.,* 2021). Time spent in rumination was estimated to be around 1/3rdof the day (8 h). This value can range from 4 to 9 hours, divided into 15-20 short intervals throughout the day (Fraser, 1983; Van Soest, 1994), with 15,000 to 20,000 chewing motions (Hodgson, 1990); this is mostly observed at night (Bremm *et al*., 2005).

Plate 8. Idle lying behaviour of goatswhilts grazing

Plate 9. Idle standing behaviour of goat during grazing

Goats were reported to show more time ruminating during summer, followed by winter and monsoon (P<0.05). This could be because the NDF content of mixed jungle grass is higher in the summer than in the winter and monsoon (Das *et al*., 2011). As a result of the impending decline in roughage quality of most tropical grasses as a result of climate change, ruminants will likely react to better utilise poor quality roughages by storing more roughage in the rumen and prolonging rumination duration (Moyo *et al*., 2019).With increasing dryness, the fraction of time spent standing while ruminating dropped (P=0.003), reaching 0.068, 0.036, and 0.014 for the rainy, mid, and late dry seasons, respectively (Safari *et al.*, 2011). However, Forminga *et al.* (2020) found that for the three seasons studied namely; transition (rainy dry), dry, and rainy seasons, the time spent on rumination activity was similar (P>0.05), with animals spending less time in this activity. Rumination took the least amount of time, which could be an attempt to limit the risk of predation.

4.1.7 Idle lying time

There was no significant difference between lying time whilst grazing at different physiological stages of Gaddi goat. In the present study, the lying behaviour of goats is less observed as the shepherd take their goats to camping site for resting and this period is not included in our study especially in mid hills. Goats were reported to show lying behaviour in afternoon, but the probability of this behaviour decreased throughout the day especially in silvipastoral system when compared to open pasture (Dada *et al.*, 2021). Decreased resting behaviour in the present study may be also due to herder's preference to let the goats eat more and they have to travel long distance to reach the camping site. As the day progressed, the goats spent more time sitting till noon and afterwards less time sitting till evening, also the animals seldom sat during the last three hours on the field (Solanki, 2000). In comparison to housed goats, Nigretti *et al.* (2020) reported that goats in an outdoor yard walked more but rested less.

4.3.8 Bi-pedal stance

It is species specific behaviour in goats which help them to browse wide range of pasture. Frequency of bipedal stance was higher (P<0.05) at ML (28.50±2.8) as compared to PK (12.50±1.7) and MP (4.17±0.6). Bipedal stance is increased in the poor grazing land, for goats it is possible to browse the mean height of 1.65 m (Sanon *et al*., 2007). Bhatta *et al*. (2021) reported it to be lowest in monsoon (0.52), highest in winter (2.86) and

intermediate in summer (0.52), all of which corresponded to the availability of forage from various strata of tree and shrub species

4.3.9 Self-grooming

Frequency of self-grooming during grazing time was significantly (P<0.05) higher at PK (14.00±2.1) than at ML (5.83±1.5) and MP (1.0±0.6). The present finding were in agreement to the earlier studies which reported that sheep and goat performed more comfort behaviour (grooming) in the woody paddock compared to the grassy paddock (Bojkovski *et al*., 2014). They reported that the maximum number of autogrooming and allogrooming were 8 and 4 times per day respectively. However, contrary to our study, self-grooming was also found to be similar in dry, early dry and late dry season (Safari *et al*., 2011).

4.3.10 Object grooming

Frequency of object grooming was significantly (P<0.05) greater at ML (2.16±0.6) as compared to MP (1.0±0.3) and PK (0.00±0.0). Absence of the shrub vegetation and tress at the high hills may be reason for goats not performing object grooming at high hills during MP. These findings are in agreement with those of Bojkovski *et al*. (2014).

4.3.11 Allogrooming

Average time spent on allogrooming during grazing period at different physiological stages of Gaddi goat was not significant. Allogrooming was reported to be significantly higher in woody paddock than grass paddock (Bojkovski *et al*., 2014).

Plate 10. Bipedal stance of goat while grazing

Plate 11. Object grooming in goat

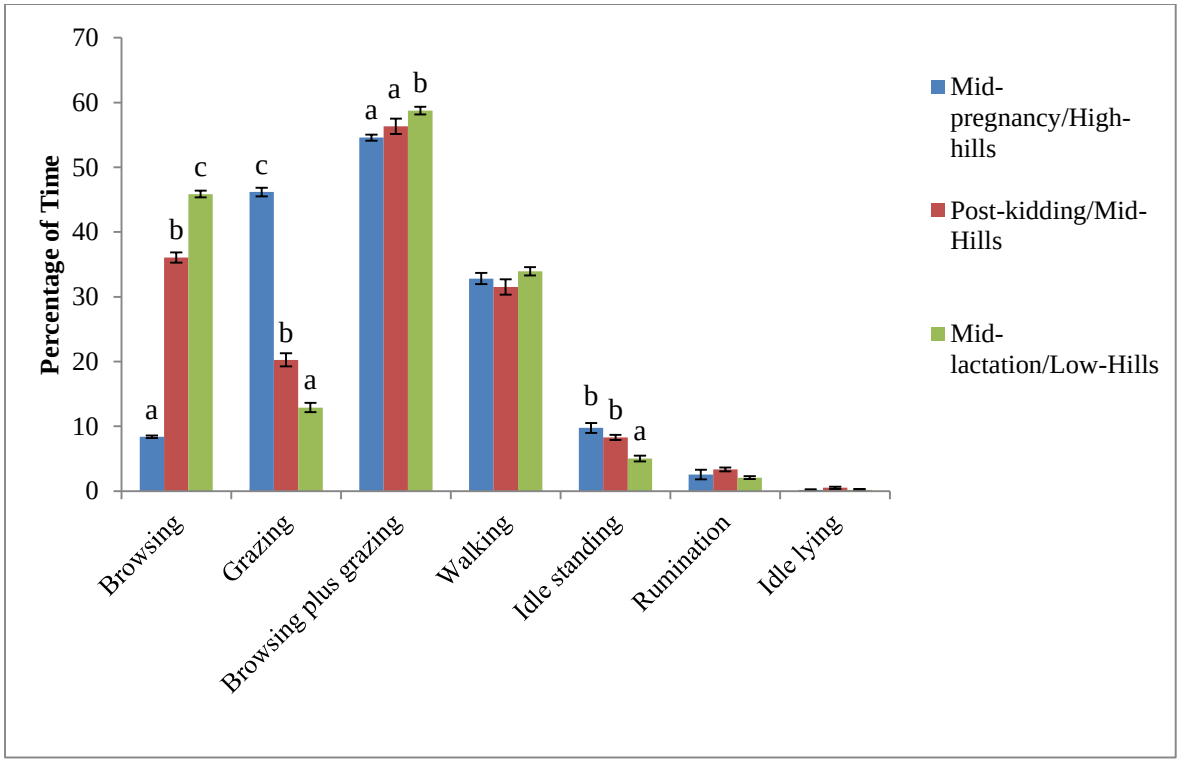


Fig. 4.1 Average time (% of total) spent on expressing different beahviours by goats during grazing period in different reproductive stages

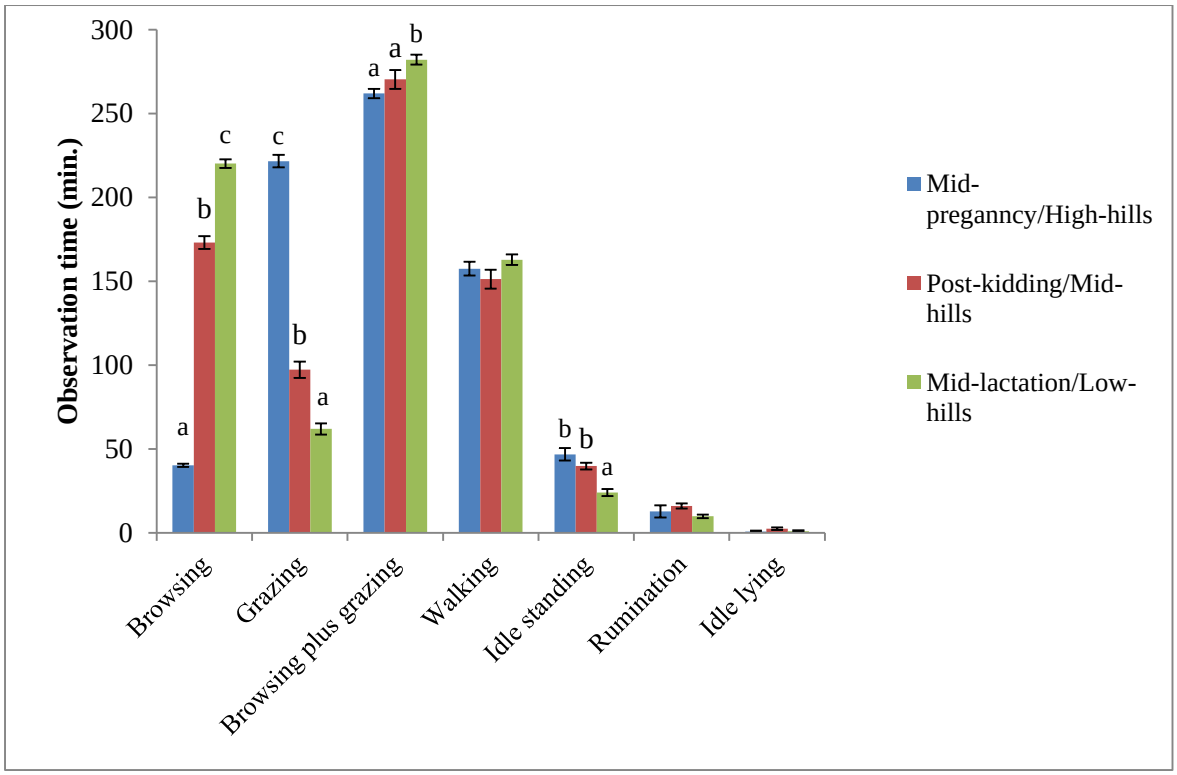


Fig. 4.2 Average time (min) spent on expressing different beahviours by goats during grazing period in different reproductive stages

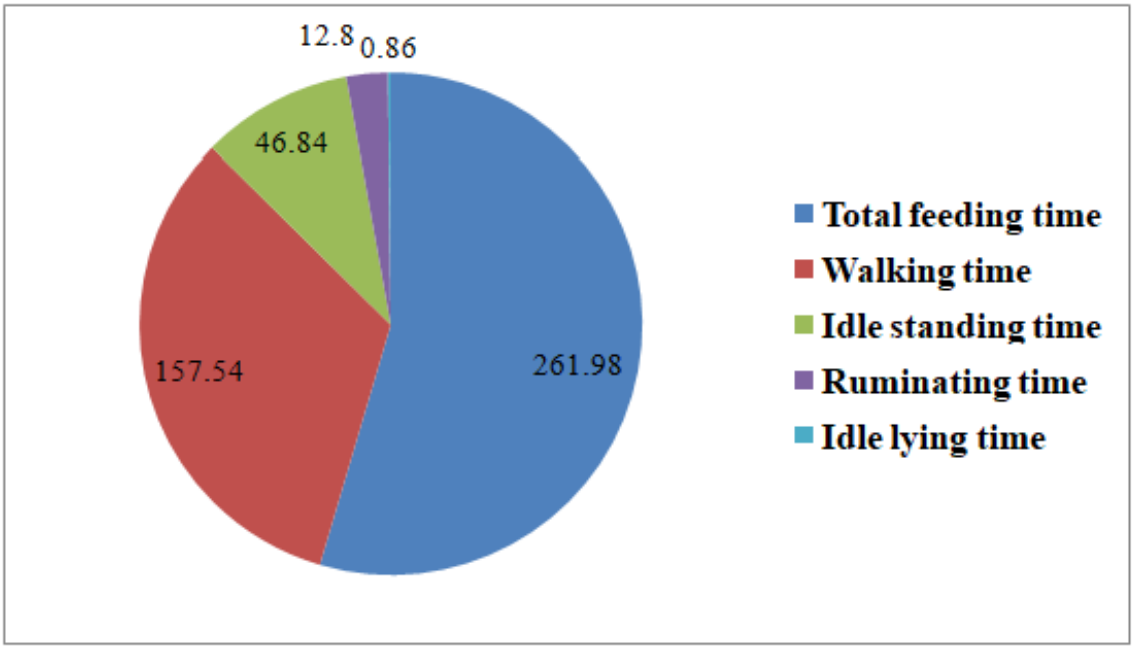


Fig. 4.3 Average time (min.) spent on expressing different beahviours by goats during Mid-Pregnancy

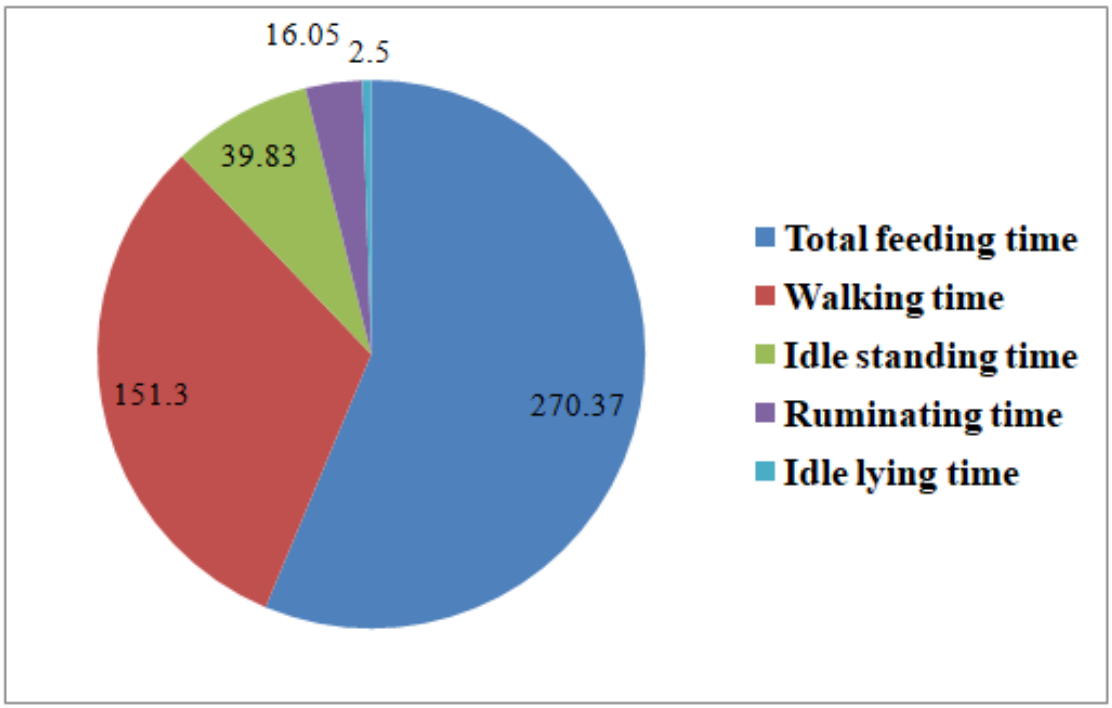


Fig. 4.4 Average time (min.) spent on expressing different beahviours by goats during Post-Kidding

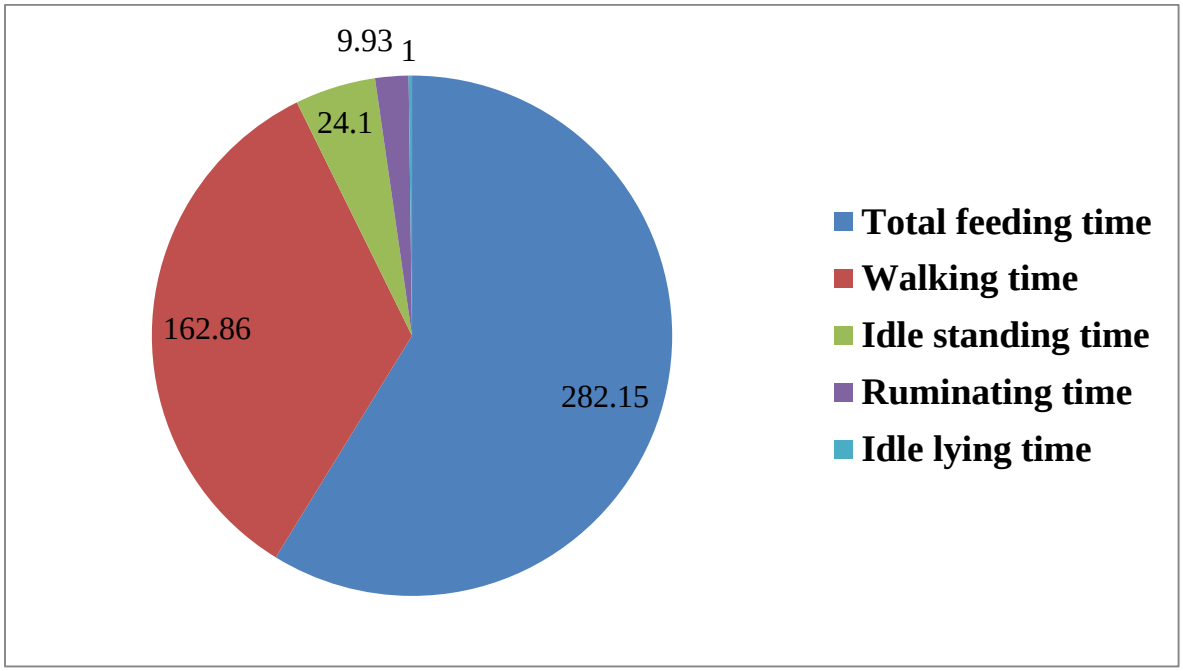


Fig. 4.5 Average time (min.) spent on expressing different beahviours by goats during Mid-Lactation

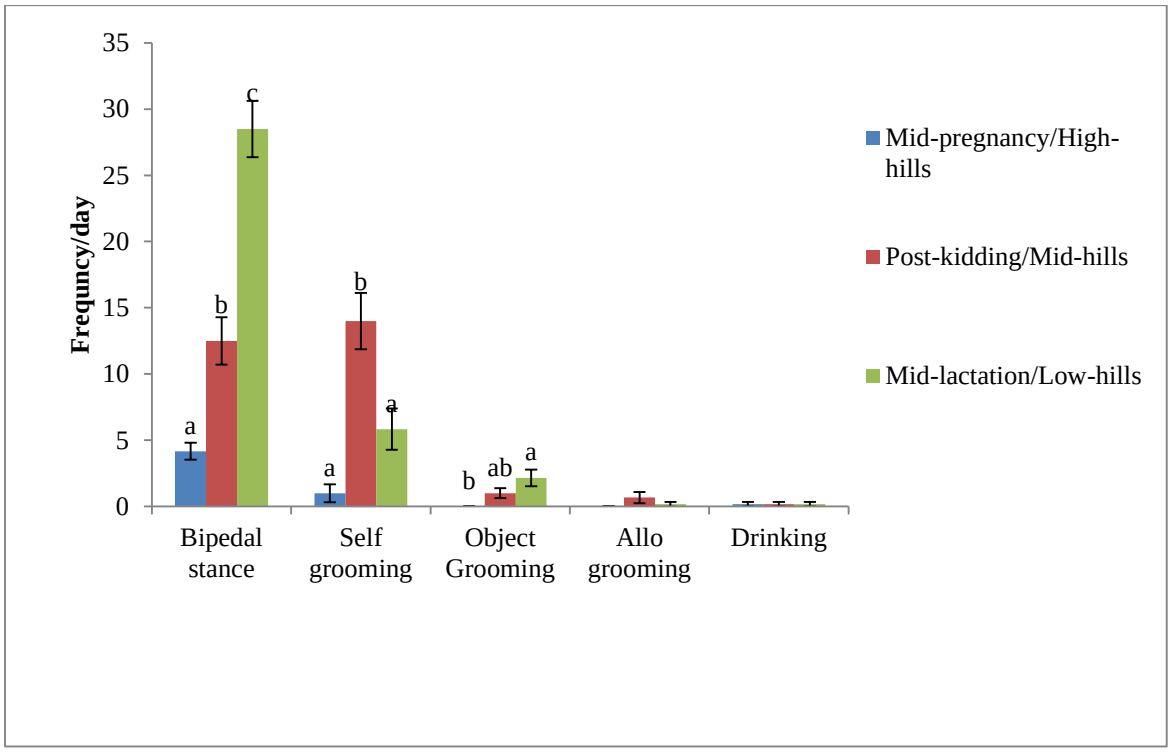


Fig. 4.6 Frequency expression of behaviour during grazing period in different reproductive stages

OBJECTIVE: 2

4.4 Development of welfare assessment protocol for migratory goats

4.4.1 Result from the literature search

AWIN project was undertaken to develop animal based protocols for assessing the welfare in different animal species, including adult dairy goats in intensive or semi-intensive production systems (Battini *et al*. 2015). For the development of welfare assessment protocol, the basic framework of AWIN (2015) for goats were adopted.Relevant literature for indicators of goat welfare was systematically searched. The search included books, peer reviewed journals, articles, project, book, reports and articles accessed through internet search engine including Google, university library.

A list of potential 106 potential welfare indicators (Table 4.6 and 4.7) was prepared from the literature search. Welfare indicators were further divided into the five welfare components (good feeding, good environment/facility around camping, good heath, appropriate behaviour and good performance). Each welfare component was presented with the welfare indicators selected from the literature search. The decision regarding use of welfare indicator in the final welfare assessment protocol was taken after expert consultation.

Table 4.6 List of potential animal and resource based welfare indicators (WI) for migratory goat production system

Animal-based indicators	Resource-based indicators
1. Body condition score	1. Grazing time (owner declaration)
2. Rumen fill score	2. Grazing distance from camping site
3. Tooth loss	3. Vegetation cover (visual assessment)
4. Skin tent test	4. Availability of pasture (according to owner declaration)
5. Coat cleanliness/ integument cleanliness	5. Supplementary feeding
6. Panting	6. Availability of drinking water (according to owner declaration)

7. Shivering/Cold stress score	7. Water availability (Visual assessment)
8. Huddling together	8. Distance to water points
9. Body and head lesions/ Skin lesions and wounds	9. Clean and Safe water
10. Lameness score	10. Water temperature
11. Abscess	11. Cleanliness around resting area/muddy soil or dry area/Pasture conditions (rough vegetation and wet and stony soil)
12. Fecal soiling/dag score	12. Space allowance or stocking density during night penning
13. Fecal consistency score/ Diarrhoea score	13. Assess to shade/shelter
14. Nasal discharge	14. Enclosure for Kids
15. Occular discharge	15. Absence of hazardous objects/Terrain or risky areas
16. Udder condition	
17. Hampered respiration	
18. Hair coat condition	
19. Claw condition	
20. Mucosa colour/FAMACHA anemia Chart	
21. External parasites	
22. Submandibular oedema	
23. Animal Lagging behind the flock	
24. Social withdrawal	
25. Behaviour synchrony	
26. Vocalisation of doe and Kids	
27. Proximity of doe and Kid	
28. Agonistic behaviour	

29. Incidence of stereotypies 30. Excessive itching 31. Oblivion 32. Maternal behaviour 33. Grooming 34. Vigilance behaviour 35. Qualitative behavioural assessment (QBA) 36. Latency to the first contact test 37. Familiar human approach test/Handling test 38. Flight distance/Avoidance distance test 39. Response to human while milking 40. Response to surprise test 41. Recovery from surprise test	

4.7 List of potential management and record based welfare indicators (WI) for migratory goat production system

Management-based indicators	Record-based indicators
1. Rest during hot hours of day	1. Per cent (%) of pre weaning kid mortality in last 12 months
2. Migratory distance travelled in a day (average)	2. No. of goat losses due to livestock depredation during last 12 months
3. Livestock guard dogs	3. No. of goat losses due to rustling during last 12 months
4. Temperament of Livestock guard dog	4. Per cent (%) Lameness/year
5. Animal health check frequency	5. Incidence of mastitis/year
6. Knowledge of ethnoveterinary practices	6. Mortality in last 12 months due to infectious diseases (FMD, Enterotoxemia, Goat Pox etc.))

7. Dipping frequency	7. Mortality in last 12 months due to consumption of poisonous plants
8. Vaccination against prevalent diseases	8. Mortality in in last 12 months due to accidental misadventures
9. Availability of veterinary facilities	9. No. of abortions or stillbirth in last 12 months
10. Stockperson awareness for on flock diseases	10. No. of bloat cases in last 12 months
11. Castration method	11. Per cent (%) of cesarean or assistant kidding
12. Pain management during castration	12. Per cent (%) of goats euthanised in last 12 months
13. Age of castration	13. Body weight at 12 months
14. Identification method used	14. Kid birth weight
15. Pain management during identification	15. Milk yield
16. Age of identification	16. Lactation period
17. Other pain inflicting management practices including ethnoveterinary practices	17. Kid weaning weight
18. Euthanasia method	18. Per cent (%) of twin births
19. Vaccination	19. Per cent (%) of kidding needed assistance
20. Deworming	20. Age at first kidding
21. Dipping	21. Kidding interval
22. Appropriate intervention at kidding	22. Kidding rate
23. No. of bucks/per goat	23. Kidding per goat (average in lifetime)
24. Source of purchase of buck (raised from own flock or from other source)	
25. Screening of buck while purchasing against diseases	

4.4.2. Expert consultation and development of welfare assessment protocol

A total of 50 experts in goat husbandry were contacted for the survey, 46 of them responded, which included scientist (16), veterinary officers (10), academicians (20). Experts were having experience of; 10 years (44.18%), 10-20 years (30.23%) and >20 years (25.58%) in goat husbandry. The weights for good feeding, good environment/facility around camping, good heath, appropriate behaviour and good performance were 25, 15, 30, 15 and 15 respectively out of total welfare score of 100 (Table 4.8). Percentage of approximate impact scores (average) for Shepherding given by EFSA (2014) were 18% to the feeding (hunger + thirst), 30% to the environment (resting+thermal+restriction), 40% to the health and 10% to the behaviour.De Wolf (2009) in their study of welfare assessment of dairy cows in pasture had also given maximum score 200 to the health indicators out of 500 (which is 40%). Also they gave ≈10% behaviour (general+farmer and staff), 25% to the feeding (water + feeding sites + pastures) and almost 10% to the environment (environmental management+loading sites+walkways+exit milking parlor) in their welfare assessment protocol.

Table 4.8 Final weightage of all the welfare components arrived after consulting the experts

Section	Welfare components	Weightage
A	Good feeding	25
B	Good environment/Facility around camping	15
C	Good health	30
D	Appropriate behavior	15
E	Good performance	15

Potential welfare indicators were selected on basis of their Weighted Average Index (WPI) values (Table 4.9). Welfare indicators that were scoring lower ranks were excluded in the final welfare assessment protocol. More weightage was given to animal based indicators as compared to resource, management and record based indicators. Finally thirty two welfare indicators were selected from the list of 106 welfare indicators for the welfare assessment of migratory goats. List of selected indicators has been presented in Table 4.10

Table 4.9 Weighted Average Index (WPAI) of potential welfare indicators for welfare assessment of migratory goats

Welfare Principle	Welfare criteria	Welfare Indicator	Total	Rank	WPAI
Good feeding	Absence of prolonged hunger	Body condition score	40.40	9	85.96
		Rumen fill score	35.60	69	75.74
		Grazing time (owner declaration)	37.80	37	80.43
		Grazing distance from camping site	36.00	64	76.60
		Time taken by kid to suckle/time taken by kid to stand	35.00	75	74.47
		Tooth loss	31.20	98	66.38
		Vegetation cover (visual assessment)	37.60	39	80.00
		Availability of pasture (according to owner declaration)	39.60	15	84.26
		Supplementary feeding	39.00	23	82.98
		Per cent (%) of pre weaning kid mortality in last 12 months	37.40	44	79.57
	Absence of prolonged thirst	Availability of drinking water (according to owner declaration)	38.20	32	81.28
		Water availability (Visual assessment)	39.20	20	83.40

		Distance to water points	37.60	39	80.00
		Clean and Safe water	41.00	6	87.23
		Skin tent test	32.00	93	68.09
		Water temperature	30.80	100	65.53
Good Environment/facility around camping	Comfort around resting	Coat cleanliness/ integument cleanliness	35.20	72	74.89
		Cleanliness around resting area/muddy soil or dry area/Pasture conditions (rough vegetation and wet and stony soil)	38.60	28	82.13
		Space allowance or stocking density during night penning	39.00	23	82.98
	Thermal comfort	Assess to shade/shelter	38.20	32	81.28
		Panting	36.20	62	77.02
		Shivering	36.40	60	77.45
		Huddling together	36.40	60	77.45
		Enclosure for Kids	40.40	9	85.96
		Rest during hot hours of day	39.60	15	84.26

	Ease of movement	Absence of hazardous objects/Terrain or risky areas	35.00	75	74.47
		Migratory distance travelled in a day (average)	39.40	18	83.83
	Absence of livestock depredation and rustling	Livestock guard dogs	39.00	23	82.98
		Temperament of Livestock guard dog	39.20	20	83.40
		No. of goat losses due to livestock depredation during last 12 months	35.60	69	75.74
		No. of goat losses due to rustling during last 12 months	34.80	79	74.04
Good health	Absence of injuries	Body and head lesions/ Skin lesions and wounds	37.60	39	80.00
		Per cent (%)Lameness/year	39.20	20	83.40
		Lameness score	39.60	15	84.26
	Absence of disease	Abscess	31.00	99	65.96
		Fecal soiling/dag score	34.20	83	72.77
		Fecal consistency score/ Diarrhoea score	37.40	44	79.57
		Nasal discharge	38.00	36	80.85

		Occular discharge	32.00	93	68.09
		Udder condition	32.40	91	68.94
		Incidence of mastitis/year	30.40	104	64.68
		Hampered respiration	36.00	64	76.60
		Hair coat condition	33.40	88	71.06
		Claw condition	35.40	71	75.32
		Animal health check frequency	37.20	48	79.15
		Knowledge of ethnoveterinary practices	35.00	75	74.47
		Dipping frequency	36.60	56	77.87
		Mucosa colour/FAMACHA anemia Chart	37.00	51	78.72
		Vaccination against prevalent diseases	43.00	3	91.49
		Availability of veterinary facilities	40.20	11	85.53
		External parasites	37.60	39	80.00
		Submandibular oedema	34.80	79	74.04

		No. of veterinary treatments in last 12 months/prevalence of diseases in last 12 months	36.80	53	78.30
		Stockperson awareness for onflock diseases	38.80	27	82.55
		Animal Lagging behind the flock	37.40	44	79.57
		Mortality in last 12 months due to infectious diseases (FMD, Enterotoxemia, Goat Pox etc.))	38.60	28	82.13
		Mortality in last 12 months due to consumption of poisonous plants	35.80	68	76.17
		Mortality in in last 12 months due to accidental misadventures	30.80	100	65.53
		No. of abortions or stillbirth in last 12 months	36.60	56	77.87
		No. of bloat cases in last 12 months	30.60	102	65.11
		Per cent (%) of cesarean or assistant kidding	27.40	105	58.30
		Per cent (%)of goats euthanised in last 12 months	25.60	106	54.47

	Absence of pain and pain induced by management procedures	Castration method	35.20	72	74.89
		Pain management during castration	35.20	72	74.89
		Age of castration	37.80	38	80.43
		Identification method used	34.60	82	73.62
		Pain management during identification	32.60	90	69.36
		Age of identification	31.40	97	66.81
		Other pain inflicting management practices including ethnoveterinary practices	31.80	96	67.66
		Euthanasia method	32.80	89	69.79
	Preventive health care practices	Vaccination	45.60	1	97.02
		Deworming	44.60	2	94.89
		Dipping	42.80	4	91.06
Appropriate behavior	Expression of social behaviour	Social withdrawal	36.20	62	77.02
		Behaviour synchrony	34.80	79	74.04
		Vocalisation of doe and Kids	37.20	48	79.15
		Proximity of doe and Kid	36.60	56	77.87
		Agonistic behaviour	36.00	64	76.60

	Expression of other behaviours	Incidence of stereotypies	32.00	93	68.09
		Excessive itching	36.80	53	78.30
		Oblivion	30.60	102	65.11
		Maternal behaviour	38.20	32	81.28
		Grooming	35.00	75	74.47
		Vigilance behaviour	36.00	64	76.60
	Positive emotional State	Qualitative behavioural assessment (QBA)	37.20	48	79.15
	Good humananimal relationship	Latency to the first contact test	33.80	86	71.91
		Familiar human approach test/Handling test	37.40	44	79.57
		Flight distance/Avoidance distance test	34.00	85	72.34
		Appropriate intervention at kidding	38.40	31	81.70
		Response to human while milking	36.80	53	78.30
	Absence of general fear	Response to surprise test	32.20	92	68.51
		Recovery from surprise test	33.60	87	71.49

Good performance	Productive performance	Body weight at 12 months	40.20	11	85.53
		Kid birth weight	41.20	5	87.66
		Milk yield	37.00	51	78.72
		Lactation period	36.40	59	77.45
		Kid weaning weight	40.80	7	86.81
	Reproductive performance	Per cent (%) of twin births	38.20	32	81.28
		Per cent (%)of kidding needed assistance	34.20	83	72.77
		Age at first kidding	39.80	14	84.68
		Kidding interval	40.00	13	85.11
		Kidding rate	39.00	23	82.98
		Kidding per goat (average in lifetime)	39.40	18	83.83
		No. of bucks/per goat	37.60	39	80.00
		Source of purchase of buck (raised from own flock or from other source)	38.60	28	82.13
		Screening of buck while purchasing against diseases	40.80	7	86.81

Table 4.10 Potential welfare indicators selected by the expert panel

Welfare component	Criterion	Indicator	Assessment type
Good feeding	Absence of prolonged hunger	Body condition score	Assessment at gather
		Availability of forage at camping site (according to owner declaration)	Open end question
		Supplementary feeding	Open end question
	Absence of prolonged thirst	Quality of drinking water at camping site	Resource
		Distance to drinking water points from camping site	Resource
Good environment/ facility around camping	Comfort around resting	Integument cleanliness	Assessment at gather
	Thermal comfort	Cold stress score	Assessment in the field
		Environmental protection to kids	Resource
	Ease of movement	Migration distance	Open end question
	Absence of livestock depredation and rustling	Livestock losses due to depredation, Rustling and accidental misadventures	Open end question
		Presence of livestock guard dog with flock	Resource

Good health	Absence of injuries	Lameness score	Assessment at gather and in Field
	Absence of disease	FAMACHA anemia chart	Assessment at gather
		Dag score/fecal score	Assessment at gather and in Field
		Hair coat condition	Assessment at gather
	Absence of pain caused by management procedures	Pain management during management procedures (castration, identification)	Open end question
	Health management practices	Availability of veterinary facilities	Open end question
		Vaccination against diseases (PPR, FMD)	Open end question
		Deworming	Open end question
		Dipping	Open end question
Appropriate behavior	Expression of social behaviour	Behaviour synchrony	Assessment in the field
		Vocalization	Assessment in the field
	Expression of other behaviour	Oblivion (goats physically or mentally isolated from group)	Assessment in the field
	Positive emotional state	Qualitative behavioural assessment (Demeanour)	Assessment in the field

	Good human-animal relationship	Familiar human approach test (FHAT)/Handling test	Assessment in the field
Good Performance	Productive performance	Average kid birth weight	Assessment at gather
		Kid survival until weaning(in last 12 months)	Assessment at gather
		Milk yield (ml per milking at 21 ± 5 days)	Assessment at gather
		Average body weight at 9 months ± 10 days of age	Assessment at gather
	Reproductive performance	Kidding percentage (in last 12 months)	Records
		Abortions/still birth (last 12 months)	Records
		Twinning percentage (in last 12 months)	Records

4.4.3 Welfare assessment protocol

After finalization of welfare indicator and their scores, the final protocol with description of each indicators and its scoring is presented as under:

Table 4.11 Welfare assessment protocol

S.No.	Welfare indicators	Default weightage
A	**Good feeding**	**25**
1.	**Body condition score (Villaquiran *et al*., 2005)**	**(10)**
	If >80 % of the goats have BCS between 2.5-3.5	10
	If between 70-80% goats have BCS between 2.5-3.5	8
	If between 60-69 % goats have BCS between 2.5-3.5	6
	If between 50-59 % goats have BCS between 2.5-3.5	4
	If between <50 % goats have BCS between 2.5-3.5	2
2	**Availability of forage at camping site (according to owner declaration)**	**(6)**
	Fully adequate	6
	Average	3
	Inadequate	0
3	**Quality of drinking water at camping site**	**(4)**
	Water is clean and clear	4
	Water is bit dirty	2
	Water is muddy or dirty in any other way	0
4	**Distance to drinking water points from camping site**	**(3)**
	Distance less than 1000 meter	3
	Between 1000 and 2000 meter	1
	More than 2000 meter	0
5	**Supplementary feeding (mineral mixture)**	**(2)**
	Yes	2
	No	0

B	**Good Environment/Facility around camping**	**15**
6.	**Environmental protection to kids**	**(3)**
	Yes	3
	No	1
7.	**Migration distance**	**(3)**
	Average migration distance travelled by the farmers with flock during camp shifting is < 10 km	3
	Average migration distance travelled by the farmers with flock during camp shifting is 10- 20 km	2
	Average migration distance travelled by the farmers with flock during camp shifting is > 20 km	1
8.	**Livestock losses due to depredation, Rustling and accidental misadventures**	**(3)**
	Livestock losses <5% annually	3
	Livestock losses 5-10% annually	2
	Livestock losses >10% annually	1
9.	**Integument cleanliness (Tiezzi *et al*., 2019)**	**(3)**
	Less than 80% of goats have optimal integument cleanliness (the body is clean, any dirt under the hock)	3
	Between 60-80%	2
	Less than <60%	1
10.	**Cold stress score (Battini *et al*., 2016)**	**(2)**
	Less than 5 % of goats show bristling hair on the back/arched posture	2
	More than 5 % of goats show bristling hair on the back/arched posture	1
11.	**Presence of livestock guard dog with flock**	**(1)**
	Yes	1
	No	0

C	**Good health**	**30**
12.	**Lameness score (LS) (Deeming *et al*., 2018)**	**(8)**
	If >90 % of the goats have LS 1-2	8
	If 60-80 % of the goats have LS 1-2	6
	If 40-59 % of the goats have LS 1-2	4
	If <40% of the goats have LS 1-2	2
13.	**Hair coat condition**	**(4)**
	If >80% of the goats have the normal hair coat condition	4
	If 60-80% of the goats have the normal hair coat condition	2
	If <60% of the goats have the normal hair coat condition	0
14.	**FAMACHA anemia chart (Vatta *et al*., 2001)**	**(4)**
	If >90 % of the goats have scoring 1-2	4
	If 70-89 % of the goats have scoring 1-2	2
	If <60 % of the goats have scoring 1-2	0
15	**Dag score/fecal score/hindquarter cleanliness (Tiezzi *et al*., 2019)**	**(4)**
	If >90% of goats have score 0-2	4
	If 70-89% of goats have score 0-2	2
	If >60% of goats have score 0-2	0
16.	**Availability of veterinary facilities**	**(3)**
	Available for 9-12 months of annual migration	3
	Available for 6-9 months of annual migration	2
	Available for <6 months of annual migration	1
17	**Vaccination against diseases (PPR, FMD)**	**(2)**
	Yes	2
	No	0
18.	**Need based deworming of flock**	**(2)**
	Yes	2
	No	0

19.	**Need based dipping of flock**	**(2)**
	Yes	2
	No	0
20.	**Pain management during management procedures (castration, identification)**	**(1)**
	Yes	1
	No	0
D	**Appropriate behaviour**	**15**
21.	**Familiar human approach test (FHAT)/handling test**	**(4)**
	Positive physical and verbal interaction/No fear	4
	Mild negative physical interaction/mild fear/ mild fear	2
	Strongly negative physical interaction, with or without verbal interaction/Strong fear or panic	0
22.	**Qualitative Behavioural Assessment (Demeanour)**	**(3)**
	If >90 % of the goats are alert and curious	3
	If 70-90% of the goats are alert and curious	2
	If <70% of goats are alert and curious	1
23.	**Vocalization**	**(3)**
	If <3 % of goat vocalize	3
	If 3-5% of goat vocalize	2
	If <5% of goat vocalize	1
24.	**Oblivion (goats physically or mentally isolated from group)**	**(3)**
	Less than 3 % of goats	3
	Between 3-5% of goats	2
	More than 5% of goats	1
25.	**Behavioural synchrony**	**(2)**
	More than 80% of goats show behavioural synchrony	2
	Between 70-80% of goats show behavioural synchrony	1
	Less than 70% of goats show behavioural synchrony	0

E	**Good performance**	**15**
26.	**Average kid birth weight**	**(3)**
	More than 2 kg	3
	Between1-2 kg	2
	Less than 1 kg	1
27.	**Kid survival until weaning(in last 12 months)**	**(2)**
	More than 80 %	2
	Between 60-80 %	1
	Less than 60 %	0
28.	**Average body weight at 9 months ± 10 days of age**	**(2)**
	More than 20 kg	2
	Between15-20 kg	1
	Less than 15 kg	0
29.	**Kidding percentage (in last 12 months)**	**(2)**
	More than 80%	2
	Between60-80%	1
	Less than 60%	0
30.	**Abortions/still birth (last 12 months)**	**(2)**
	Less than 5%	2
	Between5-10%	1
	More than 10%	0
31.	**Milk yield (ml/day)**	**(2)**
	More than 500	2
	Between250-500	1
	Less than 250	0
32.	**Twinning percentage (in last 12 months)**	**(2)**
	More than 20%	2
	Between 10-20%	1
	Less than <10%	0
	Total welfare score	**100**

4.5. TESTING THE RELIABILITY AND VALIDITY OF SCALE

4.5.1 RELIABILITY OF THE WELFARE ASSESSMENT PROTOCOL

For testing the reliability of the developed welfare assessment scale the Cronbach's alpha was calculated as described in Chapter-3. The value of Cronbach's alpha based on standardized items was 0.90 which indicated high correlation for the 32 indicators selected thus the reliability and internal consistency of the scale in this method was confirmed. The case processing summary, mean and SD of i times considered for reliability testing is given in Table 4.12 and 4.13 respectively.

Table 4.12 Case processing summary

Case Processing Summary			
		N	%
Cases	Valid	43	93.5
	Excluded[a]	3	6.5
	Total	46	100.0

a. List wise deletion based on all variables in the procedure.

Table 4.13 Mean and SD of items considered for reliability testing

Item Statistics			
Welfare Indicator	**Mean**	**Standard deviation**	**N**
BCS	0.85	0.17	43.00
Fodder availability	0.84	0.14	43.00
Quality of water	0.83	0.19	43.00
Distance to water points	0.80	0.15	43.00
Supplementary feeding	0.84	0.17	43.00
Environmental protection to kids	0.87	0.15	43.00
Migration distance	0.85	0.17	43.00

Livestock Losses	0.75	0.14	43.00
Livestock guard dog	0.82	0.16	43.00
Cold stress score	0.77	0.19	43.00
Integument cleanliness	0.73	0.18	43.00
Lameness score	0.84	0.16	43.00
Hair quality	0.73	0.14	43.00
FAMACHA anemia chart	0.81	0.18	43.00
Dag score	0.74	0.19	43.00
Veterinary facility	0.87	0.16	43.00
Vaccination	0.98	0.08	43.00
Deworming	0.95	0.11	43.00
Dipping	0.91	0.15	43.00
Pain management practices	0.72	0.19	43.00
FHAT	0.80	0.16	43.00
QBA	0.79	0.14	43.00
Vocalization	0.80	0.19	43.00
Oblivion	0.70	0.15	43.00
Behaviour synchrony	0.75	0.17	43.00
Kid birth weight	0.92	0.11	43.00
Survivability of kids	0.80	0.17	43.00
Weight at 9 months	0.87	0.14	43.00
Kidding percentage	0.84	0.14	43.00
Abortions	0.80	0.20	43.00
Daily milk yield	0.80	0.12	43.00
Twinning percentage	0.84	0.15	43.00

4.5.2 VALIDITY OF WELFARE ASSESSMENT PROTOCOL

In this study we mainly relied on content validity. Although there are no direct statistical measures for content validity, it can be determined by having various experts appraise the appropriateness of the items presented and comparing their ratings (Cronbach and Meehl, 1995). As many as 50 experts were again consulted for content validity, out of which 46 responded to the scale. Out of 46 experts, 42 experts who scored the scale were retained for final consideration because of their agreement, and rests 4 expressed their disagreement with the contents of the scale. In percentage terms 91.30 % of experts agreed with the appropriateness of items included in the scale and 8.7 % did not agree. So the validity of scale was confirmed on the basis of agreement of experts (Threshold level for validity of the scale being 80% of the experts) in agreement (Voutilainen and Liukkonen, 1995).

4.6. TESTING THE FEASIBILITY OF THE VALIDATED INDICATORS

Feasiblity is one of the key factors for indicators used during on farm welfare indicators. Feasiblity of the AWIN indicators is well eastablished for the intensive and semi-intensive production system. However the feasibility of these indicators has not been tested for the migratory goats. It is not possible to track a large number of the same animals in the migratory system during different physiological stages. Therefore only iceberg indicators were used to study the feasibility of these indicators in the migratory goat production system. Iceberg indicators from the AWIN protocol were tested on four flocks of Gaddi goats, 50 goats from each flocks were radomly selected for welfare assessment. Goats were tagged for identification and welfare assessment was done at different altitudes viz. high, mid and low-hills. Results of the welfare indicators are presented in Table 4.14

The mean values of welfare indicators are presented in table 4.13. The body condition score recorded in high hills was found significantly ($P<0.05$) higher as compared to that recorded in mid hills and low hills. Overall welfare in terms of FAMACHA, hair quality, integument cleanliness, dag score was significantly ($P<0.05$) better in high hills as compared to both mid hills and low hills whereas no significant difference was observed in the lameness scoring among all the three groups.

Table 4.14 Welfare assessment of the Gaddi goats at high, mid and low hills using AWIN Protocol

Welfare Indicator	High hills N=200	Mid hills N=200	Low hills N=200	Overall
Body condition score	2.85 [b] ± .04	2.41 [a] ± .03	2.34 [a] ± .02	2.53 ± .02
FAMACHA	1.61 [a] ± .07	2.20 [b] ± .10	2.10 [b] ± .08	1.97 ± .05
Hair quality score	1.05 [a] ± .02	1.14 [ab] ± .03	1.23 [b] ± .04	1.14 ± .02
Integument cleanliness score	1.06 [a] ± .02	1.26 [b] ± .05	1.39 [b] ± .07	1.26 ± .03
Lameness score	1.15 ± .05	1.29 ± .07	1.22 ± .05	1.22 ± .03
Dag score	0.61 [a] ± .10	1.02 [b] ± .14	0.88 [ab] ±.13	0.83 ± .07

Values within a row with different superscript are significantly different ($p < 0.05$).

Welfare indicator was awarded with a score of 0 when welfare is good and score of 1 was awarded when welfare has been poor and unacceptable

4.6.1 Body condition scoring

Mean value of BCS at different altitudes at low, mid and high hills was 2.34± 0.02, 2.41± 0.03, and 2.85± 0.04 respectively; while overall mean BCS was 2.53± 0.02. BCS was significantly (P<0.05) higher at the high hills, as compared to mid and low hills. High quality fodder availability of the alpine pasture might have resulted in the higher BCS at high hills. Moreover, when the flocks were at low hills they were facing the fodder scarcity and the harsh winter conditions due to winter accompanied by lactation, which might have resulted in depletion of body reserves. During the winter season, feed availability in the low hills has been viewed as a key constraint for Gaddi nomadic pastoralism (Singh *et al*., 2006).

4.6.2 FAMACHA©

The mean values of FAMACHA© at low, mid and high hills were 2.10± 0.08, 2.20± 0.10 and 1.61± 0.07 respectively while overall mean FAMACHA was1.97± 0.05. Gaddi goats when at high hills have significantly lower FAMACHA© score as compared to low and mid hills. Significant correlation was reported between the eye color score (FAMACHA© score) and *Haemonchus*infection (Abay *et al*., 2015). Highest incidence of

gastrointestinal parasites in Gaddi goat were reported in rainy season (91.66 per cent) followed by summer (87.50 per cent) and lowest in winter season (79.16 per cent). In the rainy season maximum prevalence of *Heamonchus contortus* (91.66 per cent) was also reported (Devina, 2004).

4.6.3 Hair quality

The mean scores of hair quality at low, mid and high hills were 1.23 ± 0.04, 1.14± 0.03 and 1.05± 0.02 respectively, with overall mean of 1.14± 0.02. The cold semi-arid environment has been found to be unfriendly for orbatid mites, intermediate hosts of cestodes, which may explain why enteric cestodes are less common (Denegri, 2001).

4.6.4 Integument cleanliness

Integument cleanliness scores at low, mid and high hills were 1.39± 0.07, 1.26± 0.05 and 1.06± 0.02 respectively and overall mean score of 1.26± 0.03. Integument cleanliness at high hills was significantly ($P<0.05$) higher as compared to low and mid hills. Less rainfall and clean lying space available to the Gaddi goats at high hills might have resulted in the better integument cleanliness score.

4.6.5 Lameness score

Mean lameness scores at low, mid and high hills were 1.22±.05, 1.29± 0.07 and 1.15± 0.05, with overall mean of lameness score of 1.22± 0.03. No significant differences were found in the lameness score at different altitudes. Non-significantly higher lameness score was found at mid hills which might be due to rainy conditions at that time of migration. Horizontal transmission of footrot is more likely to develop during the wet season as a result of flocks sharing common pastures, when the ground is wet (Gelasakis *et al*., 2019).

4.6.6 Dag score

Average values of Dag scores at different altitudes viz. mid, high and low hills were 0.88± 0.13, 1.02± 0.14 and 0.61± 0.10, with an overall mean of Dag score of0.83± 0.07. Dag scores were highly significant ($P<0.05$) at different altitudes and at mid hills it wassignificantly higher than at low hills. DISCO/Diarrhoea score (Dag score) is vulnerable to a variety of pathogens (including coccidia, GIN, and Moniezia), necessitating parasitological diagnostics to be more efficient in controlling gastrointestinal tract infections (Cabaret *et al.,* 2019).

Plate 12. Tagging of Gaddi goats for welfare assessment

Plate 13. Assessment of BCS at high hills

OBJECTIVE: 3

4.7. Welfare assessment of goats

The welfare assessment protocol developed in the present study was adapted from AWIN framework for goats (AWIN, 2015). It was categorized into five welfare domains (feeding, environment/ facility around camping, health, behaviour and performance) with 32 welfare indicators (5, 6, 9, 5 and 7 from each domain respectively) and domains were assigned a welfare score (WS) of 25,15,30,15 and 15 respectively aggregating into 100. Welfare assessment was performed at low hills on two migratory routes on 24 flocks categorized into small (S<100 goats), medium (M=100-200 goats) and large (L>200 goats) with eight flocks each. The results of the welfare assessment of different flock size categories has been presented below

4.7.1 Component A: Good feeding

The mean values of the welfare scores of good feeding components in different categories of flock sizes is presented in table 4.15. Mean scores of body condition score recorded in small flocks was significantly (P<0.05) higher as compared to large flocks. The mean scores of availability of fodder was significantly (P<0.05) higher for small flocks as compared to large flocks. Welfare scores of distance to water points was significantly (P<0.05) higher in small flocks as compared to both large and medium flocks.

Table 4.15 Mean welfare scores of 'Feeding' component in different categories of migratory flocks of Gaddi goat

Welfare indicator	Maximum score	Flock size category			Overall score
		Small	Medium	Large	
BCS	10	$5.50^{b} \pm 0.33$	$4.75^{ab} \pm 0.36$	$4.25^{a} \pm 0.25$	4.83 ± 0.21
Forage availability (as per owner declaration)	6	$2.75^{b} \pm 0.25$	$2.00^{ab} \pm 0.38$	$1.50^{a} \pm 0.33$	2.08 ± 0.21
Quality of drinking water	4	3.50 ± 0.33	3.00 ± 0.38	3.50 ± 0.33	3.33 ± 0.19
Distance to the water points	3	$2.50^{b} \pm 0.33$	$1.25^{a} \pm 0.41$	$0.88^{a} \pm 0.35$	1.54 ± 0.25
Supplementary feeding	2	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Total	25	$14.25^{b} \pm 0.80$	$11.00^{a} \pm 1.32$	$10.12^{a} \pm 0.88$	11.79 ± 0.66

Values within a row with different superscript are significantly different (p < 0.05).

4.7.1.1 MEAN VALUES OF WELFARE SCORES OF INDIVIDUAL WELFARE INDICATORS UNDER COMPONENT A

1. Body Condition Scoring

The BCS could be a useful technique for immediate assessment of an animal's nutritional status and determining when to adopt remedies to guarantee goats get all of their nutritional needs, improving both productivity and welfare. The mean value of welfare indicator BCS of goats out of 10 in small flocks, medium flocks and large flocks were 5.50±0.33, 4.75±0.36 and 4.25±0.25, and the overall score was 4.83±0.21. The mean value of welfare score of small flocks was significantly ($P<0.05$) higher than large flocks. Lower BCS in all the categories of flocks may be due to lower body reserves during early-mid lactation stage, the condition was further aggravated by absence of any supplementary feed. The higher demand of the nutrients and body fat mobilization required by the animals at pasture due to their movement and extreme environmental conditions as compared to indoor reared animals (McGregor and Butler, 2008).

In their on-farm welfare assessment of goat farms in UK, Anzuino *et al.* (2010) determined cut-off marks for visibly thin as 1.5 and 4 for very fat.BCS of 2.91 ± 0.05 and 2.98 ±0.06 was observed 15 and 30 days after kidding respectively in the commercial farm of Alpine goats. McGregor and Butler (2008) discovered a link between BCS and goat mortality, indicating that when BCS was < 2.0, death increased significantly in cold weather conditions, with no mortality at BCS ≥ 2.5. Viera *et al*. (2015) reported that for the creation and validation of a visual body condition grading system for dairy goats using picture-based training, a cut-off of 2 for very thin goats was used. From BCSK (Body condition score at kidding) to the first week postpartum, there was a 0.23 unit drop in mean BCS, which remained up to 11 weeks postpartum. The average postpartum loss was 0.23 – 0.75 (Venkata Reshma *et al*., 2021). Most of the goats which were showing optimum welfare were in the BCS approaching to value of 2, which could lead to a negative energy balance, and further metabolic problems and decreased performance.A total of 520 extensively reared sheep were assessed across all farms of Columbia, with 80.2 percent (n = 417) having a BCS of ≤ 2 (Hernandez *et al*., 2020). None of the intensive (N= 21) and semi-intensive farms (N=11) were reported to have very thin goats during welfare assessment of goats in Italy (Tiezzi *et al*., 2019) as they all have given antiparasitic treatments.Body condition score of goats reared in extensive system of Brazil were

categorized as very thin (n=28; 14.50%), thin (n=68; 35.23%), adequate (n=72; 37.30%), fat (n=21; 10.88%) and very fat (n=4; 2.07%) (Leite *et al*., 2020).

The higher BCS in the smaller flock size might be due to more fodder availability and lesser competition. It's likely that lactating animals' high nutrient demand contributed to the high rate of ME intake, which remained constant regardless of stocking rate or forage nutritive value (Askar *et al.*, 2013). The low BCS in the rangeland may also be due to higher locomotor activity and higher (14.2-46.6%) above maintenance requirement, especially in the low hills where there is lower forage availability (Lachica *et al*., 1997, Lachica *et al*., 1999). Nutritional content of pastures on large hill systems is typically insufficient, and animal nutrition is sub-optimal (Morris, 2017; Doughty *et al*., 2019), which might have resulted in the lower BCS score in goats.

2. Forage availability

The mean value of welfare indicator fodder availability (as per owner declaration) out of 6 in small flocks, medium flocks and large flocks were 2.75±0.25, 2.00±0.38and 1.50±0.33, and the overall score of 2.08±0.21. The mean value of welfare score of small flocks was significantly ($P<0.05$) higher than large flocks. Prolonged hunger in ewes has been rated as the most compromising welfare issue in extensive and very extensive management system (EFSA, 2014).

3. Quality of drinking water

The mean value of welfare indicator quality of water out of 4 in small flocks, medium flocks and large flocks were 3.50±0.33, 3.00±0.38 and 3.50±0.33, and the overall score was 3.33±0.19. There was no significant difference between the mean value of welfare score of small, medium and large flocks. Drinking water was present in all the camping sites of the migratory goats. However, assess of clean drinking water to the migratory goats need to be improved and it can be done by repairing the ponds/natural water resources. Also, there is a practice of providing the water to the flocks only after 2-3 alternate days due to perception that the animals will eat less if provided daily water.

4. Distance of water points

The mean value of welfare indicator distance to the water points out of 3 in small flocks, medium flocks and large flocks were 2.50±0.33, 1.25±0.41and 0.88±0.35, and the overall score was1.54±0.25. The mean value of welfare score of small flocks was significantly ($P<0.05$) higher than medium and large flocks. Providing the water points

near the pasture area can be serious welfare problem especially in summers. In larger flocks the distance of water points in larger than >1500 meters while it is less in the smaller flocks. Battini *et al*. (2021) also reported that distance of water points from pasture area ranged from 0 to 1500 m in goats kept in semi-extensive farming conditions.

5. Supplementary feed

Farmers rarely employed proper care and supplemental feeding of pregnant does, since it was impractical to do so during migration (Sankhyan *et al*., 2014). None of the farmers was found to offer any supplementary feed to goats and therefore the welfare score for this indicator was zero in all categories of flocks. Salt was given only once a week, which is believed to increase the forage intake of goats. Methi/ Fenugreek (*Trigonella foenum-graecum*)/Tara meera (*Eruca sativa*)/alsi (Linseed, *Linum usitatissimum*) were provided only to bucks as a supplementary feed before breeding season. Adoption of practicing supplementary feeding to flock is lacking in nomads which may be due to insufficient knowledge, cost and time consumption. Feed scarcity and a lack of adoption of better technologies and management methods are the reasons of lower goat productivity is traditional goat production (Singh and Kumar, 2007).

Plate 14. Gaddi goat with poor body condition

Plate 15. Feeding of salt as supplement to goats

4.7.2 Component B: Good environment/ facility around camping

The mean welfare scores of 'Environment/ facility around camping' component in different categories of migratory flocks of Gaddi goats are presented in Table 4.16. No significant difference were observed for environmental protection, migration distance, livestock losses, livestock guard dog, cold stress score. However, score for integument cleanliness was significantly (P<0.05) higher in small and medium flocks as compared to large flocks. Overall score for the small flocks scored significantly (P<0.05) higher when compared to large and medium flocks.

Table 4.16 Mean welfare scores of 'Environment/ facility around camping' component in different categories of migratory flocks of Gaddi goat

Welfare indicator	Maximum score	Flock size category			Overall score
		Small	Medium	Large	
Environmental protection	3	2.50 ± 0.33	1.75 ± 0.36	1.50 ± 0.33	1.92 ± 0.21
Migration distance	3	2.00 ± 0.00	2.00 ± 0.00	2.25 ± 0.16	2.08 ± 0.06
Livestock losses	3	2.50 ± 0.19	1.88 ± 0.29	2.00 ± 0.33	2.13 ± 0.16
Livestock guard dog	1	0.63 ± 0.18	0.38 ± 0.18	0.63 ± 0.18	0.54 ± 0.10
Cold stress Score	2	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00	2.00 ± 0.00
Integument cleanliness	3	2.75^{b} ± 0.16	2.38^{b} ± 0.18	1.63^{a} ± 0.18	2.25 ± 0.14
Overall	15	12.37^{b} ± 0.62	10.37^{a} ± 0.46	10.00^{a} ± 0.78	10.91 ± 0.41

Values within a row with different superscript are significantly different (p < 0.05).

4.7.2.1 MEAN VALUES OF WELFARE SCORES OF INDIVIDUAL WELFARE INDICATORS UNDER COMPONENT B

1. Environmental protection

The mean value of welfare indicator Environmental Protection out of 3 in small flocks, medium flocks and large flocks were 2.50±0.33, 1.75±0.36 and 1.50±0.33, and the overall score of 1.92±0.21. There was no significant difference among the mean value of welfare score of small, medium and large flocks. Welfare score for environmental protection to kids was non-significantly higher in the smaller flocks as compared to the medium and larger ones. Kidding in case of Gaddi goats generally takes place at low hills accompanied by the winter. Shepherds provide the protection to the kids from extreme weather by using bamboo baskets and using temporary stones housing near camping.

2. Migration distance

On average, 49± 6.9 days were reported to be taken by the Gaddis for one-way movement that involves covering a distance of ~400 km (Sharma *et al*., 2022).The mean score of welfare indicator migration distance out of 3 in small flocks, medium flocks and large flocks were 2.00±0.00, 2.00± 0.00 and 2.25±0.16, with overall score of 2.08±0.06. There was no significant difference among the mean value of welfare score of small, medium and large flocks. Welfare score of larger flocks is non-significantly higher in the larger flocks when compared to medium and smaller flocks. Problem of migration with the larger flock when moving on the roads and high traffic might have resulted in covering lesser distance. Small flocks generally travel >15 km/day whereas larger flocks reported to travelled distance of <10 Km/day.

3. Livestock losses

Livestock losses in Gaddi flocks were reported mainly due to predation, rustling, plant poisoning etc. The mean scores of welfare indicator livestock losses out of 3 in small flocks, medium flocks and large flocks were 2.50±0.19, 1.88±0.29 and 2.00±0.33, while the overall score of 2.13±0.16. There was no significant difference among the mean value of welfare score of small, medium and large flocks.Livestock losses were reported to be non-significantly lower in the flocks having Livestock Guard Dog (Gaddi dog).

4. Livestock Guard Dog

LGD is a predator-repelling dog that generally stays with the flock without harming them (Green and Woodruff, 1999). The mean value of welfare indicator Livestock Guard

Dog out of 1 in small flocks, medium flocks and large flocks were 0.63±0.18, 0.38±0.18 and 0.63±0.18, and the overall score of 0.54±0.10. There was no significant difference among the mean value of welfare score of small, medium and large flocks. No significant differences were observed in the different categories of flock sizes in relation to keeping of Livestock Guard Dog (LGD). Gaddi dogs have proven to be the most effective non-lethal method in preventing the livestock losses due to depredation during migration (Thakur *et al*., 2021).

5. Cold stress score

The mean value of welfare indicator cold stress score out of 2 in all the flocks was 2.00±0.00, and the overall score of2.00±0.00. There was no significant difference among the mean value of welfare score of small, medium and large flocks. No significant differences were observed in the welfare score for the cold stress in all categories of flock sizes. The percentage of Goats showing signs of cold stress was reported to be considerably lower than the goats showing signs of heat stress (Battini *et al*., 2014). Moreover, the temperature conditions remain favorable due to continuous migration of Gaddi goats in search of pastures. The temperatures at high and low hills remain between 10-22 degree Celsius.

6. Integument cleanliness

Integument cleanliness is used to obtain information on the availability of clean ground and quality of environment available to the goats. The mean value of welfare indicator integument cleanlinessof goats out of 3 in small flocks, medium flocks and large flocks were 2.75±0.16, 2.38±0.18and 1.63±0.18, and the overall score of 2.25±0.14. The mean value of welfare score of large flocks was significantly ($P<0.05$) higher than small and medium flocks.

Integument cleanliness was significantly ($P<0.05$) higher in small and medium sized flocks as compared to larger flocks. Larger flocks rested in the area with higher stocking density during the night surrounded by the fences made of bushes and thorn, this might have resulted in the lower welfare scoring. Favorable weather conditions along the whole migratory route resulted in the higher welfare scores for integument cleanliness. Earlier it had been reported that 48.5 per cent of the sheep reared in extensive rural farms of Columbia also reported to have good integument cleanliness (Hernandez *et al*., 2020).

Plate 16. Camping site of the Gaddi nomads during migration

Plate 17. Environmental protection in winter to goat kids by providing dome shape bamboo basket

Plate 18. Gaddi breed of dog kept as Livestock Guard Dog (LGD) with the flocks

Plate 19. Coat cleanliness of goat

4.6.3 Component C: Good health

The mean welfare scores of 'health' component in different categories of migratory flocks of Gaddi goat is presented in Table 4.17. The welfare in terms of lameness score and ectoparasitic Score recorded was significantly (P<0.05) better in small flocks as compared to large flocks whereas no significant difference was recorded for other indicators such as FAMACHA, dagscore, veterinary facility, vaccination, deworming, dipping. There was absence of pain mitigation treatments while performing managemental procedures such as identification, castration and during treatment of lantana poisoningregardless of the flock size.

Table 4.17 Mean welfare scores of 'Health' component in different categories of migratory flocks of Gaddi goat

Welfare indicator	Maximum score	Flock size category			Overall score
		Small	Medium	Large	
Lameness score	8	$8.00^{b} \pm 0.00$	$7.50^{ab} \pm 0.33$	$7.00^{a} \pm 0.38$	7.50 ± 0.18
Hair coat condition	4	$3.50^{b} \pm 0.33$	$2.75^{ab} \pm 0.36$	$2.00^{a} \pm 0.00$	2.75 ± 0.20
FAMACHA anemia chart	4	3.75 ± 0.25	3.50 ± 0.33	3.00 ± 0.38	3.42 ± 0.19
Dag score	4	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00	4.00 ± 0.00
Veterinary facility	3	2.25 ± 0.16	2.50 ± 0.19	2.13 ± 0.12	2.29 ± 0.09
Vaccination	2	1.75 ± 0.25	1.75 ± 0.25	1.50 ± 0.33	1.67 ± 0.15
Deworming	2	1.50 ± 0.33	1.00 ± 0.38	1.00 ± 0.38	1.17 ± 0.21
Dipping	2	1.75 ± 0.25^{b}	1.25 ± 0.36^{ab}	0.75 ± 0.36^{a}	1.25 ± 0.20
Pain management	1	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Good health	30	$26.25^{b} \pm 1.10$	$24.25^{a} \pm 0.95$	$21.37^{a} \pm 0.82$	24.04 ± 0.69

Values within a row with different superscript are significantly different ($p < 0.05$).

4.7.3.1 MEAN VALUES OF WELFARE SCORES OF INDIVIDUAL WELFARE INDICATORS UNDER COMPONENT C

1. Lameness

The mean value of welfare scores oflameness out of 8 in small flocks, medium flocks and large flocks were 8.00±0.00, 7.50±0.33and 7.00±0.38, and overall score of 7.50±0.18. The mean value of welfare score of small flocks was significantly ($P<0.05$) higher than large flocks.

Lameness is a variation from normal gait that may or may not be accompanied by pain and distress. It jeopardizes goat welfare by causing long-term pain and disrupting natural behaviour. It's more of a sign rather than a disease itself, and is frequently caused by injuries, lesions, deformities or diseases that affect the limbs, joints or other body parts.

Footrot (Christodoulopoulos, 2009; Kaler and Green 2009), white line lesions (Winter, 2009), foreign substances (Mgasa *et al*., 1993), foot abscesses, and sole ulcerations (De Aguiar *et al.,* 2009) are the common causes of lameness in goats. Goats become lame due to disorders in their hooves caused by poor diet, the environment, and anatomical reasons (Pugh and Baird, 2012). Injury, interdigital pouch inflammation, and foreign substances may be common causes of foot-related lameness in arid and semi-arid locations with extensive and semi-extensive farming systems of sheep (Bokko *et al*., 2003). Footrot (*Dichelobacternodosus*) is responsible for 90% of lameness cases in sheep (Kaler *et al*., 2008). *Dichelobacternodosus* has also been identified as a cause of goat lameness (Depiazzir *et al*., 1991; Bennett *et al*., 2009). However, a synergistic activity with *Fusobacterium necrophorum* is required for infection to occur. The latter bacterium is found in soil and excrement as a natural inhabitant. It produces interdigital dermatitis, which permits *D. nodosus* to invade (Wani and Samanta, 2005). Feet exposure to ambient and damp grass, excrement and urine for long periods of time increases the risk of infection and disease transmission between animals (Egerton, 2002).

According to reports (Anzuino *et al*., 2010), up to 100% of dairy goat farms may have overgrown feet, with up to 91.7 percent of farms having goats with significantly overgrown feet (>2.5 cm). In dairy goats, severely enlarged or malformed feet are linked to higher mobility scores and claw temperatures, perhaps contributing to farm lameness (Ajuda *et al*., 2013). However, in the migratory goat production grazing on rough, stony terrains allows the hooves to naturally wear down and prevents them from overgrowing,

allowing them to maintain their proper form and size. In low-input systems, improper feeding can also contribute to poor-quality claw horn, which can lead to injuries and foot-related lameness. Hard, abrasive rocks during migration may predispose the Gaddi goats to foot injuries and the region's sub-temperate, wet climate contributes to the development of foot lesions.

Severe lameness was reported in the 19.05% (N=21) of intensive goat farms, while it was reported only 10% in semi-intensive farms (N=11) of Italy. In a four-year survey of various affections in Himachal Pradesh's migratory sheep, 23.8 percent were reported to be attributable to musculoskeletal affections, with foot problems being the most common concern (Sharma *et al*., 2002). Low prevalence (3.44% , N=29 foot swabs) of foot rot due to *D. nodosus* was reported in Gaddi goats, which may have occurred due to mixing of the migratory flocks at pastures. Foot-related lameness in dairy sheep can be exacerbated by flock size and housing conditions. In semi-intensive and intensive dairy sheep farms, the incidence of lameness has been reported to be lower in larger flocks. This conclusion could be ascribed to large farms' better knowledge of how to use the right infrastructure and technologies in meat sheep in the UK, There is no link between flock size and the frequency of foot-related lameness (Kaler *et al*., 2009).

Overcrowding in the larger flocks accompanied by accumulation of urine and feces increased the moisture in the resting area (muddy condition) compromising the hygiene status and favouring the proliferation and transmission of lameness causing bacteria. When compared to more than 2 m^2 per ewe, a housing space of less than 2 m^2 per ewe was related with a 2.3 times higher probability of developing lameness (Gelasakis *et al*., 2013). According to the owners' account, on average, 10–20 percent of each sheep and goat flock showed signs of lameness during, or in the months after monsoon rains (Wani *et al*., 2005). Overall lameness of 4.7% (N= 5909 of 32 farms) was observed in the extensively managed sheep flocks of Australia (Munoz *et al*., 2019). Management system (i.e., access to pastures) was reported to be not associated with more lameness, however higher stocking densities in sheep are associated with more lameness (O'Connor *et al*., 2015). Leite *et al*. (2020) reported minor lameness (0.37, N=264) and lameness (1.13, N=274) was reported in the welfare assessment of extensive goats of Brazil. In migratory routes, the presence of bare soil and contact of the sole with the presence of stones may have promoted natural abrasion of hooves, preventing lameness.

2. Hair coat

Scoring systems for hair coat condition are used to assess animal welfare across a variety of species. Berg *et al.* (2009) emphasised that assessing the quality of the hair coat may be crucial for determining welfare since it can help identify health issues before they become serious. This is true even when no pathology is anticipated.The mean value of welfare score of hair coat condition out of 4 in small flocks, medium flocks and large flocks were 3.50±0.33, 2.75±0.36and 2.00±0.00, and overall score of 2.75±0.20. The mean values of welfare score of small flocks was significantly ($P<0.05$) higher than large flocks.

Poor hair coat condition was reported in 12.12% (32, N=264) of the assessed goats reared under extensive system of Brazil (Leite *et al*., 2020). It could be due to various pathologies or diseases in animals (Berg *et al*., 2009). Poor hair coat condition of around 62.75% (54/86) was fond prevalent in the extensive goats in all farms of Serbia (Nenadovic *et al*., 2021). Different factors are responsible for poor hair coat condition viz. low BCS, mineral deficiencies and ectoparasitic infestation (Battini*et al*., 2015; Veit *et al*., 1993; Szefer and Nariagu 2007). Longer exposure to cold (indirectly due to higher energy for maintenance) and endoparasitic infestation can also be a cause of poor coat condition (Battini *et al*., 2015; Waller, 2006). Hair coat condition (62.79 percent, 54/86) with an average score of 0.63 ± 0.03 was the most inadequate and undesirable welfare indicator in goats (Nenadović *et al*., 2021). The high incidence of coccidian oocysts has been shown linked with poor hair coat condition, as these destroy the intestinal cells of hosts and electrolyte loss exacerbates mineral deficiencies (Wang *et al*., 2010; Szefer and Nriagu, 2007). Integument alterations in the form of hairless patches have also been observed in the present study.

3. FAMACHA©

FAMACHA© score is related to gastrointestinal infestation for clinical evaluation of anemia, highly dependent on the presence of *Haemnchuscontortus*, not sensitive to the other parasitic burdens. The mean value of welfare score forFAMACHA© out of 4 in small, medium and large flocks were 3.75±0.25, 3.50±0.33 and 3.00±0.38, and overall score of 3.42±0.19. There was no significant difference for this welfare indicator between small, medium and large flocks. Sixteen percent of the animals (n=84) found to haveFAMACHA©score of ≥4, while 52.8% (n=274) showed a score of ≤ 2 (Hernandez *et al*., 2020). The present study has been performed in the winters (Mid-Lactation) at low

hills which might have resulted in the higher welfare score in all the flocks. Gastrointestinal (GI) nematode infections, particularly *haemonchosis*, are very common in goats housed in places with warm and wet environment conditions (Besier *et al*., 2016).

4. Dag Score/ Fecal Soiling

The mean values of welfare indicator Dag Score out of 4 in small flocks, medium flocks and large flocks were 4.00±0.00, 4.00±0.00 and 4.00±0.00, while the overall welfare score for this indicator was 4.00±0.00. There was no significant difference for this welfare indicator between small, medium and large flocks. Similar observations were recorded by Salas *et al*. (2020) where none case of diarrhea was reported from 33 semi-intensive farms. Battini *et al*. (2021) also found absence of fecal soiling in 100% of the 13 semi-intensive goat farms of Italy.

5. Veterinary facilities

The mean values of welfare indicator Veterinary facility out of 3 in small flocks, medium flocks and large flocks were 2.25±0.16, 2.50±0.19 and 2.13±0.12, and overall score of 2.29±0.09. No significant differences were observed in the availability of veterinary facilities across different flock categories. Difficulty of providing veterinary facilities due to migration of the Gaddi's across different altitudes from 350 m above MSL to 5000 mts above MSL and difficult terrains might have resulted in lower scoring. Same results have been reported by Sankhyan *et al*. (2016) when studying improved management strategies of the Gaddi flocks. Most of the flock owners were not happy with the veterinary services due to non-availability of supplies. Also, they have lower number of stockperson to look after flocks and they can't leave the flocks for treatment of animals.

6. Health management practices (vaccination, deworming and dipping)

The mean values of welfare score for vaccination out of 2 in small, medium and large flocks were 1.75±0.25, 1.75±0.25 and 1.50±0.33, and overall score of 1.67±0.15. There was no significant difference for this welfare indicator between small, medium and large flocks. The mean values of welfare score for deworming out of 2 in small flocks, medium flocks and large flocks were 1.50±0.33, 1.00±0.38 and 1.00±0.38, and overall score of 1.17±0.21. There was no significant difference for this welfare indicator between small, medium and large flocks. The mean values of welfare score for dipping out of 2 in small flocks, medium flocks and large flocks were 1.75±0.25, 1.25±0.36 and 0.75±0.36,

and overall score of 1.25±0.20. Small flocks scored significantly higher score in dipping when compared to large flocks

No significant differences were found in the health management practices (deworming, dipping and vaccination) in different flock size categories. The level of adoption of the heath management practices was higher in the small flock owners as compared to medium and large flock owners. Handling of the goats for these management practices is time consuming task that might have resulted lower score in large and medium flock sizes. Dipping is the least practiced activity practices by the large sized flocks. The perception of farmers that dipping might result in spread of infection from one flock to other need also be addressed. Dipping, deworming and vaccination were reported to be done by the Gaddi nomads during downward migration in the veterinary facility of the government only. Prevalence of 33.33% (Ticks), 22.80 % (Chewing lice), 10.53 % (Sucking lice), 5.26 %Concurrent infestation (suking and chewing lice), 26.31% Concurrent infestation (Ticks and Lice) and no ectoparasites (1.75%) were observed in the 57 screened samples of Gaddi goats from Kangra district of Himachal Pradesh (Devi *et al*., 2021).

7. Pain management practices

The mean value of welfare indicator pain management out of 1 in all the flocks were 0.00±0.00, while the overall welfare scores for this indicator was 0.00±0.00. There were no significant differences in flock sizes across the various groups. Gaddi goats were subjected to painful procedures such as ear cuts for identification at early age (5-10 days) and castration of bucks was also done by them without using any analgesics. Treatment of Lantana poisoning was also done by making ear cuts and draining out blood. Hernandez *et al*. (2020) also reported that none of the farmers in rural sheep farms of Columbia used anesthesia or pain relief methods for castration and tail cutting procedures. Ear cuts were also reported to be performed by the farmers in meat goats of Brazil with use of knives without analgesia and pain relief measures (Leite *et al*., 2020.

Plate 20. Hoof examination of lame goat

Plate 21. FAMACHA scoring of goat

Plate 22. Poor hair coat condition of goat

Plate 23. Ethno veterinary practices (tying part of *Bishkhapar* plant to the neck with a necklace)followed by Gaddi nomads for Mastitis

Plate 24. Ear cuts performed in goats with scissor for identification

Plate 25. Vaccination of Gaddi flock against Peste des Petits Ruminants (PPR)

4.7.4 Good Behaviour

The mean welfare scores of 'Behaviour' component in different categories of migratory flocks of Gaddi goat is presented in Table 4.18. Welfare in terms of FHAT and behaviour synchrony was found significantly (P<0.05) higher in small flocks as compared to large flocks, however no significant difference was recorded for welfare indicators such as QBA, Vocalizations and Oblivion under different categories of migratory flocks of Gaddi goats.

Table.4.18 Mean welfare scores of 'Behaviour' component in different categories of migratory flocks of Gaddi goat

Welfare indicator	Maximum score	Flock size category			Overall score
		Small	Medium	Large	
FHAT	4	$3.75^{b} \pm 0.25$	$3.00^{ab} \pm 0.38$	$2.50^{a} \pm 0.33$	3.08 ± 0.21
QBA	3	3.00 ± 0.00	3.00 ± 0.00	3.00 ± 0.00	3.00 ± 0.00
Vocalization	3	3.00 ± 0.00	3.00 ± 0.00	3.00 ± 0.00	3.00 ± 0.00
Oblivion	3	3.00 ± 0.00	3.00 ± 0.00	2.88 ± 0.12	2.96 ± 0.04
Behaviour synchrony	2	$2.00^{b} \pm 0.00$	$1.63^{ab} \pm 0.18$	$1.38^{a} \pm 0.18$	1.67 ± 0.10
Overall	15	$14.75^{b} \pm 0.25$	$13.62^{ab} \pm 0.53$	$12.75^{a} \pm 0.45$	13.71 ± 0.29

Values within a row with different superscript are significantly different ($p < 0.05$).

4.7.4.1 MEAN VALUES OF WELFARE SCORES OF INDIVIDUAL WELFARE INDICATORS UNDER COMPONENT D

1. FHAT (Familiar Human Approach Test)

The mean scores of welfare indicator FHAT out of 4 in small flocks, medium and large flocks were 3.75±0.25, 3.00±0.38 and 2.50±0.33, with overall score of 3.08±0.21. The mean value of welfare score of small flocks was significantly (P<0.05) higher than large flocks. This test evaluates an animal's fear level and is based on previous human-animal interactions (Mattiello *et al*., 2010). The average flight distance was lower when the farmers were trained for handling (Hernandez *et al*., 2020). Stockperson attitude and behaviour can influence the welfare and productivity of the goats. In migratory goat

production there is infrequent contact of animals with the humans. More stress was also experienced by the shepherds for animal gathering in larger flock sizes which may result in the lower FHAT score. When Familiar Human Approach Test was applied to the 15 intensive goat farms it showed favorable interaction, with goats approaching the farmer voluntarily in more than 60% of the farms. However, the animals avoided contact with the farmer in more than 30% of the farms (Mattiello *et al.,* 2010). Leite *et al*. (2020) do not found positive Human Animal Relationship (HAR) in semi-intensive (N=6) and semi-intensively reared goats.

Mattiello *et al*. (2010) reported that smaller farms had a shorter avoidance distance, with 70.4 percent of contacts in small farms compared to 29.4 percent of contacts in large farms (Pearson Chi2 = 43.83,df = 1, $p < 0.001$). When FHAT applied to semi-intensive goats, they aggressively moved toward the farmers and interacted with them in 61.5 percent of the farms (sniffing, nosing). The goats in one farm remained still when a human approached, however a prompted flight response was reported in 30.8 percent of the farms (Battini *et al*., 2021). Lower contact of the goats and hiher number of goats per shephered in larger flocks may have resulted in lower values of welfare score. Increasing the flock size and decreasing the stockperson to goat ratio might compromise the welfare due to less human supervision. Similar findings have been reported by Mattiello *et al*. (2009). Regular gentle handling may offer a friendlier environment in adverse situations, for example positive interactions are related with high confidence levels in humans and reduced fear reactions (Waiblinger *et al*., 2006).

2. QBA (Quality Behavioural Assessment)

Qualitative behavioural assessment analysis both, positive and negative behaviour of goats (AWIN, 2015). Conventional quantitative behavior focused on which behaviours are present, while this approach focuses on how these behaviours are being executed. Animals are scored against the qualitative terms (e.g. anxious, fearful) that decrsibes the interaction of animal's body language with their evirnonment. QBA score all the flock was 3.00±0.00 out of 3. Tiezzi *et al*. (2019) reported that 100% (N=11) of the semi-intensive farms and 80.9 % (N=21) of the intensive farms were having >30% of the relax goats. In ruminants, access to the pasture improves complex natural behaviour patterns such as inquisitive and interactive behaviour (Casamassima *et al*., 2001), whereas confinement can

hinder the expression of grazing behaviour (Dwyer, 2009; Braghieri *et al*., 2011), which might have resulted in more alert and curious goats in nomadic pastoralism.

3. Vocalizations

Vocalizations are useful for the communicating, expressing emotions and assessing quality of social behavior in goats (Manteuffel *et al.,* 2004; Mazurek *et al*., 2007; Siebert *et al*., 2011; Briefer *et al*., 2019). Combination of vocalizations and other measures of emotions have been reported to be the promising on farm tool to monitor positive emotions (Laurijs *et al*., 2021). The vocalization score of all flocks was 3 out of 3 as goats were free to express their natural behavior and have full freedom of communication and other social behaviours. Freedom to express natural behavior in migratory goat producton system and absence of negative feelings might have resulted in higher score of vocalisations in all the flock categories. In goats, the frequency of vocalization had been reported to show less fluctuations during positive compared to negative situations (Laurijs *et al.,* 2021).

4. Oblivion

Anecdotal reports from farmers and technicians indicate that visibly ill or dull goats frequently withdraw themselves from the group, stand motionless and face housing elements like walls (Battini *et al*., 2014). The mean scores of welfare indicator oblivion out of 3 in small, medium and large flocks were 3.00± 0.00, 3.00± 0.00 and 2.88±0.12, with overall score of2.96±0.04. There was no significant difference for this welfare indicator among small, medium and large flocks. Higher score of this indicator may be due to better health of animals in migratory goat production system in which animals have freedom to express most of their natural behaviour. Leite *et al.,* (2020) reported oblivion goats to be significant higher in the semi- intensive (4.20%) production system of Brazil when compared to the extensive system (0.37%).

5. Behaviour synchrony

Social animals, like sheep, are driven to behave in synchrony with their fellow group members, but when they are unable to do so owing to resource and space constraints, their welfare may be jeopardized (Asher and Collins, 2012). The mean scores of welfare indicator behaviour Synchrony out of 2 in small, medium and large flocks were 2.00±0.00, 1.63±0.18and1.38± 0.18, withoverall score of1.67±0.10. The mean value of welfare score of small flocks was significantly ($P<0.05$) higher than large flocks.

Plate 26. Familiar Human Approach Test (FHAT) performed at camping site of Gaddi nomads

Plate 27. Behavioural Synchrony of goats during resting

Behaviour synchrony is related to individual distance (proximity of neighbour), behavioural decisions (time spent searching food, social interactions) and predators (Couzin and Krause, 2003; Cavagnna *et al*., Pays *et al*., 2009; McDougall *et al*., 2018). Social interactions, both positive and negative were reported to decline with increase in group size in goats (Andersen *et al*., 2011). Sheep were reported to recognize only 50 other individuals (Kendrick *et al*., 2001) and to lessen the competition in larger groups, more animals were reported to opt to do fewer critical tasks at the same time (Nielsen *et al*., 1995; Boissy and Dumont, 2002). Similar to the present findings, larger groups of sheep have decreased synchrony in resting and feeding (Jorgensen *et al*., 2011)

4.7.5. Good performance

The mean welfare scores of 'performance' component in different categories of migratory flocks of Gaddi goat are presented in Table 4.19. The scoring of welfare indicator such as survival, weight at 9 months and abortion was significantly ($P<0.05$) higher in small as compared to medium and large flocks. No significant difference was observed in other welfare indicators kid birth weight, kidding percentage, daily milk yield and twinning pecentage under different categories of migratory flocks of Gaddi goats.

Table 4.19 Mean welfare scores of 'Performance' component in different categories of migratory flocks of Gaddi goat

Welfare indicator	Maximum score	Flock size category			Overall score
		Small	Medium	Large	
Birth weight of kids	3	3.00 ± 0.00	3.00 ± 0.00	2.88 ± 0.12	2.96 ± 0.04
Survivability of kids	2	2.00^{b} ± 0.00	1.50^{a}± 0.19	1.50^{a} ± 0.19	1.67 ± 0.10
Weight at 9 months	2	2.00^{b} ± 0.00	1.38^{a} ± 0.18	1.13^{a} ± 0.12	1.50 ± 0.10
Kidding percentage	2	1.63 ± 0.26	1.38 ± 0.32	1.00 ± 0.33	1.33 ± 0.18
Abortions	2	1.50^{b}± 0.27	0.50^{a} ± 0.27	0.38^{a} ± 0.18	0.79 ± 0.17
Daily milk yield	2	1.00 ± 0.00	1.00 ± 0.00	0.75 ± 0.16	0.92 ± 0.06
Twinning percentage	2	1.63^{b} ± 0.26	1.00^{a} ± 0.27	1.00^{a} ± 0.27	1.21 ± 0.16
Overall	15	12.75^{b} ± 0.72	9.75^{a} ± 1.03	8.62^{a} ± 1.03	10.38 ± 0.63

Values within a row with different superscript are significantly different ($p < 0.05$).

4.7.5.1 MEAN VALUES OF WELFARE SCORES OF INDIVIDUAL WELFARE INDICATORS UNDER COMPONENT E

1. Birth weight of kids

Gaddis prefer to take only 1 kidding per year due to their traditional migratory practices. Kidding is more suited only during winter as during migration some kids can be sold on way back to mid hills (Sankhyan *et al.*, 2016). The mean scores of welfare indicator kid birth weight out of 2 in small, medium and large flocks were 3.00 ± 0.00, 3.00 ± 0.00 and 2.88 ± 0.12, with overall score of 2.96 ± 0.04. There was no significant difference of kid birth weight scores in different categories of flock sizes. Average birth weight of Gaddi kids have been rerpoted to 2.88±0.02 (Sankhyan *et al*., 2016).

2. Survivability rate of kids

The mean scores of welfare indicator survivability rate of kids out of 2 in small, medium and large flocks were 2.00±0.00, 1.50±0.19 and 1.50±0.19 with overall score of 1.67±0.10. The mean value of welfare score of is singnificanllty ($P<0.05$) higher than medium and larger flocks. Lack of providing environmental protection of kids in medium and large flocks resulted in lower welfare scores. Combined stressors (heat and nutritional) significantly reduced the birth weight of lambs (Sejian *et al*., 2010). Pre weaning mortality of Gadid goat kids in different flocks have been reported to vary between 9-16 per cent (Sankhyan *et al*., 2016).

3. Body weight at 9 months

The mean scores of welfare indicator weight at 9 months out of 2 in small, medium and large flocks were 2.00±0.00, 1.38±0.18 and 1.13±0.12 respectively, withoverall score of 1.50±0.10. The mean value of small flocks was significantly ($P<0.05$) higher than mean value of welfare score obtained by the medium and large flocks. Higher body weight is small flocks was due to lower stocking density which resulted in more forage availability to the individual animal and higher body conditions scores.Average body weight of 1.54 ± 0.07 and 13.40 ± 0.20 was observed in 346 goat kids and 356 does of Changthangi goats reared by the traditional nomads respectively (Ganai *et al*., 2011). Karthik *et al*. (2021) reported significantly lower ADG (612.91 g/d in the sheep reared under extensive system when compared to those reared in semi-intensive (716.83 g/d) and intensive goat production system (733.32 g/d).

4. Kidding percentage

The mean scores of welfare indicator kidding percentage out of total 2 in small, medium and large flocks were 1.63±0.26, 1.38±0.32 and 1.00±0.33 respectively, with overall score of 1.33±0.18. The mean welfare score was significantly (P<0.05) higher in small flocks as compared to medium and large flocks. Higher welfare scores of BCS might have improved the reproductive performance of goats in smaller flocks. Kidding percentage and litter size of Changthangi does was reported to be 97.58±2.23% and 1.02±0.50 respectively (Ganai *et al.*, 2011).

5. Abortions

The mean scores of welfare indicator abortion out of total 2 in small, medium and large flocks were 1.50±0.27, 0.50±0.27 and 0.38±0.18 respectively, with overall score of 0.79±0.17. Significant difference was observed among three groups. It was significant higher in small flocks as compared to medium and large flocks. Still birth has been reported to be very low (<1 %) in the Changthangi does (Ganai *et al.*, 2011), however in the present study the Gaddi goats had been reported with higher still births which may be due to nutritional deficiencies from the poor quality pastures. Presence of still birth in the larger flocks may have resulted in the lower birth weight of the kids. Same results have been observed in the sheep flocks reared under intensive production system, in which higher birth weight were found in flocks having absence of stillbirth (Karthik *et al*., 2021).

6. Daily milk yield

Gaddi goats are not primarily reared for milk production but still milk yield is important for survival of kids. The surplus milk is daily consumed by the nomads and various milk products are made from it like butter, ghee etc. The mean scores of welfare indicator milk yield out of 2 in small, medium and large flocks were 1.00±0.00, 1.00±0.00 and 0.75±0.16, with overall score of 0.92±0.06. There was no significant difference among the mean value of welfare score of small, medium and large flocks. Earlier studies also reported moderate milk yield of 27.53, 50.66 and 64.78 litres at 30, 60 and 90 days was reported in the Gaddi goats (AICRP Annual report, 2019). In the dry season, the nutrient content of forages in xerophytic habitats does not match the nutritional needs of pregnant and lactating goats (García-Monjaras *et al*., 2021).

The lower milk production in the herds may also be due to the adaptability of goats to the replenishing the body reserves. The mean 105 days total milk yield for

mediumproducer and low producer mixed breed goats reared in the rangeland was 45.2 ± 12.5 and 20.7 ± 5.2 L, respectively (Flore-Najera *et al*., 2021). The birth weight of kids and weaning weight were both found to be positively related to the dam's body weight ($p \leq 0.05$), while milk yield and composition throughout 105-d lactation had no effect on the offspring's body weight increase or weaning weight (Flores-Najera *et al*., 2021).

7. Twinning percentage

The mean scores of welfare indicator twinning percentage out of 2 in small, medium and large flocks were 1.63±0.26, 1.00±0.27 and 1.00± 0.27, with overall score of 1.21±0.16. Small flocks were having singnificanlty higher score as compared to medium and large flocks. Average Litter of the does reared under rangeland of northern Mexico has been found to be 1.4±0.1, while the birth weight of kids was averaged 2.7±0.1 (Flores-Najera *et al*., 2021).Twinning percentage in Gaddi goat was found to be 20 per cent (Sankhyan *et al*., 2016).

Plate 28. Recording of milk yield of doe

Plate 29. An aborted doe

4.8 OVERALL WELFARE SCORE OF DIFFERENT COMPONENTS OF MIGRATORY GOAT'S WELFARE

The overall welfare score of different components of migratory goat's welfare are presented in Table 4.20. The most compromised component of welfare in the migratory goat production system was "Good feeding". The overall welfare scores of good feeding component out of 25 in small, medium and large flocks of goats were 14.25±0.80, 11.00±1.32 and 10.12±0.88respectively, overall score was 11.79±0.66. The mean welfare score of the component in small flocks was significantly ($P<0.05$) higher as compared to medium and large flocks.Higher welfare score in the small flocks may be attributed to higher mean body condition score and more forage availability score. Small flocks were having less than 100 goats which make the resources more available to all the animals due to lesser competition. However, the supplementary feeding was a compromised indicator in all the flocks.

Table 4.20 Mean welfare score of different Components of migratory goat's welfare

Welfare Components	Maximum Score	Flock size category score			Overall
		Small	Medium	Large	
Good feeding	25	14.25 ^{b}±0.80	11.00 ^{a}±1.32	10.12 ^{a}±0.88	11.79±0.66
Good environment	15	12.37 ^{b}±0.62	10.37 ^{a}±0.46	10.00 ^{a}±0.78	10.91±0.41
Good health	30	26.25 ^{b}±1.10	24.25 ^{a}±0.95	21.37 ^{a}±0.82	24.04±0.69
Appropriate behavior	15	14.75 ^{b}±0.25	13.62 ^{ab}±0.53	12.75 ^{a}±0.45	13.71±0.29
Good performance	15	12.75 ^{b}±0.72	9.75 ^{a}±1.03	8.62 ^{a}±1.03	10.38±0.63
Total	100	80.62 ^{b}±2.44	69.00 ^{a}±3.73	62.87 ^{a}±3.32	70.83±2.34

Means bearing different superscript in a row differ significantly P<0.05

The mean welfare scores of good environment component out of 15 in small, medium and large flocks of goats were 12.37±0.62, 10.37±0.46 and 10.00±0.78 respectively, and the overall score was 11.79±0.66. The mean welfare score of the component in small flocks was significantly (P<0.05) higher as compared to medium and large flocks. Smaller flocks scored better in this component due to higher environmental protection and integument cleanliness.

The mean welfare score of good health component out of 30 in small, medium and large flocks of goats were 26.25± 1.10, 24.25±0.95 and 21.37±0.82 respectively, and the overall score was 26.29±0.79 which was significantly (P<0.05) higher in small flocks as compared to medium and large flocks. Small flocks scored better among flock categories in health component due to less prevalence of lameness and good hair coat condition. Pain management was compromised in all the flock categories. Lack of monitoring due to reductiom in ability of stock people in managing the animals in the large flocks may havecompromised the heatlh component. It has also been earlier reported that lack of awareness in migratory goat production towards health management practices may worsen the body condition score and anemia problems in herd (Mondragón-Ancelmo *et al*., 2019).

The mean welfare score of appropriate behaviour component out of 15 in small, medium and large flocks of goats were 14.75±0.25, 13.62±0.53 and 12.75±0.45, respectively,and the overall score was 13.71±0.29. The score was significantly (P<0.05)

higher in small flocks as compared to medium and large flocks. Small flocks score higher in this component than the larger ones due to higher behavioral synchrony and familiar human approach test scores. Lack of space constraints in migratory goat production and feeding to express natural behavior might have resulted in the higher score.

The mean welfare score of good performance component out of 15 in small, medium and large flocks of goats were 12.75±0.72, 9.75±1.03and 8.62±1.03 respectively, and the overall score was 10.38± 0.63 which was significantly ($P<0.05$) higher in small flocks as compared to medium and large flocks. Large flocks scored significantly lesser than small and medium ones due to poor scores in survivability of kids, weight at 9 months and higher prevalence of abortions. Cultural differences also have been reported to show an impact over the production parameters due to management and avaialability of resources (Nyam *et al*., 2020)

The total welfare score in small, medium and large flocks of goats were 80.62, 69.00 and 62.87respectively, and the overall score was 70.83±2.34. The total welfare score of small flocs was significantly ($P<0.05$) higher than the other two categories. The smaller flocks scored higher on account of welfare indicators viz. BCS, forage availability, integument cleanliness, lower lameness, better hair coat condition, better kid birth weight, survivability of kids, higher FHAT scores, weight at 9 months, lower abortions and higher twinning percentage. Same results had been reported by Mondragón-Ancelmo *et al*., (2019) in small flock sheep owners of Mexico when compared to larger production systems. Doughty *et al.* (2019) also observed that a smaller flock size for sheep might improve the animals' welfare. Contrary to the present study, Hernandez *et al*., (2020) found no statistically significant differences when compared animal welfare scores between large farms (600 and 2000 animals) and small farms (9 to 27 animals) of extensively reared sheep. In dairy cattle Robbins *et al*. (2016) also found no association between farm size and animal welfare and suggested that focus should be made only on improving animal welfare, independently from the farm size.

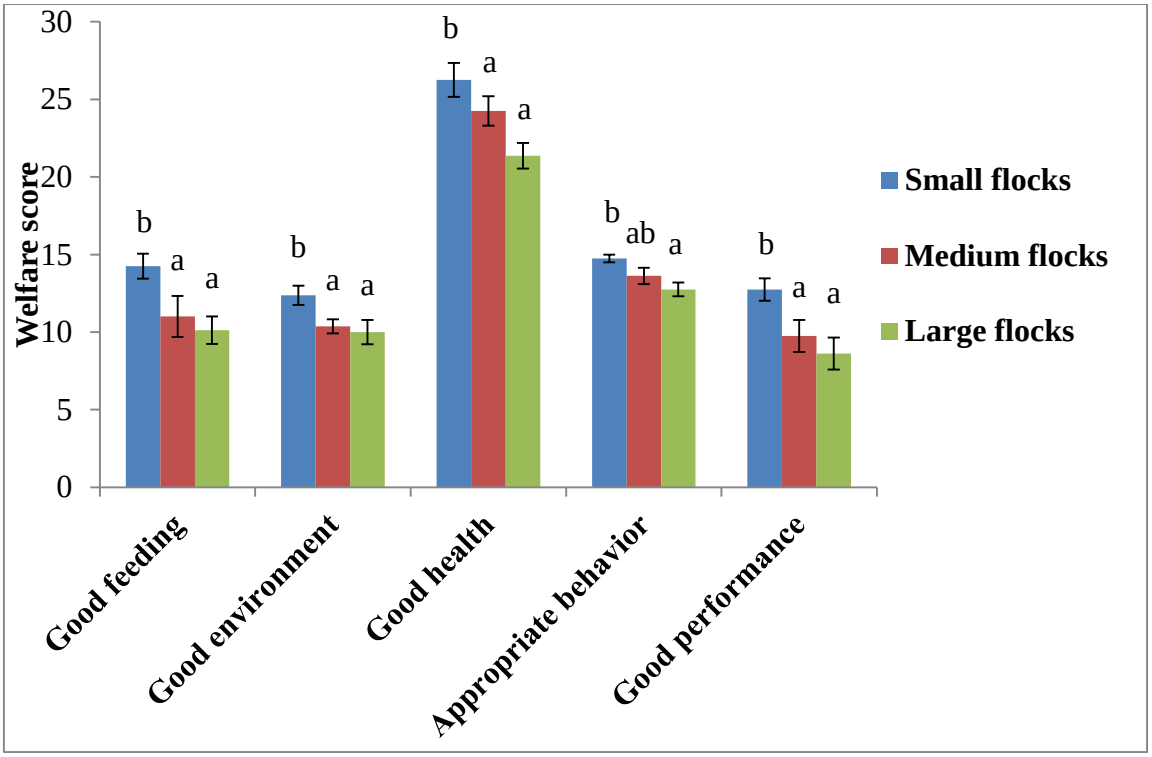


Fig. 4.7 Mean welfare scores of different components of welfare in different categories of flocks

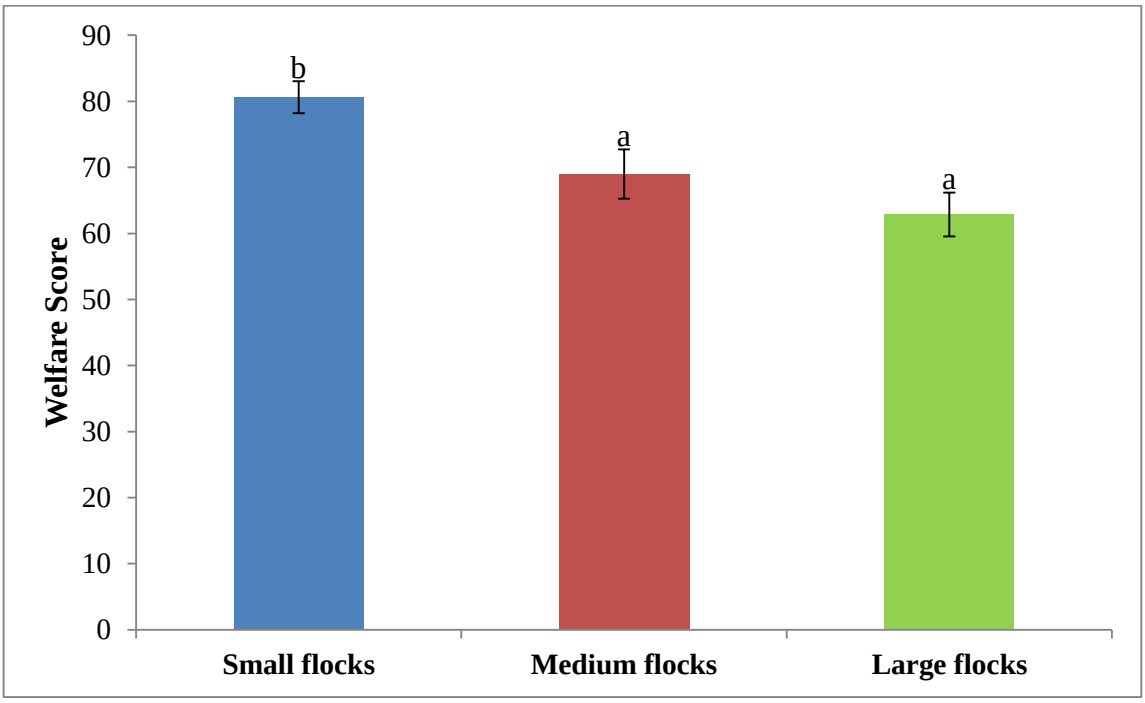


Fig. 4.8 Overall welfare scores of different categories of flocks

4.9 OVERALL RANKING OF MIGRATORY GOAT FLOCKS

The distribution of migratory goat flocks in different welfare categories is depicted in Table 4.21Based on overall welfare ranking of migratory flocks, the percentage of farms under excellent, very good and average was 10 (41.67%), 9 (37.50%) and 6 (25.00%) respectively. None of the flock was having poor welfare score. In case welfare score of 60 is treated as acceptable then 75 per cent of the flocks had an acceptable welfare level whereas remaining 25 per cent of the flocks had an unacceptable welfare level. Welfare of 75 per cent of medium and 50 per cen of large flock was found to be acceptable.

Table 4.21 Overall welfare ranking of three categories of migratory goat flock sizes

Welfare category	Welfare score	Flock size category			Total
		Small	Medium	Large	
Excellent	>80	6 (75.00%)	2 (25.00 %)	1(12.50 %)	9 (37.50%)
Very Good	60-80	2 (25.00%)	4 (50.00 %)	3 (37.50 %)	9 (37.50%)
Average	40-59	-	2 (25.00%)	4 (50.00 %)	6 (25.00%)
Poor	<40	-	-	-	-

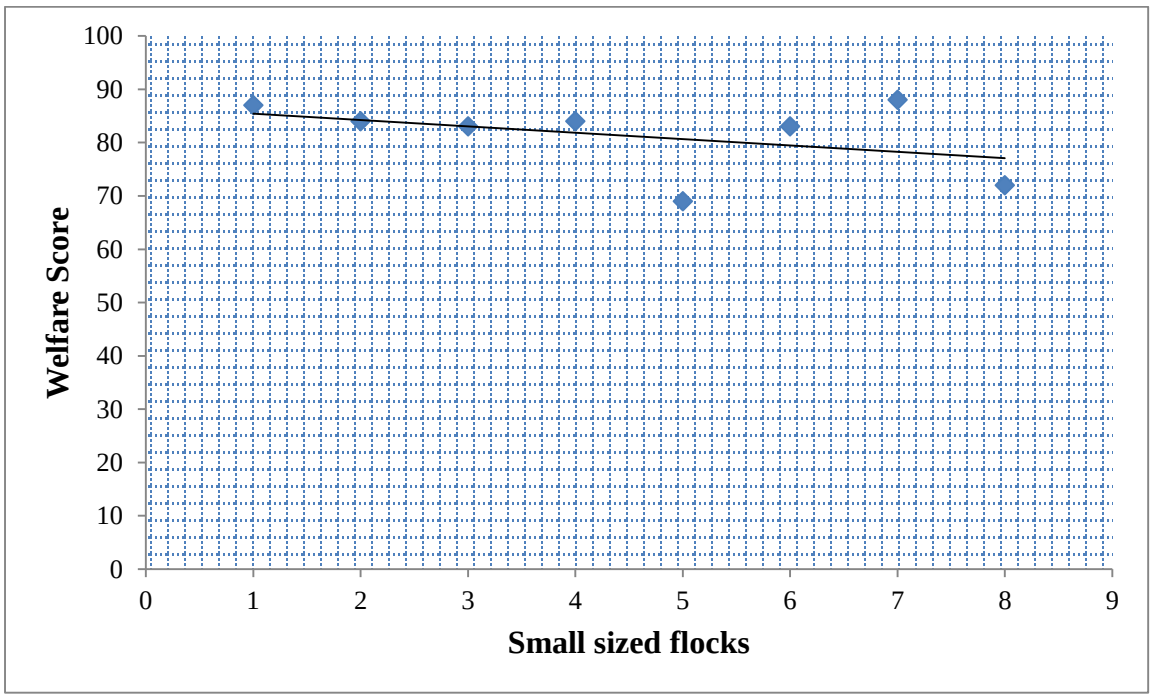


Fig. 4.9 Distribution of small sized flocks

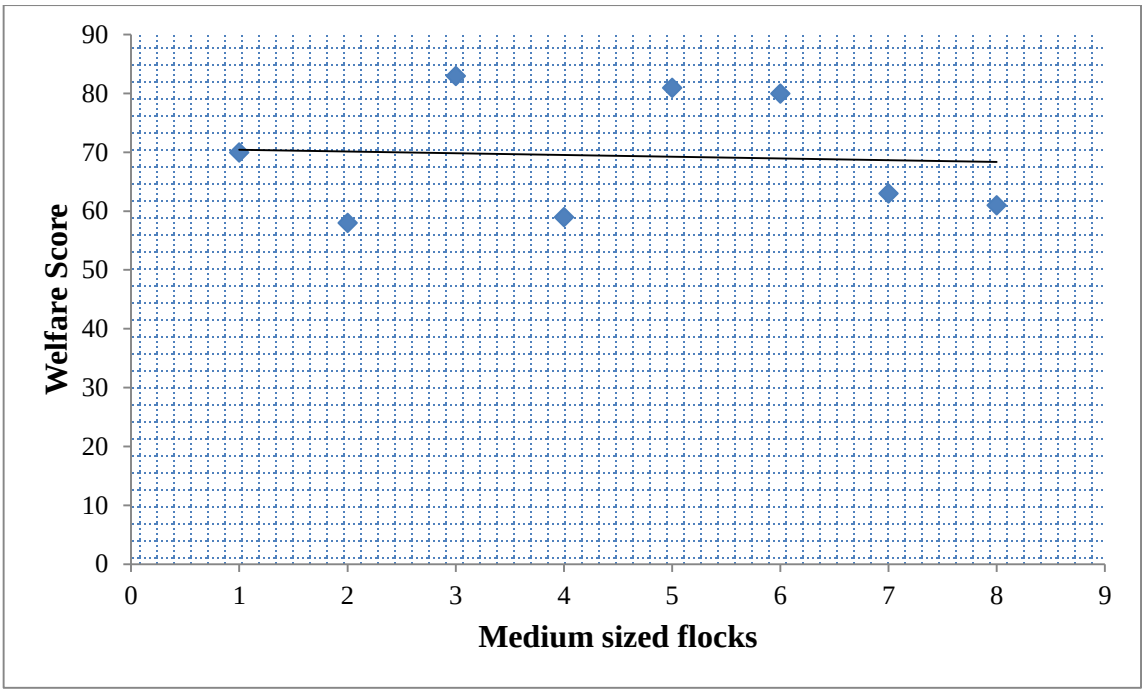


Fig 4.10 Distribution of medium sized flocks

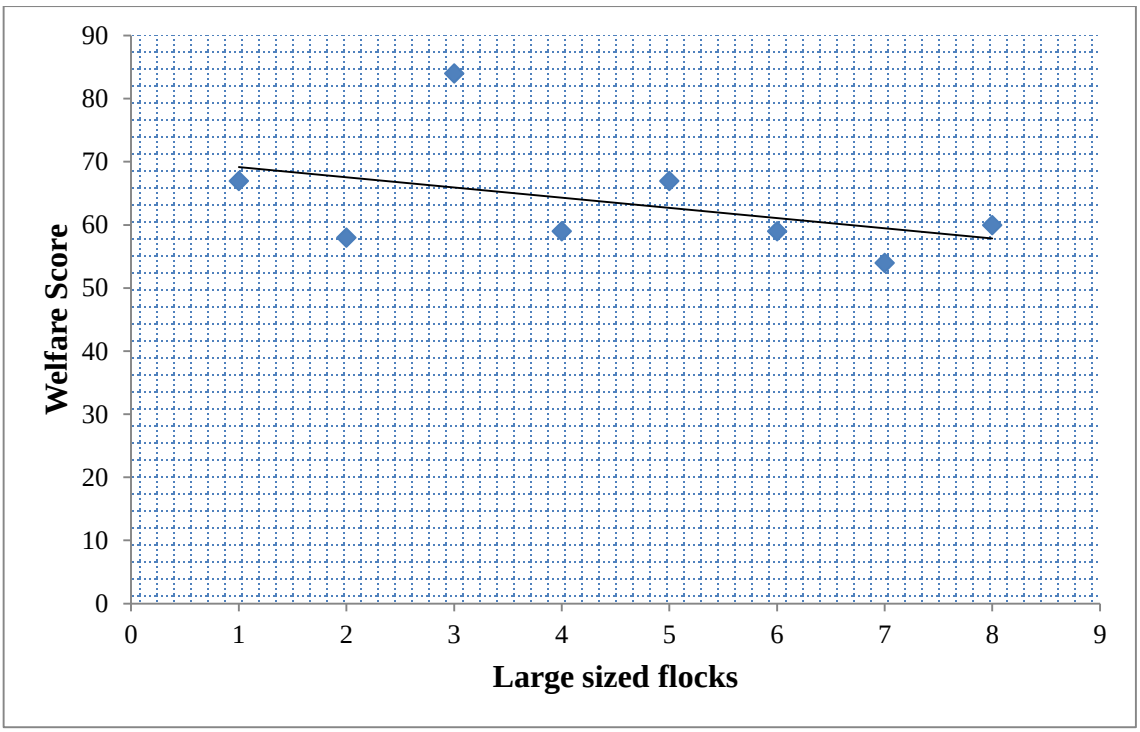


Fig. 4.11Distribution of large sized flocks

4.10 MOST COMPROMISED WELFARE INDICATORS IN DIFFERENT CATEGORIES OF FLOCK SIZES

Comprmised indicators have been presented in the different categories of flock sizes in Table 4.22, 4.23, 4.24 and 4.25. Indicators that were scoring less than 60% of their maximum score were named as compromised indicators. The indicator with low percentage were selected as the most compromised in ranking. Most compromised welfare indicators in the small flocks size were Supplementary feeding, Pain management practices, milk yield, fodder availability, BCS. Medium flocks were having Supplementary feeding, Pain management practices, Livestock guard dog, Abortions, fodder availability, BCS, deworming, milk yiled and twinning percentage. Most compromised indicators in large flocks were Supplementary feeding, pain management practices, abortions, dipping, milk yield, BCS, hair coat condition, Livestock guard dog, deworming, kidding percentage and weight at 9 months. Overall flocks were having compromised indicators viz. supplementary feeding, pain management practices, fodder availability, abortions, BCS, deworming and milk yield.

Table 4.22 Most compromised welfare indicators in small flock sizes

Welfare issues (Scoring less than 60% of the maximum value)	Maximum Score	Overall Score attained	Per cent age of score attained	Rank
Supplementary feeding	2	0	0	I
Pain management practices	1	0	0	II
Milk yield	2	1	50.00	III
Forage availability	6	2.75	45.80	IV
BCS	10	5.50	55.00	V

Table 4.23 Most compromised welfare indicators in medium flock sizes

Welfare issues (Scoring less than 60% of the maximum value)	Maximum Score	Overall Score attained	Per cent age of score attained	Rank
Supplementary feeding	2	0	0	I
Livestock guard dog	1	0.25	25.00	III
Abortions	2	0.50	25.00	IV
Forage availability	6	2.00	33.33	V
BCS	10	4.75	47.50	VI
Deworming	2	1.00	50.00	VII
Milk yield	2	1.00	50.00	VIII
Twinning percentage	2	1.00	50.00	VIII

Table 4.24 Most compromised welfare indicators in large flock sizes

Welfare issues (Scoring less than 60% of the maximum value)	Maximum Score	Overall Score attained	Per cent age of score attained	Rank
Supplementary feeding	2	0	0	I
Pain management practices	1	0	0	II
Abortions	2	0.38	19.00	III
Forage availability	6	1.50	25.00	IV
Dipping	2	0.75	37.50	V
Milk yield	2	0.75	37.50	VI
BCS	10	4.25	42.50	VII
Hair coat condition	4	2.00	50.00	VIII
Deworming	2	1.00	50.00	IX
Kidding percentage	2	1.00	50.00	X
Integument cleanliness	3	1.63	54.33	XI
Weight at 9 months	2	1.13	56.50	XII

Table 4.25 Most compromised welfare indicators in overall flocks

Welfare component	Welfare issues (Scoring less than 60% of the maximum value)	Maximum Score	Overall Score attained	Per cent age of score attained	Rank
Good feeding	BCS	10	4.83	48.30	V
	Forage availability	6	2.08	34.66	III
	Supplementary feeding	2	0	0	I
Good environment	Livestock guard dog	1	0.54	54.00	VI
Good health	Deworming	2	1.17	58.00	VII
	Pain management practices	1	0	0	II
Good behaviour	-	-	-		
Good performance	Milk yield	2	1.21	60.00	VIII
	Abortions	2	0.79	39.50	IV

4.11 PRINCIPAL COMPONENT ANALYSIS (PCA)

The PCA was applied to the welfare indicators in the welfare assessment protocol of migratory goats. The value obtained for the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.54. A KMO-MSA of less than 0.5 was not accepted, and a KMO-MSA of more than 0.5 is required for successful factor analysis (Vohra *et al*., 2015). The widely used and accepted method of rotation (varimax) was applied (Fernandez, 2002) as it maximizes the sum of the variances of the squared loadings (squared correlations between variables and components) (Vohra *et al*., 2015).

In total 16 variables (welfare indicators) were included in PCA, of which four principal components (PCs) were extracted (Table 4.26 and 4.27) using Kaiser Rule criterion (Johnson and Wichern, 1982) to determine the number of components i.e. retaining only the components that have eigen value greater than 1. Scree plot can also depict various components and could be used to decide actual number of the components to be included for analysis (Vohra *et al*., 2015); components having eigen values up to the point "bent of elbow" are usually considered. Table shows rotated factor (Varimax) matrix of independent variables with factor loadings for each variable. Liu *et al*. (2003) classified the factor loading according to the loading values as strong (>0.75), moderate (0.75-0.50) and weak (0.50-0.30). All the welfare components were strongly loaded on their respective PCs except first PC which has two moderate (Integument cleanliness and abortion) and one weakly loaded welfare indicator (FAMACHA).

The most important variables for the first PC includes ten welfare indicators viz. BCS, Fodder availability, Environmental protection, Weight at 9 months, Behaviour Synchrony, FHAT, Ectoparasitic Score, Integument cleanliness, Abortion and FAMACHA. So, the first PCS is defined by three indicators from health component, two indicators from Feeding component, one from environment, and two from behaviour and one each from production and reproduction parameter.

The second PC was characterized by reproductive indicators (Kidding percentage and Twinning percentage) while third PC was characterized by Productive indicators (Milk yield and Kid birth weight). Environmental indicators viz. Livestock losses and Livestock Guard Dog were included in the fourth PC.

Table 4.26 Result from the principal component analysis and total variance explained by different components

Total Variance Explained									
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	7.64	47.75	47.75	7.64	47.75	47.75	6.09	38.05	38.05
2	2.03	12.72	60.46	2.03	12.72	60.46	2.53	15.80	53.85
3	1.63	10.16	70.62	1.63	10.16	70.62	2.00	12.47	66.31
4	1.21	7.57	78.19	1.21	7.57	78.19	1.90	11.88	78.19
5	0.94	5.88	84.08						
6	0.60	3.76	87.83						
7	0.57	3.55	91.38						
8	0.43	2.69	94.07						
9	0.28	1.76	95.83						
10	0.23	1.44	97.27						
11	0.16	1.01	98.28						
12	0.10	0.60	98.88						
13	0.09	0.58	99.46						
14	0.07	0.41	99.86						
15	0.02	0.10	99.97						
16	0.01	0.04	100.00						

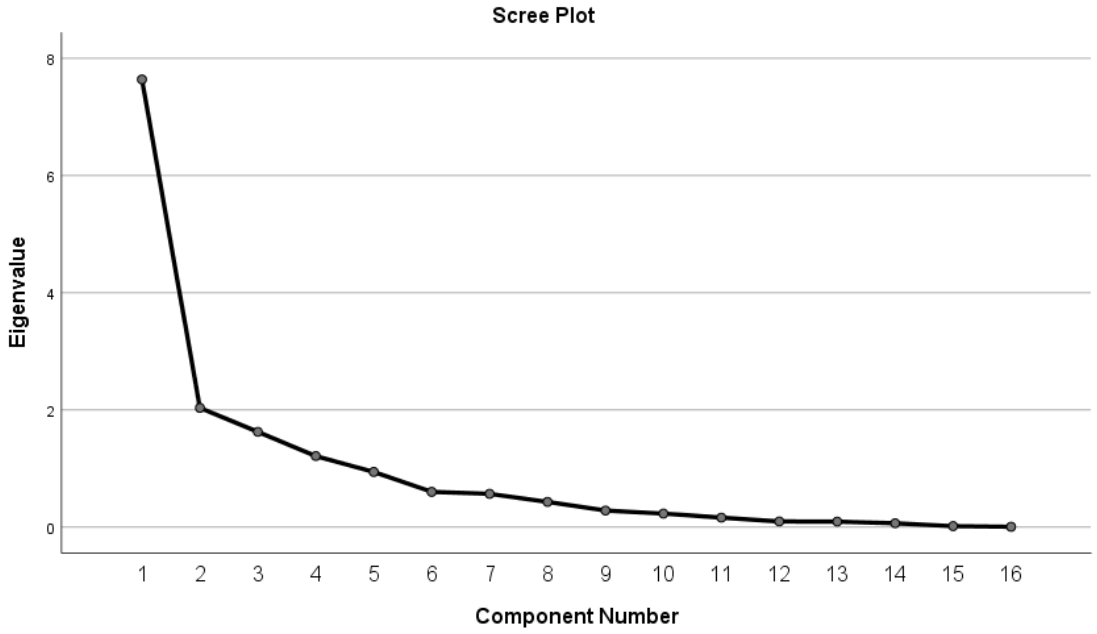


Fig.4.12 Scree plot showing component number with Eigen values

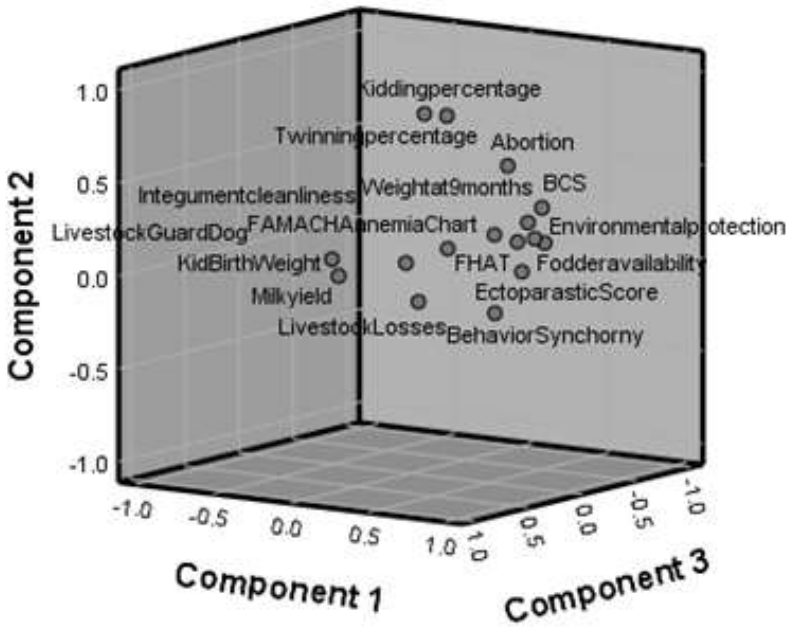


Fig. 4.13 Component plot in rotated space

Table 4.27 Four PCSs derived by PCA with factor loadings for variables

Variables (Welfare Indicator)	Principal Components			
	F1	**F2**	**F3**	**F4**
BCS	**.862**	.407	.020	.024
Forage availability	**.856**	.212	-.015	.063
Environmental protection	**.839**	.243	.054	-.091
Weight at 9 months	**.836**	.339	.112	.053
Behavioursynchrony	**.797**	-.117	.362	.004
FHAT	**.786**	.233	.137	.103
Ectoparasitic score	**.777**	.063	.084	-.062
Integument cleanliness	**.720**	.282	.256	.049
Abortion	**.621**	.604	-.008	-.023
FAMACHA	**.443**	.184	.292	-.210
Twinning percentage	.360	**.874**	.181	-.011
Kidding percentage	.227	**.874**	.199	-.199
Milk yield	.155	.094	**.888**	.155
Kid birth weight	.107	.179	**.881**	-.101
Livestock guard dog	-.105	-.006	-.105	**.954**
Livestock losses	.155	-.151	.151	**.917**
Per cent (%) of variance	**47.75**	**12.72**	**10.16**	**7.57**

CHAPTER –5

Summary and Conclusions

SUMMARY AND CONCLUSIONS

Goat, the most adaptable and geographically widespread livestock species, serves as livelihood, nutritional and financial security to the local tribes of the state. Pastoralism is the main occupation of the weaker sections of society in the tribal areas of Himachal Pradesh. Pastoralists are "members of castes or ethnic groups with a strong traditional association with livestock-keeping, where a significant proportion of the group derives over 50% of household consumption from livestock products or their sale, where over 90% of animal consumption is from natural pasture or browse, and where households are responsible for the full cycle of livestock breeding. Gaddi nomads migrate along with their flocks from foothills of the Himalayas (Shivalik foothills of the Himalya on the Himachal Pradesh-Punjab border) to high altitude alpine ranges (high Himalayan summer pasture of Lahul and Spiti) during the summer months and then descend back to the foothills and plains during the winter season . In the month of July, shepherds move from high hills towards mid hills, and finally by September-October reach low hills and plains where they settle temporally up to March, and again start their return journey for high hills. Therefore, the present study welfare assessment scale for Gaddi goat was undertaken to study natural behaviour of Gaddi goats at different altitudes, to develop a protocol for welfare assessment in migratory goats and to assess the level of welfare of Gaddi goats in different flock sizes.

Behaviours were recorded for 15 min/hour for 8 hours of grazing daily for four consecutive days using focal sampling by video cameras on four flocks at key stages of production cycle during post-kidding (PK) at low-hills, during mid-lactation (ML) at mid-hills and at mid-pregnancy (MP) at hill-hills. The assessment protocol was adapted from AWIN framework for goats (AWIN, 2015). Welfare assessment was performed at low hills on two migratory routes on 24 flocks categorized into small (S<100), medium (M=100-200) and large (L>200) with eight flocks each. Data were analyzed using one-way analysis of variance (ANOVA) in SSPS.

Natural behaviour of Gaddi goats

Total daily feeding time (browsing plus grazing) was higher ($P<0.05$) at ML (282.15±2.8 min; 58.77±0.5%) as compared to PK (270.37±5.6 min; 56.33±1.1%) and MP (261.98±2.7 min; 54.58±0.4%). Time devoted to browsing was higher ($P<0.05$) at ML

(220.18±2.6 min; 45.87±0.5%) as compared to PK (173.08±3.8 min; 36.06±0.7%) and MP (40.32±0.9 min; 8.40±0.1%) while daily grazing time was greatest at MP (221.66±3.6 min) followed by PK (97.29±4.8 min) and ML (61.97±3.3 min). Standing time was greater ($P<0.05$) at MP (46.83±3.7 min) and PK (39.80±1.9 min) as compared to ML (24.01±2.1 min). Daily times spent on walking, rumination and lying were similar at three stages. Frequency of bipedal stance was higher ($P<0.05$) at ML (28.50±2.1) as compared to PK (12.50±1.7) and MP (4.17±0.6). Frequency of self-grooming was higher ($P<0.05$) at PK (14.00±2.1) than at ML (5.83±1.5) and MP (1.0±0.6) while frequencies of allogrooming was similar at three stages. Frequency of object grooming was greater ($P<0.05$) at ML (2.16±0.6) as compared to PK (1.0±0.3) and MP (0.00±0.0).

Development of Welfare assessment protocol for migratory goats

The assement protocol was developed on the framework of AWIN protocol. Firstly potential welfare indicators that were important for migratory goat production system were reviewed from the existing literature. Experts were consulted to select most important welfare indicators considering validity, feasibility and reliability. Total 32 welfare indicators were selected from the 106 welfare indicators. Welfare assessment protocol of migratory goats was categorized into five welfare domains (feeding, environment/facility around camping, health, behaviour and performance) with 32 welfare indicators (5, 6, 9, 5 and 7 from each domain respectively) and domains were assigned a welfare score (WS) of 25,15,30,15 and 15 respectively aggregating into 100. The adapted protocol was tested for its validity (by expert judgment) and reliability by Cronbach's alpha. The adapted welfare assessment protocol was found valid (91.3 percent of experts agreement) and reliable with the value of Cronbach's α as 0.90.

Assessment of migratory Gaddi goat welfare

Welfare assessment was performed at low hills on two migratory routes on 24 flocks categorized into small ($S<100$), medium ($M=100-200$) and large ($L>200$) with eight flocks each.

Component A: Good Feeding

In feeding component scoring of welfare indicators viz. body condition score, forage availability, distance to water points were significantly ($P<0.05$) higher in small flocks as compared to large flocks. Welfare score for supplementary feeding was zero in all the category of flocks. Most compromised welfare indicators in small flocks was

supplementary feeding and body condition score. In all the category of flock sizes BCS, forage availability and suppementry feeding were found to be most compromise welfare indicators.

Component B: Environmental protection

Integument cleanliness was scored significantly ($P<0.05$) higher in small flocks when compared to medium and large flocks. Livestock Guard dog was compromised welfare indictor in medium flocks. In large flocks integument cleanliness was found to be of welfare concern. Small flocks in environmental domains showed no compromised welfare indicator

Component C: Health

Lameness, hair coat condition and dipping welfare indicators scored significantly ($P<0.05$) higher in the small flocks as compared to large flocks. Pain management practices scored zero in all category of flock sizes. Pain management was the only welfare indicator in environmental domain that is compromised in small flocks. In medium flocks deworming and pain management were the compromised welfare indicator, while in large flocks hair coat condition, deworming, dipping and pain management were of welfare concern.

Component D: Behaviour

FHAT welfare indicator ($P<0.05$) was significantly higher scores in large flock when compared to large flocks. None of the welfare indicators was found to be compromisd in different catgories of flock sizes.

Component E: Performance

Survivability of kids, weight at 9 months, abortions and twinning percentage scored significantly higher in small flock when compared to medium and large flocks. Milk yield, abortions and twinning percentage were the compromisd welfare indicators in both medium and large flocks. In addition weight at 9 months was of welfare concern in large flocks. However, in small flocks milk yield was found to be the only welfare indicator that was compromised.

Overall ranking of migratory goat flocks

Small/S flocks scored higher ($P<0.05$) than Medium/M and Large/L flocks in feeding (14.25±0.8 vs. 11.00±1.3 and 10.12±0.8), health (26.25±1.1 vs. 24.25±.9 and

21.37±0.8) and environmental domains (12.3±0.6 vs.10.37±0.5 and 10.00±0.8). Scores WS of behavioural domain in S flocks (14.75±0.2) were higher (P<0.05) than L (12.75±0.4) but were not different from M flocks (13.62±0.5) whereas scores of performance were higher (P<0.05) in S (12.75±0.7) and M (9.75±1.0) than L flocks (8.62±1.0). Overall WS in S (80.62±2.4) were higher (P<0.05) than in L (62.87±3.3) and M (69.00±3.7) flocks. Welfare was found acceptable (WS >60) at all S, 75% of M, 50% of L flocks and 75% of all studied flocks.

Conclusions

1. Gaddi goats spend most of day time in feeding and walking with little time spent on standing, lying and rumination. Feeding was undertaken through grazing predominantly at high-hills and through browsing in bipedal stance during lactation at low and mid-hills.
2. Welfare assessment protocol based on 32 welfare indicators (5, 6, 9, 5 and 7 from each domain respectively) was developed for assessment of welfare status of migratory goats.
3. Welfare was found acceptable (welfare score >60) in 75% of all studied flocks which includes all the small flocks, most of medium flocks and a half of large flocks. Welfare of most of Gaddi goat flocks was acceptable with animals in small flocks performing better than medium and large flocks.
4. Supplementary feeding, pain management practices, livestock guard dog, forage availability, abortions, body condition score, need based deworming and milk yield were the most compromised welfare indicators under migratory system of goat rearing.

5.1 Suggestion to improve welfare of Gaddi goats

Goats reared in the migratory system showed advantages in terms of animal welfare in environment, behaviour, performance and health domains, but the disadvantage exists in terms of feeding domains. Investigation through the present study revealed many potential welfare problems of different categories of goat flocks. Most of the flocks were having acceptable welfare while it is lacking in 25 per cent of the flocks. All the small flocks were having acceptable welfare score, while 25 per cent of medium and 50 per cent of large flocks were having welfare scores that were unacceptable. Following recommendations can help substantially in enhancing welfare of migratory goats.

- Supplementation of mineral mixture need to be integrated with the practice of salt feeding by the Gaddi nomads. Goat body reserves need to be properly managed over the course of their production cycle during migration to achieve optimum productive and reproductive performance. Concentrate feeding can be introduced at low hills when the BCS of animal is poor. Improving the nutrition of the pastoralist's goats especially in the low hills would help in reducing the weight losses during the winters which will further help lowering the mortality losses.
- Alternatives to the traditional managemental practices that were inflicting pain in the animals also need to be explored and replaced. Raising awareness of nomads towards pain alleviation of animals during management practices (e.g. ear cuts for identification, cutting of ear in lantana poisoning, castration of bucks etc.) through trainings.
- Increasing adoption of the Livestock Guard Dogs especially Gaddi breed dog, as it will help in reducing livestock losses due to wildlife and rustling
- Improving forage availability through governmental schemes and NGO's
- Regular deworming of flocks after proper screening and ensuring proper dosage to each animal.
- Improving availability of forage and supplementary feeding can further help in improving the body condition scoring and milk yield of the animals

Bibliography

BIBLIOGRAPPHY

Abay, G., Demissie, T., Fekadu, A.andTeklue, T. 2015. Sheep Infection by Haemonchus Species: Effect on Haematocrit and Evaluation of the FAMACHAŠ Method in Arsi Negele District, Oromia, Ethiopia.*Animal and Veterinary Sciences,* **3**(2): 74-79

Acharya, R.M. 1982. Sheep and goat breeds of India.Food and Agriculture Organization of the United Nations.

Ahmed, M.M.M.and El Hag, F.M. 2003.Energy supply to livestock from tropical rangeland during the dry season. *Tropical animal health and production*, **35**(2): 169-177.

Andersen, I.L., Tønnesen, H., Estevez, I., Cronin, G.M. and Bøe, K.E. 2011.The relevance of group size on goats' social dynamics in a production environment.*Applied Animal Behaviour Science*, **134**(3-4): 136-143.

Anzuino, K., Bell, N.J., Bazeley, K.J. and Nicol, C.J. 2010.Assessment of welfare on 24 commercial UK dairy goat farms based on direct observations. *Veterinary Record*, **167**(20): 774-780.

Appleby, M.C., Olsson, A.S.and Galindo 3rd, F. 2011. Animal Welfare, Wallingford. *UK: CABI*.

Araújo, M.J.D., Medeiros, A.N.D., Carvalho, F.F.R.D., Silva, D.S.D., and Chagas, E.C.D.O. 2009. Consumoe digestibilidade dos nutrientesemcabrasMoxotórecebendodietas com diferentesníveis de feno de maniçoba.*Revista Brasileira de Zootecnia*, **38**(6): 1088-1095.

Arnold, G.W. 1985. Association and social behaviour. In: Fraser, A.F. (Ed.), Ethology of Farm Animals. Elsevier, Amsterdam, pp. 79–104.

Asher, L. and Collins, L.M. 2012. Assessing synchrony in groups: Are you measuring what you think you are measuring?*Applied Animal Behaviour Science*, **138**(3-4): 162-169.

Askar, A.R., Gipson, T.A., Puchala, R., Tesfai, K., Detweiler, G.D., Asmare, A. and Goetsch, A. L. 2013. Effects of stocking rate and physiological state of meat

goats grazing grass/forb pastures on forage intake, selection, and digestion, grazing behaviour, and performance. *Livestock Science*, **154**(1-3): 82-92.

Askins, G.D.and Turner, E.E. 1972.A behavioural study of angora goats on west Texas range. *Rangeland Ecology and Management/Journal of Range Management Archives*, **25**(2): 82-87.

Asrani, R.K., Battn, M.K., Katoch, R.C., Jithendran, K.P., Sharma, M.D., Singh, S.P.andGupta, V.K. (1999). Outbreaks of verminous bronchopulmonitis among sheep and goats in Himachal Pradesh.

Atmoko, B.A., Maharani, D., Bintara, S.andBudisatria, I.G.S. 2020.The behaviour of Etawah Grade goats in early and late pregnancy period in a tropical area. *Journal of Animal Behaviour and Biometeorology*, **8**(2): 136-141.

AWIN. 2015. AWIN welfare assessment protocol for goats.doi:10.13130/AWIN_goats_2015

Bartussek, H. 1999. A review of the animal needs index (ANI) for the assessment of animals' well-being in the housing systems for Austrian proprietary products and legislation. *Livestock Production Science*, **61**(2-3): 179-192.

Bath, G. F.and Van Wyk, J. A. 2009.The Five Point Check© for targeted selective treatment of internal parasites in small ruminants. *Small Ruminant Research*, **86**(1-3): 6-13.

Battini, M. 2013.Animal-based indicators for on-farm welfare assessment on cattle and goats. Università degli Studi di Milano, Italy, Doctoral Thesis.

Battini, M., Vieira, A., Barbieri, S., Ajuda, I., Stilwell, G., and Mattiello, S. 2014. Invited review: Animal-based indicators for on-farm welfare assessment for dairy goats. *Journal of dairy science*, **97**(11): 6625-6648.

Battini, M., Barbieri, S., Fioni, L.and Mattiello, S. 2016. Feasibility and validity of animal-based indicators for on-farm welfare assessment of thermal stress in dairy goats. *International journal of biometeorology*, **60**(2): 289-296.

Battini, M., Barbieri, S., Vieira, A., Stilwell, G.and Mattiello, S. 2016. Results of testing the prototype of the AWIN welfare assessment protocol for dairy goats in 30 intensive farms in Northern Italy. *Italian Journal of Animal Science*, **15**(2): 283-293.

Battini, M., Renna, M., Giammarino, M., Battaglini, L.and Mattiello, S. 2021. Feasibility and Reliability of the AWIN Welfare Assessment Protocol for Dairy Goats in Semi-extensive Farming Conditions. *Frontiers in Veterinary Science, 8*.

Bennett, G., van Loenen, A., Zhou, H., Sedcole, R. and Hickford, J. 2009.The detection of *Dichelobacternodosus* and *Fusobacterium necrophorum* from footrot lesions in New Zealand goats. *Anaerobe*, **4**(15): 177.

Berg, W., Jolly, A., Rambeloarivony, H., Andrianome, V. and Rasamimanana, H. 2009. A scoring system for coat and tail condition in ringtailed lemurs, Lemur catta. American Journal of Primatology: *Official Journal of the American Society of Primatologists*, 71(3):183-190.

Besier, R.B., Kahn, L.P., Sargison, N.D.and Van Wyk, J.A. 2016.The pathophysiology, ecology and epidemiology of *Haemonchuscontortus* infection in small ruminants. *Advances in parasitology*, **93**: 95-143.

Bhatta, R, Sankhyan SK, Shinde, A.K. and Verma, D.L. 2001. Seasonal changes in diet selectivity and grazing behaviour of goats on semi-arid rangeland. *Indian Journal of Animal Sciences*, **71**(1): 62-65.

Blokhuis, H.J., Hopster, H., Geverink, N.A., Korte, S.M.and Van Reenen, C.G. (1998).Studies of stress in farm animals. *Comparative Haematology International*, **8**(2): 94-101.

Blokhuis, H.J., Veissier, I., Miele, M.and Jones, B. 2010. The Welfare Quality® project and beyond: Safeguarding farm animal well-being. *Acta Agriculturae Scand Section A*, **60**(3): 129-140.

Boissy, A.and Dumont, B. 2002. Interactions between social and feeding motivations on the grazing behaviour of herbivores: sheep more easily split into subgroups with familiar peers. *Applied Animal Behaviour Science*, **79**(3): 233-245.

Bojkovski, D., Štuhec, I., Kompan, D.and Zupan, M. 2014.The behaviour of sheep and goats co-grazing on pasture with different types of vegetation in the karst region. *Journal of Animal Science*, **92**(6): 2752-2758.

Bokko, B. P., Adamu, S. S.and Mohammed, A. 2003.Limb conditions that predispose sheep to lameness in the arid zone of Nigeria. *Small Ruminant Research*, **47**(2): 165-169.

Botreau, R., Veissier, I., Butterworth, A., Bracke, M. B.and Keeling, L. J. 2007.Definition of criteria for overall assessment of animal welfare. *Animal Welfare-Potters Bar Then Wheathampstead*, **16**(2): 225.

Braghieri, A., Pacelli, C., Girolami, A., and Napolitano, F. 2011. Time budget, social and ingestivebehaviours expressed by native beef cows in Mediterranean conditions. *Livestock Science*, **141**: 47–52.

Brambell, F.W.R. 1965. Report of the Technical Committee to inquire in to Welfare of Animals Kept under Intensive Livestock Husbandry Systems.Great Britain. Parliament.HM Stationery Office. Pp: 1-84

Bremm, C., Rocha, M.G.D., Restle, J., Pilau, A., Montagner, D.B., Freitas, F.K.D. and Neves, F.P. 2005. Efeito de níveis de suplementaçãosobre o comportamentoingestivo de bezerrasempastagem de aveia (Avena strigosaSchreb.) e azevém (Lolium multiflorum Lam.). *Revista Brasileira de Zootecnia*, **34**(2): 387-397.

Briefer, E.F., Vizier, E., Gygax, L., and Hillmann, E. 2019. Expression of emotional valence in pig closed-mouth grunts: Involvement of both source-and filter-related parameters. *The Journal of the Acoustical Society of America*, **145**(5): 2895-2908.

Broom, D.M. and Fraser, A. F. 2010.Behaviour and welfare of domestic animals. *Behaviour and welfare of domestic animals.*, (Ed. 4). CAB International.

Burns, J.C., Mayland, H.F.and Fisher, D.S. (2005). Dry matter intake and digestion of alfalfa harvested at sunset and sunrise. *Journal of Animal Science*, **83**(1): 262-270.

Can, E., Vieira, A., Battini, M., Mattiello, S.and Stilwell, G. 2016. On-farm welfare assessment of dairy goat farms using animal-based indicators: the example of 30 commercial farms in Portugal. *Acta Agriculturae Scandinavica, Section A—Animal Science*, **66**(1): 43-55.

Capdeville, J.andVeissier, I. 2001.A method of assessing welfare in loose housed dairy cows at farm level, focusing on animal observations. *Acta Agriculturae Scandinavica, Section A-Animal Science*, **51**(30): 62-68.

Caroprese, M., Casamassima, D., Pier Giacomo Rassu, S., Napolitano, F. and Sevi, A. 2009. Monitoring the on-farm welfare of sheep and goats. *Italian Journal of Animal Science*, **8**(1): 343-354.

Casamassima, D., Sevi, A., Palazzo, M., Ramacciato, R., Colella, G.E. and Bellitti, A. 2001. Effects of two different housing systems on behaviour, physiology and milk yield of Comisana ewes. *Small Ruminant Research*, **41**: 151–161.

Casimir, M.J.and Rao, A. 1985. Vertical control in the western Himalaya: some notes on the pastoral ecology of the nomadic Bakrwal of Jammu and Kashmir. *Mountain Research and Development*, 221-232.

Cavagna, A., Cimarelli, A., Giardina, I., Parisi, G., Santagati, R., Stefanini, F. and Viale, M. 2010.Scale-free correlations in starling flocks. *Proceedings of the National Academy of Sciences*, **107**(26): 11865-11870.

Christodoulopoulos, G. (2009). Foot lameness in dairy goats. *Research in veterinary science*, **86**(2): 281-284.

Cissé, M., Ly, I., Nianogo, A.J., Sane, I., Sawadogo, J.G., N'diaye, M.andFall, Y. 2002. Grazing behaviour and milk yield of Senegalese Sahel goat. *Small Ruminant Research*, **43**(1): 85-95.

Colebrook, E.and Wall, R. 2004.Ectoparasites of livestock in Europe and the Mediterranean region. *Veterinary Parasitology*, **120**(4): 251-274.

Coppinger, R., Coppinger, L., Langeloh, G., Gettler, L.and Lorenz, J. 1988. A decade of use of livestock guarding dogs. In *Proceedings of the Thirteenth Vertebrate Pest Conference (1988)* (p. 43).

Couzin, I.D. and Krause, J. 2003.Self-organization and collective behaviour in vertebrates. *Advances in the Study of Behaviour*, **32**(1): 10-1016.

CSWRI. 2001. Improvement in Migratory Sheep Production Programme for Tribal Farmers in North West, Annual Progress Report 2000-2001, Avikanagar: Central Sheep and Wool Research Institute.

Dada, J.M.V., dos Santos, M.L.P., Muniz, P.C., Nunes-Zotti, M.L.A., de Barros, F.R.O. and Vieira, F.M.C. 2021. Postpartum behavioural response of Santa inês x dorper ewes and lambs in a silvopastoral system. *Small Ruminant Research*, **203**: 106495.

Das, A., De, D. and Katole, S. 2011. Seasonal variation in eating behaviour and nutritive value of mixed jungle grass for goats.*Animal Nutrition and Feed Technology***11**: 195-202.

De Aguiar, G.M.N., Assis, A.C.O., da Silva, T.R., Araujo, J.R.B., Garino Junior, F., Simoes, S. V.and Riet-Correa, F. 2009. Infectious foot problems in sheep and goats in the semiarid region of Paraíba. *Ciência Animal Brasileira*, **10**(Supplement 1): 585-590.

De Wolf, A. 2009. A welfare assessment system for dairy cows on pasture and the comparison to a welfare scoring system for cows in cubicles. Research Project Veterinary Medicine, University of Utrecht.

Depiazzi, L.J., Richards, R.B., Henderson, J., Rood, J.I., Palmer, M. and Penhale, W.J. 1991.Characterisation of virulent and benign strains of Bacteroides nodosus. *Veterinary microbiology*, **26**(1-2): 151-160.

Devina, S. 2004. Epidemiological studies on gastrointestinal helminths of sheep and chemotherapy of Haemonchus contours. *MVSc thesis, CSK, Himachal Pradesh, Krishi Vishvavidyalaya, Palampur*, 1-74.

Dickinson, E.R., Stephens, P.A., Marks, N.J., Wilson, R.P.and Scantlebury, D.M. 2021. Behaviour, temperature and terrain slope impact estimates of energy expenditure using oxygen and dynamic body acceleration. *Animal Biotelemetry*, **9**(1): 1-14.

Dogra, P.K., Sankhyan, V., Kumari, A., Thakur, A. and Kumar, N. 2018. Enhancing profitability of nomadic Gaddi goat production system for augmenting farmer's income. *Indian Journal of Animal Production and Management*, **34**: 36-39.

Dogra, P.K., Sharma, V.K., Panda, A.K., Sood, P., Sankhayn, V., Sharma, P., and Ashutosh 2011. All India Co-Ordinated Research Project On Goat Improvement Gaddi Field Unit– CSK HPKV, Palampur Annual Report.

Dogra, P.K., Pankaj, S., Sankhyan, V, Sharma, A., Verma, N., Thakur, A. and Suman, M. 2019. All India Co-Ordinated Research Project On Goat Improvement Gaddi Field Unit– CSK HPKV, Palampur Annual Report 2018-19.

Doughty, A.K., Horton, B., Corkrey, R. and Hinch, G.N. 2019. Key factors affecting mortality of adult ewes in extensive Australian conditions: Applications for welfare assessment. *Small Ruminant Research*, **170**: 1-7.

Dwyer, C.M. and Lawrence, A.B. 2008. Introduction to animal welfare and the sheep.In *The welfare of sheep* (pp. 1-40).Springer, Dordrecht.

Dwyer, C.M. 2003. Behavioural development in the neonatal lamb: effect of maternal and birth-related factors. *Theriogenology*, **59**(3-4): 1027-1050.

Dwyer, C.M. 2004. How has the risk of predation shaped the behavioural responses of sheep to fear and distress?*Animal Welfare*, **13**(3): 269-281.

Dwyer, C.M. and Bornett, H.L.I. 2004. Chronic stress in sheep: assessment tools and their use in different management conditions. *Animal Welfare*, **13**(3): 293-304.

Dwyer, C.M., Lawrence, A.B., Bishop, S.C., and Lewis, M. 2003. Ewe–lamb bonding behaviours at birth are affected by maternal undernutrition in pregnancy. *British Journal of Nutrition*, **89**(1): 123-136.

EFSA Panel on Animal Health and Welfare (AHAW). 2012. Statement on the use of animal- based measures to assess the welfare of animals. *EFSA Journal*, **10**(6): 2767.

Egerton, J.R. 2002. Management of foot-rot in small ruminants.*International Symposium On Lameness In Ruminants*, 12.

El Aich, A., El Assouli, N., Fathi, A., Morand-Fehr, P.andBourbouze, A. 2007.Ingestivebehaviour of goats grazing in the Southwestern Argan (Argania spinosa) forest of Morocco. *Small Ruminant Research*, **70**(2-3): 248-256.

Farm Animal Welfare Council 1993. Second Report on Priorities for Research and Development in Farm Animal Welfare. Londres: DEFRA.

Farm Animal Welfare Council 2009. Farm animal welfare in Great Britain: Past, present and future. Farm Animal Welfare Council.

Fernandez, G. 2010. *Data mining using SAS applications*.CRC press.

Fernández-Juricic, E., Siller, S.andKacelnik, A. 2004. Flock density, social foraging, and scanning: an experiment with starlings. *Behavioural ecology*, **15**(3): 371-379.

Flores-Najera, M.J., Cuevas-Reyes, V., Vázquez-García, J.M., Beltrán-López, S., Meza-Herrera, C. A., Mellado, M. and Rosales-Nieto, C.A. 2021. Milk yield and composition of mixed-breed goats on rangeland during the dry season and the effect on the growth of their progeny. *Biology*, **10**(3): 220.

Formiga, L.D.A.D.S., Paulo, P.F.M.D., Cassuce, M.R., Andrade, A.P.D., Silva, D.S.D.and Saraiva, E.P. 2020. Ingestivebehaviour and feeding preference of goats reared in degraded caatinga. *Ciência Animal Brasileira*, **21**.

Fraser D. 2003. Assessing animal welfare at the farm and group level: the interplay ofscience and values. *Animal Welfare,* **12**: 433–43.

Fraser, A.F. 1983. The behaviour of maintenance and the intensive husbandry of cattle, sheep and pigs. *Agriculture, Ecosystems and Environment*, **9**(1): 1-23.

Fraser, D., Weary, D.M., Pajor, E.A.and Milligan, B.N. 1997.A scientific conception of animal welfare that reflects ethical concerns.*Animal welfare*, **6**: 187-205

Furtado, G. (2008). Respostascomportamentais de cabras Saanen submetidas a estressetérmiconaMesoregião Central Potiguar. Departamento de Aprendizagem Rural, SENAR – Serviço Nacional de Aprendizagem Rural, Natal, RN, Brasil.

Furtado, G.D. and Crispim, M.C. 2015. Avaliação do comportamentoem campo de um rebanho de caprinos das raças Saanen e Parda Alpina no semiáridocomocontribuição para o entendimento do impacto do aquecimento global. *Gaia scientia*, **9**(1): 28-36.

Ganai, T. A. S., Misra, S. S.and Sheikh, F. D. 2011.Characterization and evaluation of Pashmina producing Changthangi goat of Ladakh. *Indian Journal of Animal Sciences*, **81**(6): 592-599.

García-Monjaras, S., Santos-Díaz, R.E., Flores-Najera, M.J., Cuevas-Reyes, V., Meza-Herrera, C.A., Mellado, M.and Rosales-Nieto, C.A. 2021. Diet selected by goats on xerophytic shrubland with different milk yield potential. *Journal of Arid Environments*, **186**: 104429.

Gelasakis, A.I., Oikonomou, G., Bicalho, R.C., Valergakis, G.E., Fthenakis, G.S.andArsenos, G. 2013. Clinical characteristics of lameness and potential risk factors in intensive and semi-intensive dairy sheep flocks in Greece.*Journal of the Hellenic Veterinary Medical Society*, **64**(2): 123-130.

Gelasakis, A.I., Kalogianni, A.I. and Bossis, I. 2019. Aetiology, risk factors, diagnosis and control of foot-related lameness in dairy sheep. *Animals*, **9**(8): 509.

Goddard, P., Waterhouse, T., Dwyer, C.and Stott, A. 2006.The perception of the welfare of sheep in extensive systems. *Small Ruminant Research*, **62**(3): 215-225.

Goddard, P.J., 2008. The Management of Sheep, in: Dwyer, C.M. (Ed.), The Welfare of Sheep,. Springer Science and Buiness Media B.V, pp. 291–323

Goetsch, A.L., Gipson, T.A., Askar, A.R.and Puchala, R. 2010.Invited review: Feeding behaviour of goats. *Journal of animal science*, **88**(1): 361-373.

Government of India (GoI).2019. 20th Livestock Census.Department of Animal Husbandry and Dairying, Ministryof Agriculture and Farmers' Welfare, New Delhi.65-73.

Grant, C. (2004). Behavioural responses of lambs to common painful husbandry procedures. *Applied Animal Behaviour Science*, **87**(3-4): 255-273.

Green J.S. and Woodruff R.A.1999. Livestock guarding dogs: Protecting sheep from predators. Agriculture information bulletin No. 588. United States Department of Agriculture; USA

Grova, L.and Bjelland, B. 1997.Feeding behaviour of goats in the Valse Thornveld of the Eastern Cape. Combined Project in Livestock and Pasture Science, Univ. Fort Hare and Agricultural Univ. Norway.

Gupta, K., Kaila, O. P. and Marwaha, C. L. 2005.Growth pattern of gaddi goat in cold arid zone of Himachal Pradesh. *The Indian Journal of Small Ruminants*, **11**(2): 187-190.

Harrison, R. 2013. *Animal machines*.Cabi.Wallingfort

Hejcmanova, P., Stejskalova, M., Pavlu, V., and Hejcman, M. 2009. Behaviouralpatterns of heifers under intensive and extensive continuous grazingon species-rich

pasture in the Czech Republic. *Applied Animal Behaviour Science*, **117**: 137–143.

Hemsworth, P.H., Coleman, G.J., Barnett, J.L. and Borg, S. 2000. Relationships between human-animal interactions and productivity of commercial dairy cows. *Journal of animal science*, **78**(11): 2821-2831.

Herbert-Read, J.E., Perna, A., Mann, R.P.,Schaerf, T.M., Sumpter, D.J.and Ward, A.J. 2011.Inferring the rules of interaction of shoaling fish. *Proceedings of the National Academy of Sciences*, **108**(46): 18726-18731.

Hernandez, R.O., Sánchez, J.A.and Romero, M.H. 2020. Iceberg indicators for animal welfare in rural sheep farms using the five domains model approach. *Animals*, **10(**12): 2273.

Hibbard, W. 2013.Definingstockmanship.*Stockmanship Journal*https:/ /stockmanshipjournal.com/defining-stockmanship.

Hill, N.P., Murphy, P.E., Nelson, A.J., Mouttotou, N., Green, L.E.and Morgan, K.L. 1997. Lameness and foot lesions in adult British dairy goats. *Veterinary record*, **141**(16): 412-416.

Hogson, J. 1990. Grazing management: science into practice (No. 636.084 H6681g Ej. 1 007557). Longman Group UK Ltd.

IUCN. 2011. Supporting Sustainable Pastoral Livelihoods: A Global Perspective on Minimum Standards and Good Practices. Second edition March 2012: published for review and consultation through global learning fora. Nairobi, Kenya: IUCN ESARO office. vi + 34 pp.

Jithendran, K.P. 1998. Epidemiology of gasterointestinal nematodes in migratory sheep and goats in north-west humid Himalayan region.*Indian Journal of Animal Sciences*, **68** (9): 894-96.

Jithendran, K.P. 2000. Helminth Parasites-A Constraint in animal health management in Himachal Pradesh.*ENVIS Bulletin Himalayan Ecology***, 8**(2)

Jithendran, K. P.and Bhat, T. K. 1996.Prevalence of dicrocoeliosis in sheep and goats in Himachal Pradesh, India. *Veterinary Parasitology*, **61**(3-4): 265-271.

Johnsen, P.F., Johannesson, T.and Sandøe, P. 2001. Assessment of farm animal welfare at herd level: many goals, many methods. *Acta Agriculturae Scandinavica, Section A-Animal Science*, **51**(S30): 26-33.

Johnson, K.G. 1991. Body temperatures and respiratory rates of free-ranging merino sheep in and out of shade during summer. *Aust. J. Agric. Res.* 42:1347–1357.

Johnson, R.A. and Wichern, D.W.(1982). Applied Multivariate Statistical Analysis. Prentice-Hall, Inc., Englewood Cliffs, NJ, USA.

Jonsson, H. 2011. Foraging behaviour of cattle, sheep and goats on semi-arid pastures in Kenya.Second cycle, A1N, A1F or AXX (AXX). Uppsala: SLU, Dept. of Animal Environment and Health

Jørgensen, G.H., Andersen, I.L., Holand, Ø. and Bøe, K.E. 2011. Differences in the spacing behaviour of two breeds of domestic sheep (*Ovis aries*)–influence of artificial selection?*Ethology*, **117**(7): 597-605.

Joshi, V.B., Nagal, K.B., Sharma, M., Katoch, R.C., Batta, M.K. and Sharma, A.K. 1996.Peste-des-petits ruminants (PPR) among Gaddi sheep and goats in Himachal Pradesh. *Indian journal of animal sciences*, **66**(11): 1126-1127.

Kaler, J. and Green, L.E. 2008. Naming and recognition of six foot lesions of sheep using written and pictorial information: a study of 809 English sheep farmers. *Preventive veterinary medicine*, **83**(1): 52-64.

Kaler, J.and Green, L.E. 2009. Farmers' practices and factors associated with the prevalence of all lameness and lameness attributed to interdigital dermatitis and footrot in sheep flocks in England in 2004. *Preventive veterinary medicine*, **92**(1-2), 52-59.

Kannan, G., Terrill, T. H., Kouakou, B., Gelaye, S.and Amoah, E. A. 2002. Simulated preslaughter holding and isolation effects on stress responses and live weight shrinkage in meat goats. *Journal of Animal Science*, **80**(7): 1771-1780.

Karthik, D., Suresh, J., Reddy, Y.R., Sharma, G.R.K., Ramana, J.V., Gangaraju, G. and Reddy, P.R.K. 2021. Farming systems in sheep rearing: Impact on growth and reproductive performance, nutrient digestibility, disease incidence and heat stress indices. *PloS one*, **16**(1): e0244922.

Kendrick, K.M., da Costa, A.P., Leigh, A.E., Hinton, M.R. and Peirce, J.W. 2001. Sheep don't forget a face. *Nature*, **414**(6860): 165-166.

Kent, J.E., Molony, V.and Graham, M.J. 2001. The effect of different bloodless castrators and different tail docking methods on the responses of lambs to the combined Burdizzo rubber ring method of castration. *The Veterinary Journal*, **162**(3): 250-254.

Kilgour, R., and Dalton C. 1984.LivestockBehaviour:APracticalGuide.Methuen, NewZealand

Kooring, R. 2017. Welfare of goats on organic goat systems in the Netherlands; testing a protocol.Master Thesis Organic agriculture.

Lachica, M., Barroso, F.G.and Prieto, A.C. 1997. Seasonal variation of locomotion and energy expenditure in goats under range grazing conditions.*Journal of Range Management*,**50**:234–238

Lachica, M. and Aguilera, J.F. 2005.Energy expenditure of walk in grassland for small ruminants. *Small Ruminant Research*, **59**(2-3): 105-121.

Lachica, M., Somlo, R., Barroso, F.G., Boza, J.and Prieto, C. 1999.Goats locomotion energy expenditure under range grazing conditions: seasonal variation. *Rangeland Ecology and Management/Journal of Range Management Archives*, **52**(5): 431-435.

Lamoot, I., Callebaut, J., Demeulenaere, E., Vandenberghe, C. and Hoffmann, M. 2005.Foraging behaviour of donkeys grazing in a coastal dune area in temperate climate conditions.*Applied Animal Behaviour Science*, **92**(1-2): 93-112.

Larrondo, C., Bustamante, H.and Gallo, C. 2018. Sheep farmers' perception of welfare and pain associated with routine husbandry practices in Chile. *Animals*, **8**(12): 225.

Laurijs, K.A., Briefer, E.F., Reimert, I. and Webb, L.E. 2021. Vocalisations in farm animals: A step towards positive welfare assessment. *Applied Animal Behaviour Science*, **236**: 105264.

Leite, L.O., Stamm, F.D.O.and Garcia, R.D.C.M. 2017.Indicators to assess goat welfare on-farm in the semiarid region of Brazilian Northeast. *Ciência Rural*, **47**.

Leite, L.O., Stamm, F.D.O., Maceno, M.A.C., Camarinha Filho, J.A.and Garcia, R.D.C.M. 2020. On-farm welfare assessment in meat goat does raised in semi-intensive and extensive systems in semiarid regions of Ceará, Northeast, Brazil. *Ciência Rural*, **50**.

Lensink, J., Boissy, A.andVeissier, I. 2000.The relationship between farmers' attitude and behaviour towards calves, and productivity of veal units.In *Annales de zootechnie* (Vol. 49, No. 4, pp. 313-327).EDP Sciences.

Ley, S.J., Livingston, A.and Waterman, A.E. 1992.Effects of clinically occurring chronic lameness in sheep on the concentrations of plasma noradrenaline and adrenaline. *Research in veterinary science*, **53**(1): 122-125.

Liu, C.W., Lin, K.H.and Kuo, Y.M. 2003. Application of factor analysis in the assessment of groundwater quality in a blackfoot disease area in Taiwan. *Science of the total environment*, **313**(1-3): 77-89.

Lynch, J.J., Hinch, G.N. and Adams, D.B. 1992. The behaviour of sheep: biological principles and implications for production. CAB international.

Madhu, D.N., Sudhakar, N.R., Maurya, P.S., Manjunathachar, H.V., Sahu, S.and Pawde, A.M. 2014. Nasal Oestrosis in a Jamunapari goat. *Journal of parasitic diseases*, **38**(4): 396-398.

Main, D.C.J., Kent, J.P., Wemelsfelder, F., Ofner, E.andTuyttens, F.A.M. 2003.Applications for methods of on-farm welfare assessment. *Animal Welfare*, **12**(4): 523-528.

Main, D.C.J., Kent, J.P., Wemelsfelder, F., Ofner, E. and Tuyttens, F.A.M. 2003.Applications for methods of on-farm welfare assessment. *Animal Welfare*, **12**(4): 523-528.

Main, D.C.J., Whay, H.R., Green, L.E. and Webster, A.J.F. 2003.Effect of the RSPCA Freedom Food scheme on the welfare of dairy cattle. *Veterinary Record*, **153**(8): 227-231.

Main, D.C.J., Whay, H.R., Leeb, C. and Webster, A.J.F. 2007.Formal animal-based welfare assessment in UK certification schemes. *Animal Welfare*, **16**(2): 233-236.

Main, D.C.J., Leeb, C., Whay, H.R., Hovi M. and Webster, A.J.F. http://www.vetschool.bristol.ac.uk/animalwelfare/images/BWAPwebovervie w.pdf

Manteuffel, G., Puppe, B. and Schön, P. C. 2004. Vocalization of farm animals as a measure of welfare. *Applied Animal Behaviour Science*, **88**(1-2): 163-182.

Mazurek, M., Marie, M. andDesor, D. 2007. Potential animal-centred indicators of dairy goat welfare. *Animal Welfare*, **16**(2): 161-164.

Markwick, G. 2007. Water requirements for sheep and cattle. *Profitable and Sustainable primary industry*.

Matthews, L.R. 1996. Animal welfare and sustainability of production under extensive conditions: a non-EU perspective. *Applied Animal Behaviour Science*, **49**(1): 41-46.

Mattiello, S., Battini, M., Andreoli, E., Minero, M., Barbieri, S. and Canali, E. 2010. Avoidance distance test in goats: A comparison with its application in cows. *Small Ruminant Research*, **91**(2-3): 215-218.

Mattiello, S., Klotz, C., Baroli, D., Minero, M., Ferrante, V.and Canali, E. 2009. Welfare problems in alpine dairy cattle farms in Alto Adige (Eastern Italian Alps). *Italian Journal of Animal Science*, **8**(sup2): 628-630.

McDougall, P.L.and Ruckstuhl, K.E. 2018. Doing what your neighbour does: neighbour proximity, familiarity and postural alignment increase behavioural mimicry. *Animal Behaviour*, **135**: 177-185.

McGregor, B.A. and Butler, K.L. 2008.Relationship of body condition score, live weight, stocking rate and grazing system to the mortality of Angora goats from hypothermia and their use in the assessment of welfare risks.*Australian veterinary journal*, **86**(1- 2): 12-17.

Mellor, D.J. 2017.Operational details of the five domains model and its key applications to the assessment andmanagement of animal welfare. *Animals*, **7**: 60.

Mgasa, M.N.and Arnbjerg, J. 1993.Occurrence of lameness and digital lesions in Tanzanian goats. *Small Ruminant Research*, **10**(1): 55-62.

Mishra, H.and Pandey, B.W. 2019.Navigating the Impacts of Social and Environmental Changes to Traditional Lifestyle: A Case Study of Gaddi Transhumance of Chamba District in Himachal Pradesh. *The Oriental Anthropologist*, **19**(2): 326-337.

Misri, B. 1998. Migratory system of goat and sheep rearing in Himachal Pradesh India. In *Pro c. 3rd., meeting/workshop of Temp. Asia Pasture and Fodder Network. Pokhara* (pp. 32-49).

Misri, B. 2003. Migratory goat and sheep rearing in Himanchal Pradesh, India. Transumant grazing system in Temperate Asia, edited by: Suttie, JM and Reynolds, SG, FAO, Rome, Italy, 331.

Mitlöhner, F.M., Morrow, J.L., Dailey, J.W., Wilson, S.C., Galyean, M.L., Miller, M.F. and McGlone, J.J. 2001. Shade and water misting effects on behaviour, physiology, performance, and carcass traits of heat-stressed feedlot cattle. *Journal of Animal Science*, **79**(9): 2327-2335.

Mohammed, A.S., Animut, G., Urge, M. and Assefa, G. 2020. Grazing behavior, dietary value and performance of sheep, goats, cattle and camels co-grazing range with mixed species of grazing and browsing plants. *Veterinary and Animal Science*, **10**: 100154.

Mondragón-Ancelmo, J., Garcia Hernandez, P., Rojo Rubio, R., Arturo Domínguez Vara, I., Del Campo Gigena, M. and Napolitano, F. 2020. Small flocks show higher levels of welfare in Mexican semi-intensive sheep farming systems. *Journal of Applied Animal Welfare Science*, **23**(3): 348-355.

Molony, V., Kent, J.E. and McKendrick, I.J. 2002.Validation of a method for assessment of an acute pain in lambs. *Applied animal behaviour science*, **76**(3): 215-238.

Morgan-Davies, C., Waterhouse, A., Pollock, M.L. and Milner, J.M. 2007. Body condition score as an indicator of ewe survival under extensive conditions. *Animal Welfare-Potters Bar Then Wheathampstead*, **17**(1): 71.

Morris, S.T. 2017. Overview of sheep production systems.In *Advances in sheep welfare* (pp. 19-35). Woodhead Publishing.

Moudgil, A.D., Sharma, A., Verma, M.S., Kumar, R., Dogra, P.K.and Moudgil, P. 2017. Gastrointestinal parasitic infections in Indian Gaddi (goat) breed bucks:

clinical, hemato-biochemical, parasitological and chemotherapeutic studies. *Journal of Parasitic Diseases*, **41**(4): 1059-1065.

Moyo, M., Adebayo, R.A. and Nsahlai, I.V. 2019.Effects of diet and roughage quality, and period of the day on diurnal feeding behaviour patterns of sheep and goats under subtropical conditions. *Asian-Australasian journal of animal sciences*, **32**(5): 675.

Munoz, C.A., Campbell, A.J., Hemsworth, P.H. and Doyle, R.E. 2019.Evaluating the welfare of extensively managed sheep. *PLoS One*, **14**(6): 1-14

Munoz, C., Campbell, A., Hemsworth, P., and Doyle, R. (2017). Animal-based measures to assess the welfare of extensively managed ewes. *Animals*, **8**(1): 2.

Muri, K., Stubsjøen, S.M. and Valle, P.S. 2013. Development and testing of an on-farm welfare assessment protocol for dairy goats. *Animal welfare*, **22**: 385-400.

Nagal, K.B., Gupta, A. and Asrani, R.K. 2014. Salvia coccinea poisoning among migratory Gaddi goats: Evidences from mid hills of Himachal Pradesh (India).*Indian Journal of Animal Sciences*, **84**: 37-38.

Napolitano, F., De Rosa, G., Ferrante, V., Grasso, F., andBraghieri, A. 2009. Monitoring the welfare of sheep in organic and conventional farms using an ANI 35 L derived method. *Small Ruminant Research*, **83**(1-3): 49-57.

Negretti, P., Bianconi, G., MeoZilio, D., Noè, L., Bartocci, S., Di Giovanni, S. and Terramoccia, S. 2020.Effect of additional outdoor yard on behaviour of lactating domestic goats (Capra hircus) in different seasons.*Journal of Ethology*, **38**(1): 61-69.

Nenadović, K., Ilić, T., Jovanović, N., Bugarski, D. and Vučinić, M. 2021. Welfare of Native Goat Breeds in Serbia—Emphasis on Parasitological Infections. *Frontiers in Veterinary Science*, **8**: 678880

Nielsen, B.L., Lawrence, A.B. and Whittemore, C.T. 1995. Effect of group size on feeding behaviour, social behaviour, and performance of growing pigs using single-space feeders. *Livestock Production Science*, **44**(1): 73-85.

Nieto, C.R., Ferguson, M.B., Macleay, C.A., Briegel, J.R., Wood, D.A., Martin, G.B. and Thompson, A.N. 2018. Milk production and composition, and progeny

performance in young ewes with high merit for rapid growth and muscle and fat accumulation. *Animal*, **12**(11): 2292-2299.

Nyam, Y.S., Matthews, N. and Bahta, Y.T. 2020. Improving livelihoods of smallholder farmers through region specific strategies: a case study of South African sheep production. *Agrekon*, **59**(1): 1-15.

O'Connor, A., Wolfe, D., Sargeant, J., Glanville, J. and Wood, H. 2015. Preparatory work for the development of a scientific opinion on the main welfare risks related to the farming of sheep for wool, meat and milk production. *EFSA Supporting Publications*, **12**(2): 678E.

Odo, B.I., Omeje, F.U. and Okwor, J.N. 2001. Forage species availability, food preference and grazing behaviour of goats in southeastern Nigeria. *Small Ruminant Research*, **42**(2): 161-166

OIE.2019. Introduction to the recommendations for animal welfare. Terrestrial Animal Health Code, **1**: 1-4.

Ouédraogo-Koné, S., Kaboré-Zoungrana, C.Y.and Ledin, I. 2006.Behaviour of goats, sheep and cattle on natural pasture in the sub-humid zone of West Africa. *Livestock Science*, **105**(1-3): 244-252.

Pakhretia, S. andPirta, R.S. 2010.A behavioural study of the sheep and goats of the transhumant Gaddis. *Journal of Human Ecology*, **29**(2): 93-100.

Pandey, R.K., Kaul, S. and Singh, D.R. 2002. Impact assessment of technology interventions and crop diversification in tribal, backward and hilly areas, In:Improvement in Migratory Sheep Production Programme for Tribal Flocks in North West, Annual Report 2001-2002, New Delhi: Indian Agricultural Statistics Research Institute.

Pathania, M.S. and Dev, I. 2015.Rearing practices of migratory sheep and goats in Himachal Pradesh: A case study of Gaddi tribe.*Indian Journal of Agroforestry*, **17**(1): 57-61.

Pati, U.S. and Kurade, N.P. 2008.Isolation, identification and in vitro antibiogram of Enterococcus fecalis from migratory sheep and goat. *The Indian Journal of Veterinary Research*, **17**(2): 32-35.

Paulo, J.L.D.A.and Lopes, F.D.A. 2014. Daily activity patterns of Saanen goats in the semi-arid northeast of Brazil. *Revista Brasileira de Zootecnia*, **43**: 464-470.

Pays, O., Dubot, A.L., Jarman, P.J., Loisel, P. and Goldizen, A.W. 2009. Vigilance and its complex synchrony in the red-necked pademelon, Thylogale thetis. *Behavioural Ecology*, **20**(1): 22-29.

Petherick, J.C. 2005. Animal welfare issues associated with extensive livestock production: The northern Australian beef cattle industry. *Applied Animal Behaviour Science*, **92**(3), 211-234.

Phillimore, P. (1982). Marriage and social organization among pastoralists of the Dhaula Dhar (Western Himalaya).Ph.D. thesis.University of Durham, Durham, United Kingdom.

Phillips, C.J. and Phillips, A.P. 2010.Attitudes of Australian sheep farmers to animal welfare. *Journal of International Farm Management*, **5**(Ed. 2): 1-26.

Phythian, C.J., Cripps, P.J., Michalopoulou, E., Jones, P.H., Grove-White, D., Clarkson, M.J. and Duncan, J. S. 2012. Reliability of indicators of sheep welfare assessed by a group observation method. *The Veterinary Journal*, **193**(1): 257-263.

Pokorná, P., Hejcmanová, P., Hejcman, M., and Pavlu, V. 2013. Activity time budget patterns of sheep and goats co-grazing on semi-natural species-rich dry grassland. *Czech Journal of Animal Science*, **58**(5): 208-16.

Pugh, D.G. and Baird, N.N. 2012.Sheep & Goat Medicine-E-Book.*Elsevier Health Sciences*.Pp: 252-256.

Rassu, S.P.G., Enne, G., Ligios, S. and Molle, G. 2004.Nutrition and Reproduction In: G. Pulina (ed.)Dairy Sheep Nutrition. CABI Publishing, Wall-ingford, UK, pp. 109-128.

Robbins, J.A., Von Keyserlingk, M.A.G., Fraser, D.and Weary, D.M. 2016. Invited review: Farm size and animal welfare. *Journal of Animal Science*, **94**(12): 5439-5455.

Romeyer, A.band Bouissou, M. F. 1992.Assessment of fear reactions in domestic sheep, and influence of breed and rearing conditions. *Applied Animal Behaviour Science*, **34**(1-2): 93-119.

Rousing, T., Bonde, M. and Sorensen, J.T. 2000. Indicators for the assessment of animal welfare in a dairy cattle herd with a cubicle housing system. *Publication-European Association For Animal Production*, **102**: 37-44.

Rueff, H., Kressel, G., and Schwartz, M. 2004. Forest fire control and Bedouin pastoralism in Israel's afforested drylands: A cost benefit Analysis. *Nomadic peoples*: 113-137.

Rushen, J., Butterworth, A., and Swanson, J.C. 2011. Animal behaviour and well-being symposium: Farm animal welfare assurance: Science and application. *Journal of animal science*, **89**(4): 1219-1228.

Safari, J., Mushi, D.E., Kifaro, G.C., Mtenga, L.A. and Eik, L.O. 2011. Seasonal variation in chemical composition of native forages, grazing behaviour and some blood metabolites of Small East African goats in a semi-arid area of Tanzania. *Animal feed science and technology*, **164**(1-2): 62-70.

Sanjabi, P.A, Fayaz, M., Zare, N., Gharanjik, A., Yeganeh, H.andAfrougheh, S. 2014. The study of preference values of forage species and grazing behaviour of taligoat in chabahar rangelands of Iran. *Journal of Rangeland Science*, **3**(4): 312-320.

Sankhyan, V., Dogra, P.K., and Thakur, Y.P. 2016. Attributes of migratory goat and sheep farming and impact of some improved management strategies en-route migration in... *Indian Journal of Animal Sciences*, **86**(9): 1079-1084.

Sankhyan, V., Dogra, P.K., Thakur, Y.P., Katoch, S., and Thakur, R. 2014.Factors affecting pre-weaning mortality in Gaddi goats of Western Himalayas under transhumance production system. *Himachal Journal of Agricultural Research*, **40**(2): 164-168.

Sanon, H. O., Kaboré-Zoungrana, C., and Ledin, I. 2007. Behaviour of goats, sheep and cattle and their selection of browse species on natural pasture in a Sahelian area. *Small ruminant research*, **67**(1): 64-74.

Sejian, V., Lakritz, J., Ezeji, T., and Lal, R. 2011. Assessment methods and indicators of animal welfare. *Asian Journal of Animal and Veterinary Advances*, **6**(4): 301-315.

Sejian, V., Maurya, V.P., and Naqvi, S.M. 2010. Adaptive capability as indicated by endocrine and biochemical responses of Malpura ewes subjected to combined stresses (thermal and nutritional) in a semi-arid tropical environment. *International journal of biometeorology*, **54**(6): 653-661.

Sharma, A., Parkash, O. and Uniyal, S.K. 2022. Moving away from transhumance: The case of Gaddis. Trees, *Forests and People*, **7**: 100193.

Sharma, A., Negi, A.S., and Bisht, V.B. 2002. Affections in migratory sheep of Himachal Pradesh.*Indian Veterinary Journal*, **79** (12): 1299-1301.

Sharma, M., Batta, M.K., Katoch, R.C., and Andersen, A.A. 2008. A field investigation of bacterial etiology of abortions among migratory sheep and goats in North-West hill states of India.*VeterinarskiArhiv* 78 (1), 65-71.

Sharma, M., Batta, M.K., Katoch, R.C., Asrani, R.K., Nagal, K.B. and Joshi, V.B. 1996. Listeria monocytogenes abortions among migratory sheep and goats in Himachal Pradesh.*Indian Journal of Animal Sciences*, **66**(11): 1117-1119.

Sharma, V.P., Köhler-Rollefson, I.and Morton, J. 2003. Pastoralism in India: a scoping study. *Indian Institute of Management and League of Pastoral Peoples, Ahmedabad, India*.

Shrader, A.M., Kerley, G.I., Kotler, B.P. and Brown, J.S. 2007.Social information, social feeding, and competition in group-living goats (Capra hircus). *Behavioural Ecology*, **18**(1): 103-107.

Siebert, K., Langbein, J., Schön, P. C., Tuchscherer, A., and Puppe, B. 2011. Degree of social isolation affects behavioural and vocal response patterns in dwarf goats (Capra hircus). *AppliedAnimal Behaviour Science*, **131**(1-2): 53-62.

Silva, R.R., do Prado, I.N., de Carvalho, G.G.P., de Santana Junior, H.A., da Silva, F.F.and Dias, D.L.S. 2008. Efeito da utilização de trêsintervalos de observaçõessobre a precisão dos resultadosobtidos no estudo do comportamentoingestivo de vacasleiteirasempastejo. *Ciência Animal Brasileira*, **9**(2): 319-326.

Singh, D.R., Kaul, S.andSivaramane, N. 2006. Migratory sheep and goat production system: the mainstay of tribal hill economy in Himachal Pradesh. *Agricultural economics research review*, **19**: 387-398.

Singh, N.P. and Kumar, S.2007. Analternative approach to researchforharnessing production potential ofgoats. Proceedings of 4th NationalExtension Congress, Jawaharlal NehruKrishi Vishwavidyalaya, Jabalpur, 9-11March.

Singh, R. (1992). *Production and Marketing of Wool and Mutton in India*.Mittal Publications.

Singh, R.P., Saravanan, P., Sreenivasa, B.P., Singh, R.K.and Bandyopadhyay, S.K. 2004. Prevalence and distribution of peste des petits ruminants virus infection in small ruminants in India. *Rev Sci Tech*, **23**(3): 807-819.

Singh, R., and Misri, B. 2006. Traditional goat health management practices in Chamba district of Himachal Pradesh.*Indian Journal of Traditional Knowledge*, **5**(3): 373-375

Solanki, G.S. 2000. Grazing behaviour and foraging strategy of goats in semi-arid region in India. *Tropical ecology*, **41**(2): 155-160.

Somvanshi, R. 2006. Veterinary medicine and animal keeping in ancient India. *Asian Agri-History*, **10**(2): 133-146.

Stilwell, G. 2016. Small ruminants' welfare assessment—Dairy goat as an example. *Small Ruminant Research*, **142**: 51-54.

Stott, A.W., Milne, C.E., Goddard, P.J. and Waterhouse, A. 2005.Projected effect of alternative management strategies on profit and animal welfare in extensive sheep production systems in Great Britain.*Livestock Production Science*, **97**(2-3): 161-171.

Stubsjøen, S.M., Hektoen, L., Valle, P.S., Janczak, A.M. and Zanella, A.J. 2011.Assessment of sheep welfare using on-farm registrations and performance data. *Animal Welfare*, **20**(2): 239-251.

Sutherland, M.A. 2011. Painful husbandry procedures and methods of alleviation: A review. *Proc. New Zeal Soc. Anim. Prod*, **71**: 178-202.

Szefer, P. and Nriagu, J.O. 2007. Mineral Components in Foods, Chemical and Functional Properties of Food Components Series. Boca Raton, FL: CRC Press; Tylor and Francis Group p. 163–95.

Tadich, N., and Hernandez, M. 2000.Prevalencia de lesionespodalesenovinos de 25 explotacionesfamiliares de la provincia de Valdivia, Chile. *Archivos de medicinaveterinaria*, **32**(1): 63-74.

Thakur, A., Sharma, A., Dogra, P.K., Kumar, A. Katoch A. and Sanhyan, V. 2021. Gaddi breed of livestock guard dog: A saviour of human-wildlife conflict in nomadic pastoralism. Poster presented at Proceedings of the 54th Congress of the ISAE. Online Congress. 2-6th Aug Pp 183

Tiezzi, F., Tomassone, L., Mancin, G., Cornale, P., and Tarantola, M. 2019. The assessment of housing conditions, management, animal-based measure of dairy goats' welfare and its association with productive and reproductive traits. *Animals*, **9**(11): 893.

Tucker, R.P. 1985. The evolution of transhumant grazing in the Punjab Himalaya.*Mountain Research and Development*, **6**:17-28.

Tuncer, S.S., Sireli, H.D. and Tatar, A.M. 2016.Behavioural Patterns of Goats. In *7th Int Sci Agri Symp.,"Agrosym* (pp. 6-9).

Turner, S.P. and Dwyer, C.M. 2007. Welfare assessment in extensive animal production systems: challenges and opportunities. *Animal Welfare*, **16**(2): 189-192.

Van Soest, P.J. (1994). Nutritional ecology of the ruminant. Cornell university press.

Veit, H.P., McCarthy, F., Friedericks, J. and Cashin, M. 1993. A survey of goat and cattle diseases in the Artibonite Valley, Haiti, West Indies.*Une*, **2**: 27-38.

Venkata Reshma, C.H., Anitha, A., Jagadeeswara Rao S. and Muralidhar, M. 2021.Relationship between Body Condition Score and Postpartum Changes in Local Goats under Field Conditions.*International Journal of Current Microbiology and Applied Sciences*, **10**(01): 2639-2645.

Verbeke, W.A. and Viaene, J. 2000. Ethical challenges for livestock production: Meeting consumer concerns about meat safety and animalwelfare. *Journal of Agricultural and Environmental Ethics*, **12**(2): 141-151.

Verma, S., Verma, L. K., Gupta, V. K., Katoch, V. C., Dogra, V., Pal, B., and Sharma, M. 2011. Emerging Capripoxvirus disease outbreaks in Himachal Pradesh, a northern state of India. *Transboundary and Emerging Diseases*, **58**(1): 79-85.

Vieira, A., Brandão, S., Monteiro, A., Ajuda, I., and Stilwell, G. 2015. Development and validation of a visual body condition scoring system for dairy goats with picture-based training. *Journal of dairy science*, **98**(9): 6597-6608.

Villaquiran, M., Gipson, T.A., Merkel, R.C., Goetsch, A.L., and Sahlu, T.2005. Body condition scoring for improved management. Proc.20th Ann. Goat Field Day, Langston Iniversity, Langston, OK: 111-117.

Vohra, V., Niranjan, S.K., Mishra, A.K., Jamuna, V., Chopra, A., Sharma, N., and Jeong, D.K. 2015. Phenotypic characterization and multivariate analysis to explain body conformation in lesser known buffalo (*Bubalus bubalis*) from North India. *Asian-Australasian Journal of Animal Sciences*, **28**(3): 311.

Vosough Ahmadi, B., Dwyer, C.M., Erhard, H.W., Morgan-Davies, C., Waterhouse, A., Milne, C.E., and Stott, A.W. 2010. *Impacts of labour on interactions between economics and animal welfare in extensive sheep farms* (No. 352-2016-18055).

Voutilainen, P.and Liukkonen, A. 1995. Senior Monitor—laadun arviointimittarin sisallon validiteetin maarittaminen. (Se-.nior Monitor—determining content validity for qualityassessment instrument). *Hoitotiede* **1:**51–56.

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.V., Janczak, A.M., Visser, E.K., and Jones, R. B. 2006. Assessing the human–animal relationship in farmed species: a critical review. *Applied animal behaviour science*, **101**(3-4): 185-242.

Waiblinger, S., Mersmann, D. and Wemelsfelder, F. 2017. Results of qualitative behaviour assessment reflect social tension in dairy goats Susanne. Proceedings of the 7th International Conference on the Assessment of Animal Welfare at Farm and Group level. Pp: 203

Waller, P.J.2006.Sustainable nematode parasite control strategies for ruminant livestock by grazingmanagement and biological control', *Animal Feed Science and Technology*, **126**: 277-89.

Wang, C.R., Xiao, J.Y., Chen, A.H., Chen, J., Wang, Y., Gao, J.F. and Zhu, X.Q. 2010. Prevalence of coccidial infection in sheep and goats in northeastern China.*Veterinary Parasitology*, **174**(3-4): 213-217.

Wani, A.H., Verma, S., Sharma, M., and Wani, A. 2015. Infectious lameness among migratory sheep and goats in north-west India, with particular focus on anaerobes. *Rev Sci Tech OIE,* **34**: 855-867.

Wani, S.A. and Samanta, I. 2005.Current understanding of the aetiology and laboratory diagnosis of footrot. *The Veterinary Journal*, **171**(3): 421-428.

Waterhouse, A. 1996. Animal welfare and sustainability of production under extensive conditions—a European perspective. *Applied Animal Behaviour Science*, **49**(1): 29-40.

Welfare Quality®. 2009.Welfare Quality® assessment protocol for cattle.Welfare Quality® Consortium, Lelystad, The Netherlands

Whay, H.R., Main, D.C.J., Greent, L.E.and Webster, A.J.F. 2003. Animal-based measures for the assessment of welfare state of dairy cattle, pigs and laying hens: consensus of expert opinion. *Animal Welfare*, **12**(2): 205-217.

Winter, A. 2009. Diagnosis of white line lesions in sheep. *In practice*, **31**(1): 17-21.

Wolf, C.A. and Tonsor, G.T. 2017. Cow welfare in the US dairy industry: willingness-to-pay and willingness-to-supply. *Journal of Agricultural and Resource Economics***42**(2): 164-179.

Yeates, J. 2018. Naturalness and animal welfare.*Animals*, **8**(4): 53.

YSP, U. 2016. Package of practices for vegetable crops. *Directorate of Extension Education, Dr. YS Parmar University of Horticulture and Forestry, Nauni Solan HP*, 13-16.

Annexures

ANNEXURE

LIVESTOCK PRODUCTION MANAGEMENT DIVISION

ICAR-NDRI KARNAL

"Studies on behaviour and welfare of migratory flocks of Gaddi goats in North-Western Himalayan region"

- Survey sheet for identification of the potential indicators sent for the expert opinion
- NI: Not important, SI: Slightly important, MI: Mildly important, I: Important, VI: Very important

Welfare components	Welfare Indicators	NI	SI	MI	I	VI
Good feeding	**Absence of Prolonged hunger**					
	Body condition score					
	Rumen Fill Score					
	Grazing time (owner declaration)					
	Grazing distance from camping site					
	Time taken by kid to suckle/time taken by kid to stand					
	Tooth loss					
	Vegetation cover (Visual assessment)					
	Availability of pasture (according to owner declaration)					
	Supplementary feeding					
	% of pre weaning kid mortality in last 12 months					
	Absence of Prolonged Thirst					
	Availability of water (according to owner declaration)					
	Water availability (Visual assessment)					
	Distance to water points					
	Clean and Safe water					
	Skin tent test					
	Water temperature					
Good Environment	**Comfort around resting**					
	Coat cleanliness/ Integument cleanliness					
	Cleanliness around resting area/muddy soil or dry area/Pasture conditions (rough vegetation and wet and stony soil)					

	Space allowance or stocking density during night penning					
	Thermal Comfort					
	Assess to shade/Shelter					
	Panting					
	Shivering					
	Huddling together					
	Enclosure for Kids					
	Rest during hot hours of day					
	Ease of movement					
	Absence of hazardous objects/Terrain or risky areas					
	Migratory distance travelled in a day (Average)					
	Absence of livestock depredation and Rustling					
	Livestock depredation					
	Livestock Guard Dogs					
	Temperament of Livestock Guard Dog					
	No. of goat losses due to livestock depredation during last 12 months					
	No. of goat losses due to rustling during last 12 months					
Good health	**Absence of injuries**					
	Body and Head lesions/ Skin lesions and wounds					
	%Lameness/year					
	Lameness score					
	Absence of Disease					
	Abscess					
	Fecal soiling/Dag score					
	Fecal consistency score/ Diarrhoea score					
	Nasal Discharge					
	Occular Discharge					
	Udder condition					
	Incidence of Mastitis/year					
	Hampered respiration					
	Hair coat condition					
	Claw condition					
	Animal health check frequency					
	Knowledge of ethnoveterinary practices					
	Dipping frequency					
	Mucosa Colour/FAMACHA anaemia Chart					

	Vaccination against prevalent diseases					
	Availability of veterinary facilities					
	External parasites					
	Submandibular oedema					
	No. of veterinary treatments in last 12 months/prevalence of diseases in last 12 months					
	Stockperson awareness for onflock diseases					
	Animal Lagging behind the flock					
	Mortality in last 12 months due to infectious diseases (FMD, Enterotoxemia, Goat Pox etc.))					
	Mortality in last 12 months due to consumption of poisonous plants					
	Mortality in in last 12 months due to accidental misadventures					
	No. of abortions or stillbirth in last 12 months					
	No. of bloat cases in last 12 months					
	Pecentage of cesarean or assistant kidding					
	% of goats euthanised in last 12 months					
	Absence of pain and pain induced by management procedures					
	Castration method					
	Pain management during castration					
	Age of castration					
	Identification method used					
	Pain management during identification					
	Age of identification					
	Other Pain inflicting management practices including Ethnoveterinary practices					
	Euthanasia method					
	Preventive Health care practices					
	Vaccination					
	Deworming					
	Dipping					
Appropriate behaviour	**Expression of social behaviour**					
	Social Withdrawal					
	Behaviour synchrony					
	Vocalisation of Doe and Kids					
	Proximity of Doe and Kid					
	Agonistic behaviour					
	Expression of other behaviours					
	Incidence of Stereotypies					
	Excessive Itching					

	Oblivion					
	Maternal Behaviour					
	Grooming					
	Vigilance behaviour					
	Positive emotional State					
	Qualitative Behavioural Assessment					
	Good humananimal relationship					
	Latency to the first contact test					
	Familiar human approach test/Handling test					
	Flight distance/Avoidance distance test					
	Appropriate intervention at kidding					
	Response to Human while milking					
	Absence of general fear					
	Response to surprise test					
	Recovery from surprise test					
Good performance	**Productive performance**					
	Body weight at 12 months					
	Kid birth weight					
	Milk yield					
	Lactation period					
	Kid weaning weight					
	Reproductive performance					
	% of twin births					
	% of kidding needed assistance					
	Age at first kidding					
	Kidding interval					
	Kidding rate					
	Kidding per goat (average in lifetime)					
	No. of Bucks/per goat					
	Source of purchase of buck (raised from own flock or from other source)					
	Screening of buck while purchasing against diseases					

Scale sent for opinion to expert

- Indicators along with the description of their patterns with scores are presented as under
- A-Agree, DA- Disagree

S.No.	Welfare indicators	Total weightage	A	DA
A	**Good Feeding**	**25**		
1.	Body condition score	(10)		
	If >80 % of the goats have BCS between 2.5-3.5	10		
	If between 70-80% goats have BCS between 2.5-3.5	8		
	If between 60-69 % goats have BCS between 2.5-3.5	6		
	If between 50-59 % goats have BCS between 2.5-3.5	4		
	If between <50 % goats have BCS between 2.5-3.5	2		
2	Availability of forage at camping site (according to owner declaration)	(6)		
	Fully adequate	6		
	Average	3		
	Inadequate	0		
3	Quality of water at camping site	(4)		
	Water is clean and clear	4		
	Water is bit dirty	2		
	Water is muddy or dirty in any other way	0		
4	Distance to water points from camping site	(3)		
	Distance less than 1000 meter	3		
	Between 1000 and 2000 meter	1		
	More than 2000 meter	0		
5	Supplementary feeding	(2)		
	Yes	2		
	No	0		
B	**Good Environment/Facility around camping**	**15**		
6.	Environmental protection to kids	(3)		
	Yes	3		
	No	1		
7.	Migration distance	(3)		
	Average migration distance travelled by the farmers	3		

	with flock during camp shifting is < 10 km Average migration distance travelled by the farmers with flock during camp shifting is 10- 20 km Average migration distance travelled by the farmers with flock during camp shifting is > 20 km	2 1		
8.	Livestock Losses due to depredation, Rustling and accidental misadventures Livestock losses <5% annually Livestock losses 5-10% annually Livestock losses >10% annually	(3) 3 2 1		
9.	Integument cleanliness <80% of goats have optimal integument cleanliness (the body is clean, any dirt under the hock) 60-80% <60%	(3) 3 2 1		
10.	Cold stress score < 5 % of goats show bristling hair on the back/arched posture >5 % of goats show bristling hair on the back/arched posture	(2) 2 1		
11.	Presence of Livestock Guard Dog with flock Yes No	(1) 1 0		
C	**Good Health**	**30**		
12.	Lameness score (LS) If >90 % of the goats have LS 1-2 If 60-80 % of the goats have LS 1-2 If 40-59 % of the goats have LS 1-2 If <40% of the goats have LS 1-2	(8) 8 6 4 2		
13.	Hair coat condition If >80% of the goats have the normal hair coat condition If 60-80% of the goats have the normal hair coat condition If <60% of the goats have the normal hair coat condition	(4) 4 2 0		
14.	FAMACHA anemia chart If >90 % of the goats have scoring 1-2	(4) 4		

	If 70-89 % of the goats have scoring 1-2	2		
	If <60 % of the goats have scoring 1-2	0		
15	Dag score/Fecal score/Hindquarter cleanliness	(4)		
	If >90% of goats have score 0-2	4		
	If 70-89% of goats have score 0-2	2		
	If >60% of goats have score 0-2	0		
16.	Availability of veterinary facilities	(3)		
	Available for 9-12 months of annual migration	3		
	Available for 6-9 months of annual migration	2		
	Available for <6 months of annual migration	1		
17	Vaccination against diseases (PPR, FMD)	(2)		
	Yes	2		
	No	0		
18.	Need based Deworming of flock	(2)		
	Yes	2		
	No	0		
19.	Need based Dipping of flock	(2)		
	Yes			
	No			
20.	Pain management during management procedures (castration, identification)	(1)		
	Yes	1		
	No	0		
D	**Appropriate behaviour**	**15**		
21.	Familiar Human approach test (FHAT)/Handling test	(4)		
	Positive physical and verbal interaction/No fear	4		
	Mild negative physical interaction/mild fear/ mild fear	2		
	Strongly negative physical interaction, with or without verbal interaction/Strong fear or panic	0		
22.	Qualitative Behavioural Assessment (Demeanour)	(3)		
	If >90 % of the goats are alert and curious	3		
	If 70-90% of the goats are alert and curious	2		
	If <70% of goats are alert and curious	1		
23.	Vocalizations	(3)		
	If <3 % of goat vocalizations	3		
	If 3-5% of goat vocalizations	2		
	If <5% of goat vocalizations	1		

24.	Oblivion (goats physically or mentally isolated from group) <3 % of goats 3-5% of goats >5% of goats	(3) 3 2 1		
25.	Behavioural synchrony >80% of goats show behavioural synchrony 70-80% of goats show behavioural synchrony <70% of goats show behavioural synchrony	(2) 2 1 0		
E	**Good performance**	**15**		
26.	Average Kid birth weight >2 kg 1-2 kg <1 kg	(3) 3 2 1		
27.	Kid survival until weaning (in last 12 months) If >80 % survivability rate If 60-80 % survivability rate If <60 % survivability rate	(2) 2 1 0		
28.	Average Body weight at 9 months ± 10 days of age >20 kg 15-20 kg <15 kg	(2) 2 1 0		
29.	Kidding percentage (in last 12 months) >80% 60-80% <60%	(2) 2 1 0		
30.	Abortions/Still birth (last 12 months) <5% 5-10% >10%	(2) 2 1 0		
31.	Milk Yield (ml per milking at 21 ± 5 days) >500 250-500 250	(2) 2 1 0		
32.	Twinning percentage (in last 12 months) >20% 10-20% <10%	(2) 2 1 0		
	Total Welfare Score	**100**		

INTERVIEW SCHEDULE

Serial No._____

1. General Information

Name of the flock owner: _____

Gender: _____

Age: _____

Education: _____

Location: _____

No of men/100 goats: _____

Experience: _____

2. Livestock inventory

Types of animals	Number
Goat	
kids	
Total flock size	
Dog	

Category of flock: Small/Medium/Large

Body condition score (5 point scale)

Number of goats evaluated/scored …….....

Number of lactating goats having BCS between 2.5-3.5 ……..

% of lactating goats having BCS between 2.5-3.5 …….

Calculations-

Integument Cleanliness

Category: Optimum/Medium/Poor

Number of goats evaluated/scored …….....

Number of lactating goats having optimum cleanliness ……..

% of lactating goats having optimum cleanliness …….

Lameness scoring (5 Point scale)

Category: 1-Normal Gait, 2-Uneven Gait, 3-Mildly lame, 4-Moderately lame, 5- Severely lame

Calculation

Number of goats evaluated/scored …….....

Number of lactating goats having lameness score of 1-2 ……..

% of lactating goats having lameness score of 1-2 …….

Hair quality

Category: Normal/Poor

Calculation

Number of goats evaluated/scored …….....

Number of lactating goats having normal coat condition ……..

% of lactating goats having normal coat condition …….

FAMACHA© anemia scoring (5 point scale)

Category: 1-Red, 2-Red Pink, 3-Pink, 4-Pink-White, 5-White

Number of goats evaluated/scored …….....

Number of lactating goats having FAMACHA© score of 1-2 ……..

% of lactating goats having FAMACHA© score of 1-2 …….

Dag scoring

Category: 0-None, 1-very slight, 2-slight, 3-moderate, 4-severe and 5-very severed soiling

Number of goats evaluated/scored …….....

Number of lactating goats having Dag score of 0-2 ……..

% of lactating goats having Dag score of 0-2 …….