Research Article

Application of the Famacha© System for the Evaluation of Haemonchosis in Small Ruminants Reared in a Communal System of the Molemole Municipality, Limpopo Province, South Africa

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Abstract | The present study was conducted to determine the occurrence of clinical haemonchosis and methods of controlling *Haemonchus contortus* and other internal parasites in a communal farming system of Limpopo province, South Africa. Twenty-six sheep and one-hundred and sixty-three goats were evaluated for clinical haemonchosis using the FAMACHA© diagnostic system. Information on the methods of control used by the smallholder farmers was gathered through a questionnaire-based survey that was carried out by interviewing forty-seven Small ruminants farmers (both males and females) of mixed ages. The average FAMACHA© score for the goats was three while for sheep the average score was 2.62. Ninety-eight goats (60%) had a FAMACHA© score of three and above while fourteen sheep (52.4%) had a FAMACHA© score of three and above. There was a high occurrence of haemonchosis in goats compared to sheep ($p<0.05$). Differences in occurrence between age groups, sex and physiological status were found to not be statistically significant in both small ruminants ($p>0.05$). The methods of internal parasite control used by the smallholder farmers in the study area were commercial anthelmintic drugs (38.3%), ethno-veterinary based methods (12%) while 46.8% did not control gastrointestinal parasites. It can be concluded that clinical haemonchosis presents a potential challenge in the study area due to a low adoption rate of internal parasite control measures among the farmers interviewed.

Keywords | Anthelmintic, Ethno-veterinary, Gastrointestinal parasites, *Haemonchus contortus*, Respondents

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INTRODUCTION

Small ruminants contribute to improved livelihoods of the rural based populations worldwide through alleviation of poverty and enhanced economic opportunities. Approximately more than 150 million poor people in sub-Saharan Africa survive on livestock based products (Berihulay et al., 2019). Small ruminants are relatively easy to produce because they can easily adapt and are geographically widespread animals hence, they can flourish (Brito et al., 2015).

They can withstand periods of drought better than any other livestock species which makes them versatile domesticates that can integrated into diverse environments and production systems (Kim et al., 2016). Small ruminants rearing requires low feed input and labour requirements making them a desirable choice for millions of smallholder farmers globally (Faraz and Waheed, 2018). According to FAOSTAT (2016), Asia has the highest percentage of

the global sheep population (46.9%), followed by Africa (24.5%), Europe (11.5%), Oceania (9.4%) and America (7.6%). The majority of the small ruminants production takes place under subsistence farming. In South Africa, livestock contributes approximately forty-seven percent of South Africa's agricultural gross domestic product (Meissner et al., 2013). However, small ruminants are highly susceptible to gastrointestinal parasites (Jackson and Coop, 2000; Hoste et al., 2010; Mavrot et al., 2015; Ruano et al., 2017). Furthermore, smallholder farmers' knowledge on these gastrointestinal parasites is limited (Rinaldi et al., 2015) making them to be among the major causes of production loss in small ruminants. Parasites affect small ruminants of any sex, age, however, lambs, and females in the peripartum period are mostly affected (Morgan, 2013). Tropical and subtropical regions experience high mortalities of livestock due to the effects of gastrointestinal nematodes. The gastrointestinal tracts of ruminants are hosts to a wide variety of parasites including helminthes and coccidia, which can cause clinical or subclinical parasitism (Kumar et al., 2008). Gastrointestinal parasites affect the health and productivity of small ruminants (Katoch et al., 2000; Singh et al., 2015). Some parasite species have developed resistance against common measures of control and the efficacy of some anthelmintic drugs has reduced over the years (Clark et al., 1996). In order to understand the severity of gastrointestinal parasites, several studies investigated the intensity of infection in relationship to species, age, sex, season and the state of animal (Islam et al., 2017; Rahman et al., 2017; Ruma et al., 2017; Squire et al., 2019).

The most economically important parasitic infections of livestock in tropical climates include haemonchosis and fasciolosis (Fox et al., 2012). Haemonchosis can lead to protein deficiency, anaemia, bottle jaw and mortalities in case of heavy infestations (Williams, 2010). The warm, humid and temperate climate of most parts of South Africa are favourable for *Haemonchus contortus* to prevail. Moreover, most of the small ruminants in smallholder farms depend on grazing which makes them more susceptible to infection (Mpofu et al., 2013). As such, *Haemonchus contortus* cannot be completely eradicated, however, the economic losses resulting from clinical infections can be controlled. Anthelmintic drugs are the most commonly used method of controlling gastrointestinal parasites because the drugs are simple to administer and cost effective. However, the challenge of anthelmintic resistance is increasing on the commonly used drugs. As a result, studies investigating the potential for alternative methods of controlling *Haemonchus contortus* using natural anthelmintics have increased over years (Bowie, 2014). However, fewer studies have reported remedies for the control of internal parasites in small ruminants among smallholder farmers in the rural communal livestock farming systems of South Africa as well as the levels of occurrence of haemonchosis in such production set-ups. Hence, the objectives of the current study were: (1) to evaluate the level of clinical haemonchosis in smallholder small ruminant farms using the FAMACHA scoring system and (2) to identify the methods utilized by the respondents from the study area to control gastrointestinal parasites. This information will serve, as a guidance to the small ruminant farmers and the agricultural extension workers in the study area regarding the allocation of resources for livestock health care since livestock farming is central to the sustainability of rural communities around the world (Morgan et al., 2013).

MATERIALS AND METHODS

The study was conducted in the Molemole municipality, Capricorn district, Limpopo Province in South Africa. Molemole municipality lies at an altitude of -23°27'45", longitude of 29°48'58". Molemole municipality has a semi-arid climate. Average temperatures reach around 21-22°C in January and fall to 11°C in July. The area has a dry climate with a summer rainy season and a pronounced dry spell during winter. Small ruminants are raised extensively. The indigenous breeds such as the Pedi, Venda and Shangaan are commonly reared in the study area since they are adapted to the local harsh conditions. Food insecurity is a serious challenge in the study area with the majority of the inhabitants falling under the poor social ranks. Therefore, livestock farming particularly small ruminants play an important socio-economic role in the study area. Ethical clearances for the study were obtained from the University of Limpopo's Animal Research Ethics Committee (AREC) (AREC/13/2020: PG) and the Turfloop Research Ethics Committee (TREC) (TREC/146/2020: PG).

Smallholder small ruminant farmers from the study area were selected using snowball-sampling method. The study had no predetermined sample size. The flock sizes as determined during the study period ranges from a minimum of two animals to a maximum of ten animals per farmer. The sampling process yielded forty-seven respondents with an inclusion ownership of 189 animals comprising of 26 sheep and 163 goats. A semi-structured questionnaire that was developed by the research team was distributed to the respondents during the summer months (August-November) of the year 2020 (Supplementary Figure 1). The researchers obtained consent from the farmers to conduct the interviews as well as to handle the animals after issues regarding the privacy of the farmers as well as the welfare of the animals were addressed. Face to face, interviews were conducted with the forty-seven respondents (25 females and 22 males). The interviews were conducted in the local vernacular language (Sepedi). The questionnaire was designed to capture information on the demographic profile of the respondents as well as control measures of

gastrointestinal parasites particularly *Haemonchus contortus* in small ruminants. Particular attention was also paid to the respondents' knowledge of internal parasite transmission as well as knowledge and adoption of ethno-veterinary practices for internal parasite control. For the respondents that mentioned the use of commercial anthelmintic drugs, particular attention was paid to their knowledge on the correct use of these remedies.

The FAMACHA© eye scoring diagnostic chart (Supplementary Table 1) was used to determine the occurrence of clinical haemonchosis in the animals. The study animals were restrained using a method described by Gouveia et al. (2013) so as to reduces stress and ensure that no injuries could occur during the scoring procedures. The animals were categorized according to species, age, sex and physiological status (Supplementary Table 1). For animals that had no records, age estimates were carried out by using the dental ageing method as described by Garriga (2019). To increase precision, one individual performed FAMACHA scoring for all the animals. The lower eye mucous membranes of the animal were exposed and matched to the FAMACHA chart and scored on a scale of one to five with one, two representing light infections, three moderate infections while four, and five represented severe infections.

Collected data was analysed using Statistical Package for Social Sciences (IBM SPSS, 2019) version 26. Analysis of variance (ANOVA) tests were carried out to find differences in occurrence of haemonchosis across the species, age, sexes and physiological status. Mean comparison was done using Fisher's LSD. Means with p values ≤0.05 were considered different.

RESULTS AND DISCUSSION

The present study interviewed forty-seven smallholder farmers. Majority of the respondents were females (53.2%). The dominant age group was 51 years and above (44.7%). Table 1 summarizes the demographic distribution of the respondents. The results showed that majority of the respondents only had basic education (57.5%). Goats were the mostly reared animals (86.2 %); however, the average flock sizes in the study area were generally very low. The present study identified methods of controlling gastrointestinal parasites used by the respondents, 46.8% did not use any method of control, whilst the commonly used method of control was commercial anthelmintic drugs (36.1%). The study revealed key information on the preparation, administration and dosage instructions that are followed for the use of ethno-veterinary based practices in controlling internal parasites. The source of knowledge of the ethno-veterinary based methods were from relatives and family members of the respondents. Of the respondents that indicated the use of ethno-veterinary based methods to control internal parasites, the majority of them (83.0 %) mentioned the use of the plant species *Aloe ferox*. Thirty-five percent of the respondents mentioned *Sorghum bicolor* mixed with water as a potent anthelmintic. This preparation is popularly known as Moroko in the local Sepedi language. However, in both instances, respondents did not quantify their preparations with the remedy being provided to the animal *ad libitum* until perceived recovery. When asked about their approach to diagnosing internal parasite infections, all the respondents said that they relied on clinical signs such as loss of weight and diarrhoea and did not engage the local animal health experts. Thirty-six percent of the respondents indicated that they used commercial anthelmintic drugs for controlling internal parasites. The most commonly used trade name was Valbazen© (albendazole), (17.6%) followed by Prodose orange© (albendzazole and closantel) (11.8%). The other popular trade names among the respondents were Virbantel©, Eradiworm© and Nilverm©. However, a significant proportion (52.9%) of the respondents who were using commercial anthelmintic drugs could not remember the names of the drugs that they had used before. Majority of the respondents who were using commercial anthelmintic drugs had acquired the knowledge from other farmers or during farmers' workshops.

Table 1: Demographic profile of the respondents and livestock statistics

Category	Number of respondents	Proportion %
Age		
<18	2	4.3
19-35	8	21.3
35-50	11	29.7
Above 51 years	26	44.7
Education level		
Basic education	27	57.5
Post matric	12	25.5
No formal education	7	14.9
Adult basic education and training	1	2.1
Gender		
Male	22	46.8
Female	25	53.2
Livestock reared		
Goats	31	66.0
Sheep	7	14.9
Both	9	19.1
Livestock numbers		
<10	27	57.4
11-21	10	21.3
22-40	7	14.9
40>	3	6.4

Table 2 represents the occurrence of haemonchosis in

small ruminants and the difference in occurrence between the two species. The mean FAMACHA© scores were 3 for goats and 2.62 for sheep and the difference in occurrence between the two species was found to be significantly significant ($p<0.05$). Table 3 represents the differences in occurrence of haemonchosis in sheep across different ages, sexes and the physiological statuses of the animals. There were no differences across different sexes of sheep. There was also no effect from the physiological statuses of the animals with regard to the occurrence of *Haemonchus contortus*. However, there were notable differences in the mean FAMACHA© scores of pregnant and lactating animals. There were no differences in the occurrence of haemonchosis across different ages. Table 4 represents the difference in occurrence across age, sex and physiological state of the animal in goats owned by the respondents. There goats that were evaluated in this study had no significant differences in occurrence of haemonchosis with regard to the age categories used in the study. There were also no differences across the different physiological statuses of the female goats.

Table 2: The levels of occurrence of haemonchosis in sheep and goats owned by the respondents.

Species	Frequencies	FAMACHA mean scores	p
Goats	163	3	0.01
Sheep	26	2.62	

*Means in the same row without common letter are different at $p<0.05$

Table 3: Occurrence of haemonchosis across different age groups, sexes and physiological statuses of sheep owned by the respondents.

Age	FAMACHA© mean Scores	p
Young (< 6 months)	2.75	
Pubertal stage (6 to 12 months)	2.71	0.68
Mature (> 12 months)	2.20	
Female physiological status		
Lactating	3.33	
Pregnant	3.11	0.14
Non-lactating, non-pregnant	2.0	
Sex		
Male	2.82	0.21
Female	2.22	

*Means in the same row without common letter are different at $p<0.05$

Majority of the respondents in the study area did not use any method of controlling internal parasites. A smaller proportion of the respondents who controlled internal parasites used ethno-veterinary based methods as compared to those that used commercial based methods. The findings of the present study are in agreement with those from a study by Mudzengi (2014) who reported a low adoption rate of ethno-veterinary medicine based practices to control gastrointestinal parasites in small ruminant communal farming systems. The authors cited lack of documentation of ethno-veterinary medicine based practices as well as lack of knowledge among communal farmers as some of the possible reasons for the low adoption rate. The present study also reported low knowledge levels among the respondents on ethno-veterinary medicine based practices for internal parasite control in Small ruminants. Knowledgeable on ethno-veterinary medicine based practices was mostly transmitted among family members. Van Niekerk et al. (2015) and Ramos (2018) also reported the same observations. Treagear and Cooper et al. (2016) showed how social interactions could be a useful tool between farmers for learning and knowledge transmission purposes.

Table 4: Occurrence of haemonchosis across different age groups, female physiological statuses and sexes in goats owned by the respondents.

Age	FAMACHA© mean scores	p
Young	3.40	
Pubertal stage	3.16	0.45
Mature	3.15	
Female physiological status		
Lactating	3.31	
Pregnant	2.82	0.46
Non-lactating, non-pregnant	3.43	
Sex		
Male	3.10	0.39
Female	3.26	

*Means in the same row without common letter are different at $p<0.05$

The present study revealed the use of *Aloe ferox* to treat gastrointestinal parasites. The Aloe family has been reported in many studies to have medicinal properties against livestock diseases that are commonly reported in South Africa (Smith et al., 2008; Maphosa and Masika, 2010) and in India as well (Jabalpur et al., 2017). Aloe *ferox* is mostly used in the Eastern Cape Province of South Africa as an anthelmintic (Maphosa et al., 2010b). Similarly, it was reported to be used against gastrointestinal parasites in a study by Masika and Afolayan (2003a). Adoption of these medicinal plants requires that the efficacy and dosage recommendations should be well documented in literature. Several studies reported that *Aloe ferox* has pharmaceutical active properties that work against gastrointestinal parasites particularly Haemonchosis (Masika and Afolayan, 2003a). *Aloe ferox* has been reported to have glycosides as its active

ingredients whose activities are beneficial to the intestines (Enna et al., 2008; Moshi and Mhane, 2013; Dzoyem et al., 2014). Toxicity is often a challenge in situations where ethno-veterinary medicine is commonly practiced. In this study, the respondents dosed the ethno-veterinary medicines *ad libitum*. Masika et al. (2003) reported that *Aloe ferox* in excessive amounts can have laxative effects. *Sorghum bicolor* was reported in the present study to be used against gastrointestinal parasites. Similarly, Okoye et al. (2014) and Pontieri and Del (2016) reported the use *Sorghum bicolor* against internal parasites of livestock and attributed its anthelmintic properties to its possession of tannins. This shows that the usage of medicinal plants seems to be one of the widely reported remedies against parasitism as such should be adopted by smallholder farmers.

The frequently mentioned commercial anthelmintic drugs were; albendazole, ivermectin and closantel based formulations. The farmers reported a good efficacy of the remedies which they assessed by observing the clinical signs indicative of internal parasite infestation. However, considering the high occurrence of anthelmintic resistance as reported worldwide, there is a need to conduct efficacy tests in the study area. Delannoy-Normand et al. (2010) and Tsotetsi et al. (2013) conducted a study were ivermectin and albendazole based formulations were predominantly used and revealed that anthelmintic resistance was detected in all the screened farms particularly to *Haemonchus* spp. The use of a combination of different active agents was reported in the present study. A combination of closantel and albendazole is recommended for arresting anthelmintic resistance of gastrointestinal nematodes. Sixty-six percent of the farmers did not quantify the remedy when administering. This facilitates the development of anthelmintic resistance. Shalaby (2013) reported that when quantification routes are not strictly followed through either under dosing or over dosing, anthelmintic resistance develops. From the study, it is evident that only a small fraction of the respondents had basic knowledge about gastrointestinal parasites and their control measures. The cause of this might be the predominantly low levels of education in the area with very few farmers having post matric education. This concurs with Odoi et al. (2007) who mentioned that farmer education was a significant predictor of the level of parasite infestation in the farm. The high number of farmers who did not know the methods of controlling gastrointestinal parasites reported in the present study could be a result of low levels of education amongst the respondents. These findings are in agreement with Piennar and Traub (2015) where the authors explained that there is a positive correlation with low levels of education and poor livestock management. Ugochukwu and Chinyelu (2020) reported that the lack of knowledge amongst poorly resourced smallholder farmers is due to lack of accessibility and high cost of veterinary services. Although in this study, only 19% of the respondents who were controlling internal parasites mentioned high drug costs as a challenge.

The FAMACHA© average scores in the current study indicated that goats are more susceptible to *Haemonchus contortus* infection than sheep. The study showed that there was a significant difference in the occurrence of haemonchosis in small ruminants. The FAMACHA© average scores reported in the present study show an overall occurrence of 52.4% for sheep and 60% for goats. These findings are contradictory to those of Qayyum et al. (2007). The authors reported that clinical infection was higher in sheep than in goats. However, the variation between the two studies could be because of the fact that a higher number of respondents owned goats when compared to sheep. Mushonga et al. (2018a) stated that sheep were more susceptible to haemonchosis as opposed to goats, and attributed this to differences in grazing behaviour between the two species. The findings of this study are consistent with those of Mengist et al. (2014) who reported a higher occurrence of *Haemonchus* spp. in goats as opposed to sheep. The authors attributed these to management systems, anthelmintic administration, stocking densities, eco-climatic and high rainfall in the study area. These conditions harbour the optimum conditions for nematode development. Improper anthelmintic administration ensures the survival of *Haemonchus* spp. larvae and anthelmintic resistance. Stocking densities of the Small ruminants favour the inter-transmission of the parasite within the flock. The present study is in agreement with that of Hossain et al. (2015a) who showed the occurrence of *H. contortus* to be higher in goats than in sheep. Factors that contribute to the variety of the occurrence includes animal factors such as (grazing behaviour, sex, breeding status and host age) and farmers' factors (level of education and economic capacity of the farmer) (Hossain et al., 2015).

In the present study, differences in occurrence of haemonchosis across age categories (young age, pubertal stage and mature age) were found to not be statistically significant. The present study is in agreement with findings by Mushonga et al. (2018) who found the differences in occurrence between young and old animals to not be statistically different. Win et al. (2020) had similar findings and concluded that helminth infections affects all animals equally regardless of age. The present findings could be a result of breed adaptability and a lower number of young animals that formed the study sample. However, there was a notable difference in the FAMACHA© scores of mature animals and the other age groups with mature animals displaying lower scores as opposed to young animals. This variation in the average scores was reported by Poddar et al. (2017) who documented that young animals are generally considered to be more susceptible to gastrointestinal parasites than mature animals. This could be because

young animals have low innate immunity and adapt less to pasture contamination when compared with mature animals (Sohail et al., 2017).

In the present study, female physiological statuses had no effect on the occurrence level of haemonchosis. However, notable differences were observed in the FAMACHA© mean scores between pregnant and lactating animals with the animals that were not pregnant or in their lactating stage. Thomas and Ali (1983) observed that ewes that are lactating or pregnant are more susceptible to internal parasitism. Saddiq et al. (2011) explained that during parturition, females are usually susceptible to worm burdens because of the relaxation of immunity. The findings in this study are contradictory to several studies (Tariq et al., 2010; Lone et al., 2012; Ayaz et al., 2013; Zvinorova et al., 2016) which reported that pregnant and lactating animals are more susceptible to worm burdens. The different findings between the present study and the other studies cited here could be because of breed adaptability, hormonal differences and different management factors such as anthelmintic use. For males, no physiological variations were expected since all males were not castrated. No significant differences were found between males and females in both small ruminants. This could be as a result of grazing practices in the study area where animals usually graze together thus having equal opportunities of helminthic infection. These findings are similar to those of Adua and Hassan (2016) and Bhangale et al. (2018) who reported that sex had no effect on infection with *H. contortus*. Barger (1993) argued that males are more susceptible to gastrointestinal parasites because of their hormonal influences. However, Rivera et al. (1983) documented that resistance to anthelmintic drugs is more popular in females than in males. The authors argued that sex steroids could increase susceptibility to *Haemonchus contortus* infections.

CONCLUSIONS AND RECOMMENDATIONS

Majority of the respondents lacked basic knowledge about gastrointestinal parasites. It can be concluded that small ruminants smallholder farmers in the study area are at a higher risk of economic loss resulting from gastrointestinal parasite infections. However, there is a potential for improved adoption of ethno-veterinary based methods of internal parasite control due to the presence of plants such as *Aloe ferox* in natural habitats in the study area. *Aloe ferox* has been reported in many studies as having the pharmaceutical properties that are necessary to combat gastrointestinal parasites. Most of the respondents that had knowledge about the gastrointestinal parasites used commercial anthelmintic drugs. The general lack of knowledge among the respondents calls for a need to engage smallholder farmers in knowledge exchange platforms. FAMACHA© evaluation chart is a very important tool that can indicate haemonchosis on a very precise level. The farmers in the study area should consider adopting the tool in order to manage haemonchosis in small stock.

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NOVELTY STATEMENT

The study explored the applicability of FAMACHA as a disease diagnostic tool in a communal livestock set up.

AUTHOR'S CONTRIBUTION

MIS, TLT and TC conceptualization, visualization, funding acquisition, methodology, writing-review, and editing. MIS and TC data collection and writing-original draft preparation. MIS, TLT and TC methodology investigation, formal analysis, visualization, writing-review, and editing. MIS, TLT and TC writing-review, and editing, formal analysis, validation, resource.

Data availability statement

The data that supports the findings of this study is available upon request.

Conflict of interest

The authors have declared no conflict of interest.

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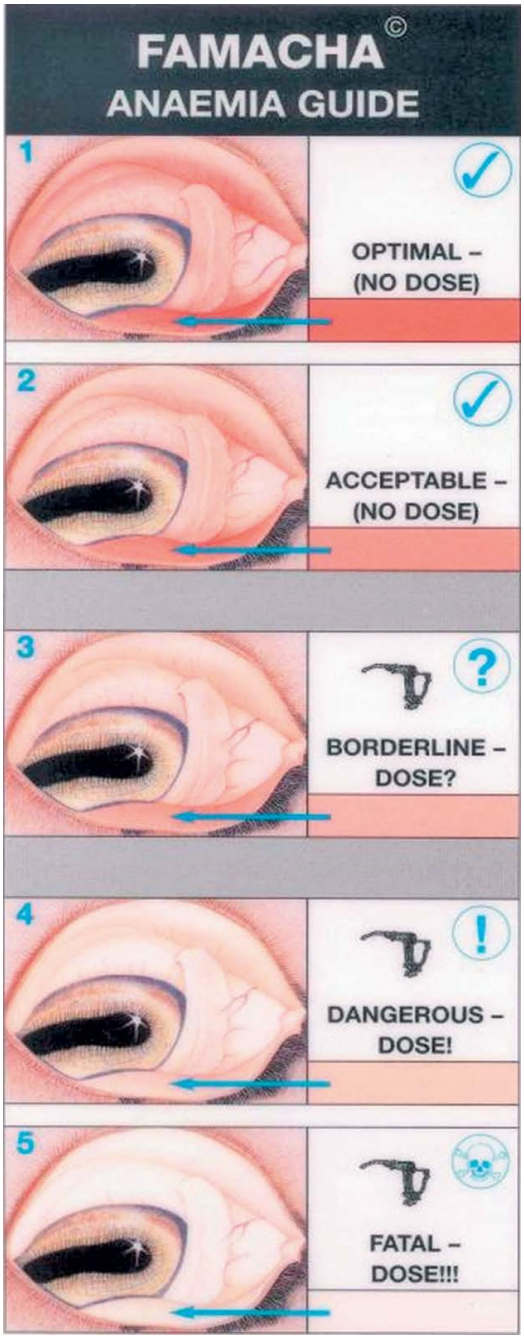
Supplementary Table 1

ID number	Species		Age			Sex		Physiological State of the animal			FAMA-CHA©	Body condition score
	Goat	Sheep	Young	Puberty	Mature	Female	Male	Lactating	Pregnant	Normal		



Supplementary Figure 1: FAMACHA© scoring sheet (Appendix D).