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Effect of different varieties of vetch hay supplementation on performance of sheep fed a basal diet of fodder oat hay

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Abstract

An experiment was conducted to evaluate the effect of different varieties of vetch hay supplementation on feed intake and weight gain of sheep fed a basal diet of fodder oat hay. Thirty-five yearling intact male sheep with initial body weight of 21.4±0.6 Kg (Mean± SD) were assigned to one of the five treatments in a randomized complete block design. The dietary treatments were *ad libitum* fodder oat hay alone (T1) and *ad libitum* fodder oat hay supplemented with 350g hay of Gebisa, Lalisa, Abdeta and *Vicia sativa* vetch varieties for T2, T3, T4 and T5 respectively. The feeding trial lasted for 90 days and weight of the sheep was taken every 10 days. Total dry matter intake of T2 (1133.1 g/day) was significantly higher ($P<0.05$) than T1, T3 and T4. Sheep supplemented with T2 diets had the highest ($P<0.001$) crude protein intake (154.5 g/day) and average daily body weight gain (152.5 g/day). In conclusion, supplementation of Gebisa vetch variety (T2) induced highest performance of sheep than all other treatments. Therefore, effort should be made to introduce and scale up the production of this variety in the farming system.

Keywords: Arsi-Bale sheep; Body weight gain ; Feed intake; Vetch Variety

1. Introduction

Livestock production plays important role in the global economy in general and smallholder farmers in particular. Sheep are among the major economically important components of the livestock subsector. Despite their numeric and economic importance as well as the tremendous potential, the livestock sub sector has remained under utilized due to a multitude of constraints (Azage *et al.*, 2010). Among livestock production constraints, shortage of feed resources in quantity and quality and poor feeding systems were repeatedly reported as a major constraints hampering livestock production and productivity (Dawit *et al.*, 2012; Zewde and Elias, 2015; Endale *et al.*, 2016). One of the alternatives to improve livestock feeding, and thereby their productivity could be the cultivation of improved forage crops and offer to animals during critical periods in their production cycle and when other sources of feeds are in short supply (Alemayehu,

2002). Forage species such as vetch and fodder oat are high potential feed sources to fill the gap of feed shortage.

Three vetch varieties; Gebisa, Lalisa and Abdeta (Dawit *et al.*, 2011) were released from Sinana Agricultural Research Center for their superiority in terms of yield or biomass production, disease resistance, wider adaptation and quality based on chemical analysis only without evaluating the feeding value to obtain intake and performance of animals. However, chemical analysis alone will be of limited value in predicting the nutritive value of feed resources, which may contain antimicrobial compounds that inhibit intake and digestibility or material toxic to the animal itself (El Hassan *et al*., 2000). Therefore, the objective of this study was to investigate the effect of varietal differences of vetch hay on feed intake and body weight change of Sheep.

2. Materials and Methods

2.1. Description of the experimental area

The experiment was conducted at Sinana Agricultural Research Center (SARC), which is located in Bale zone of Oromia National Regional State, south eastern Ethiopia. The research center is situated 463 km south east of Addis Ababa (capital city of Ethiopia) at 07^0 07' N latitude and 40^0 10' E longitude and at an altitude of 2400 m above sea level. The area is characterized by bimodal rainfall pattern with total annual precipitation ranging from 750 to 1000 mm and the mean annual maximum and minimum temperature are 21^0C and 9^0C, respectively (SARC, 2014).

2.2. Experimental feeds preparation

The experimental feeds, all varieties of vetch and fodder oat were sown according to their respective agronomic practices during the main rainy season of the area (August-December) on a plot size of 1200m^2 for each vetch variety and 7500m^2 for oat. The vetch varieties were harvested at 50% flowering, while fodder oat was harvested at heading stage during which they give optimum performance in terms of dry matter yield and nutritive value (SARC, 2015). The harvested fresh forages were field-cured and stored as hay under a roofed shelter to protect from rain and intense sun light. During the feeding period, the oat and vetch hays were chopped to about 3-5 cm in length to make uniform for sampling and easier to be seized by the animals.

2.3. Experimental animals and their management

Thirty-five yearling intact male Arsi-Bale sheep with similar body weight were purchased from the nearby markets. The age of the sheep was estimated based on dentition and asking information from the owners of the sheep. The sheep were held in quarantine for 21 days and observed for any health problem. During this time, the sheep were vaccinated against ovine pasteruolosis, anthrax and sheep pox and dewormed against internal and external parasites. The animals were placed in individual pens equipped with a bucket and a feeding trough in a well-ventilated concrete floor experimental barn.

2.4. Experimental design and treatments

Randomized complete block was used for the study. To minimize the error due to differences in initial body weight, the experimental sheep were blocked into seven blocks of five animals each based on their initial body weight. Sheep within a block were assigned randomly to one of the five dietary treatments indicated in table 1. The basal diet (fodder oat hay) was offered *ad libitum* to all experimental animals based on previous few days' intake at about 15% refusal while the supplementary feeds were offered in two equal meals at 8:00 AM and 4:00 PM in separate feeding troughs. Drinking water and common salt block were freely available to all experimental sheep throughout the experimental period.

Table 1.Dietary treatments

Treatments	Fodder oat hay	Vetch hay supplements (DM g/day)			
		Gebisa	Lalisa	Abdeta	*Vicia sativa*
T1	*Ad libitum*	0	0	0	0
T2	*Ad libitum*	350	0	0	0
T3	*Ad libitum*	0	350	0	0
T4	*Ad libitum*	0	0	350	0
T5	*Ad libitum*	0	0	0	350

2.5. Feeding trial

After an acclimatization period of 15 days to the experimental diets and pens, the feeding trial was conducted for 90 days. The daily feed offered and refusals were weighed and recorded for each sheep. Daily dry matter and nutrient intake were calculated as the difference between the feed offered and refused. Samples of feed offered were collected per batch while samples of refusal were taken from each sheep daily and pooled per animal individually over the experimental period and stored in plastic bags. Sub-samples of feed offered and refusals were taken after thorough mixing for determination of nutrient composition, and the sub-samples taken were dried at 60^{o}C for 72 hours in a forced draft oven to make it ready for grinding and chemical analysis.

2.6. Body weight change and feed conversion efficiency

Body weight of the animals was taken at the beginning of the feeding trial and at 10 days interval during the 90 days of feeding. All animals were weighed in the morning hours before feed provision using weighing balance with a sensitivity of 100 grams. Average daily body weight gain was calculated as the difference between final live weight and initial live weight divided by the number of feeding days. Feed conversion efficiency was determined by dividing the daily average body weight gain (ADG) by daily total DM intake of the animal.

2.7. Laboratory Analysis

Samples of feed offered and refusals were ground to pass through a 1 mm sieve mesh. Analysis for DM, ash and N contents was done according to AOAC (2005) procedures. Total nitrogen (N) content was determined by using Kjeldahl method and crude protein (CP) was calculated as N×6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by using the procedures of Van Soest and Robertson (1985).

2.8. Statistical Analysis

The statistical model used for data analysis was:

$$\mathbf{Y_{ij} = \mu + T_i + B_j + E_{ij}},$$

where: Y_{ij} = Response variable; μ = Overall mean; T_i = Treatment effect; B_j = Block effect; E_{ij} = Random error

Data on feed intake and body weight change were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS, 2004) version 9.1. When significant, Least Significance Difference (LSD) test was employed to locate differences between the treatment means.

3. Results

3.1. Chemical composition of experimental feeds and refused feed

Gebisa vetch variety had highest CP content and lowest NDF, ADF, hemicellulose and cellulose contents compared to other vetch varieties, while Lalisa had highest NDF, ADF and ADL. This variation in chemical composition might have impact on feed intake and weight gain.

Table 2. Chemical composition of experimental feeds and refused feed

Feed offered	DM%	Ash	OM	CP	NDF	ADF	ADL	HC	Cell
					%DM				
Fodder oat hay	87.2	10.6	89.4	8.9	53.7	30.0	2.7	23.7	27.3
Vetch hay supplements									
Gebisa	87.5	15.0	85.0	21.1	36.5	27.1	5.0	9.4	22.1
Lalisa	87.1	15.7	84.3	19.5	48.3	36.9	7.7	11.3	29.2
Abdeta	86.6	11.9	88.1	18.0	39.6	28.8	4.6	10.8	24.1
V. sativa	87.7	17.9	82.1	18.4	42.1	32.0	6.4	10.1	25.7
Fodder oat hay refusal									
T1	84.7	9.9	90.1	7.3	59.0	33.4	2.9	25.6	30.5
T2	84.3	9.9	90.1	7.5	56.5	32.9	2.5	23.6	30.4
T3	84.2	10.1	89.9	7.5	57.4	33.4	2.9	24.0	30.5
T4	83.4	10.4	89.6	7.4	58.6	32.7	2.8	25.9	29.9
T5	84.9	9.9	90.1	7.5	56.5	32.6	3.3	23.9	29.3

ADF=Acid Detergent Fiber; ADL=Acid Detergent Lignin; Cell=Cellulose; CP=Crude Protein; DM=Dry Matter; HC=Hemicelluloses; NDF=Neutral Detergent Fiber; OM=Organic Matter.

The CP content of fodder oat hay refusal in this study was lower by 15.7% for T2, T3 and T5 and by 18 and 16.9% for T1 and T4, respectively, as compared to the CP content of the offered fodder oat hay. Fodder oat hay refusals in all treatments had comparatively higher contents of NDF, ADF and cellulose than the basal fodder oat hay offered.

3.2. Dry Matter and Nutrients Intake

All sheep readily consumed the dietary supplement without any refusal across the experiment. The sheep in T1 consumed highest ($p<0.001$) amount of fodder oat hay. Sheep in T2 had higher ($P<0.05$) total DM intake than sheep in T1, T3 and T4. Regarding the effect of supplementation on total DM intake, supplementation of vetch varieties increased the total DM intake by 16.1, 6.4, 7.4 and 12.2% for T2, T3, T4 and T5, respectively as compared to T1.

Table 3. Average daily dry matter and nutrients intake of sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

Intake	Treatments					SEM	SL
	T1	T2	T3	T4	T5		
Oat hay DM (g/day)	951.0^{a}	783.1^{b}	665.9^{c}	677.1^{c}	732.8^{bc}	22.19	***
Supplement DM (g/day)	-	350	350	350	350	-	-
Total DM (g/day)	951.0^{c}	1133.1^{a}	1015.9^{bc}	1027.1^{bc}	1082.8^{ab}	17.04	*
DM (%BW)	3.2	3.2	3.2	3.2	3.3	0.03	ns
DM (g/Kg W$^{0.75}$)	75.0	78.6	76.1	76.0	78.4	0.85	ns
OM (g/day)	843.5^{b}	992.1^{a}	887.0^{b}	912.3^{ab}	937.3^{ab}	14.59	*
CP (g/day)	99.9^{c}	154.5^{a}	136.8^{b}	133.4^{b}	139.9^{b}	3.38	***
NDF (g/day)	460.3^{c}	526.4^{ab}	502.0^{abc}	469.0^{bc}	520.3^{ab}	8.07	*
ADF (g/day)	253.0^{b}	307.1^{a}	306.3^{a}	285.6^{a}	312.8^{a}	5.21	***
ADL (g/day)	23.8^{e}	40.2^{b}	43.6^{a}	33.7^{c}	29.4^{d}	1.27	***
HC (g/day)	207.3^{ab}	219.3^{a}	195.4^{ab}	183.4^{b}	207.6^{ab}	3.71	*
Cell (g/day)	229.9^{b}	266.9^{a}	262.7^{a}	251.6^{ab}	275.4^{a}	4.25	**

$^{a, b, c, d, e}$ means with different superscripts in a row are significantly different; ***= (P<0.001); **= (P<0.01); *= (P<0.05); ADF=Acid Detergent Fiber; ADL=Acid Detergent Lignin; BW=Body Weight; Cell=Cellulose; CP=Crude Protein; DM=Dry Matter; HC=Hemicelluloses; NDF=Neutral Detergent Fiber; ns=non-significant; OM=Organic Matter; SEM=Standard Error of the Mean; SL=Significance Level.

Supplementation of vetch varieties has increased CP intake by 54.7, 36.9, 33.5 and 40% for T2, T3, T4 and T5, respectively, as compared to T1. The highest CP intake was recorded for sheep supplemented with Gebisa vetch variety, whereas, the lowest was recorded for the non-supplemented group. Similar trend of total DM intake was observed across all treatments as the total DM intake was steadily increasing with a decreasing rate throughout the experiment (Figure 1).

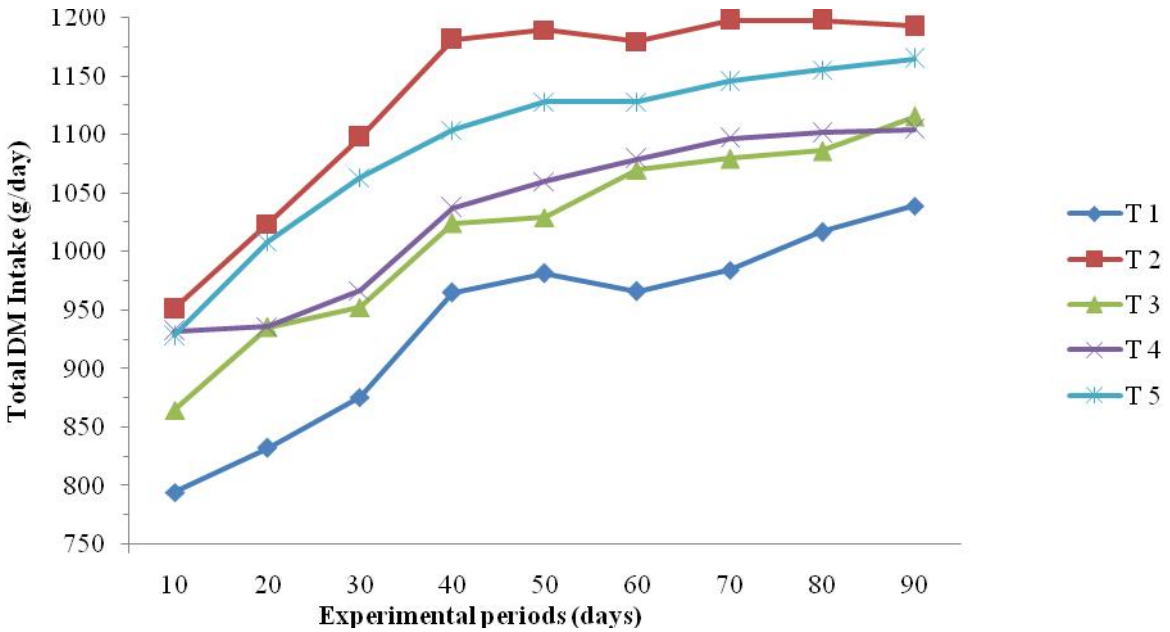

Fig 1 Trends in total dry matter intake of sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

3.3. Weight gain and feed conversion efficiency

Supplementation of the vetch varieties increased the ADG of sheep by 68.9, 25.9, 33.6 and 44.3% for T2, T3, T4 and T5, respectively, as compared to the control. Among supplemented groups, the highest ADG (152.5 g/day) was recorded for those sheep supplemented with Gebisa vetch variety (T2). Supplementation of the vetch varieties also improved feed conversion efficiency (FCE) by 42.1, 16.8, 24.2 and 27.4% for T2, T3, T4 and T5, respectively. Among supplemented groups FCE was highest (P<0.001) for those sheep supplemented with Gebisa vetch variety.

Table 4. Body weight change and feed conversion efficiency of sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

	Treatments						
Parameters	T1	T2	T3	T4	T5	SEM	SL
IBW (kg)	21.4	21.3	21.4	21.4	21.4	0.10	Ns
FBW (kg)	29.5^{d}	35.1^{a}	31.6^{c}	32.2^{bc}	33.1^{b}	0.38	***
BWC (kg)	8.1^{d}	13.7^{a}	10.2^{c}	10.9^{bc}	11.7^{b}	0.37	***
ADG (g/day)	90.3^{d}	152.5^{a}	113.7^{c}	120.6^{bc}	130.3^{b}	4.11	***
FCE (g ADG/g TDMI)	0.095^{c}	0.135^{a}	0.111^{b}	0.118^{b}	0.121^{b}	0.003	***
PCE (g ADG/g TCPI)	0.902^{ab}	0.987^{a}	0.826^{b}	0.905^{ab}	0.933^{a}	0.015	**

$^{a, b, c, d}$ means with different superscripts in a row are significantly different; ***= (P<0.001); **= (p<0.01); ADG=Average Daily Gain; BWC=Body Weight Change; FBW=Final Body Weight; FCE=Feed Conversion Efficiency; IBW=Initial Body Weight; ns=not significant; PCE= Protein Conversion Efficiency; SEM=Standard Error of the Mean; SL=Significance Level; TDMI= Total Dry Matter Intake; TCPI= Total Crude Protein Intake.

The trends in body weight change showed steady increase across the growth period in all experimental treatments though the rate of increment differs (Figure 2). In all treatments the body weight of animals under all treatments were increasing throughout the experiment though the rate at which animals gained their body weight was decreasing as experimental day advances.

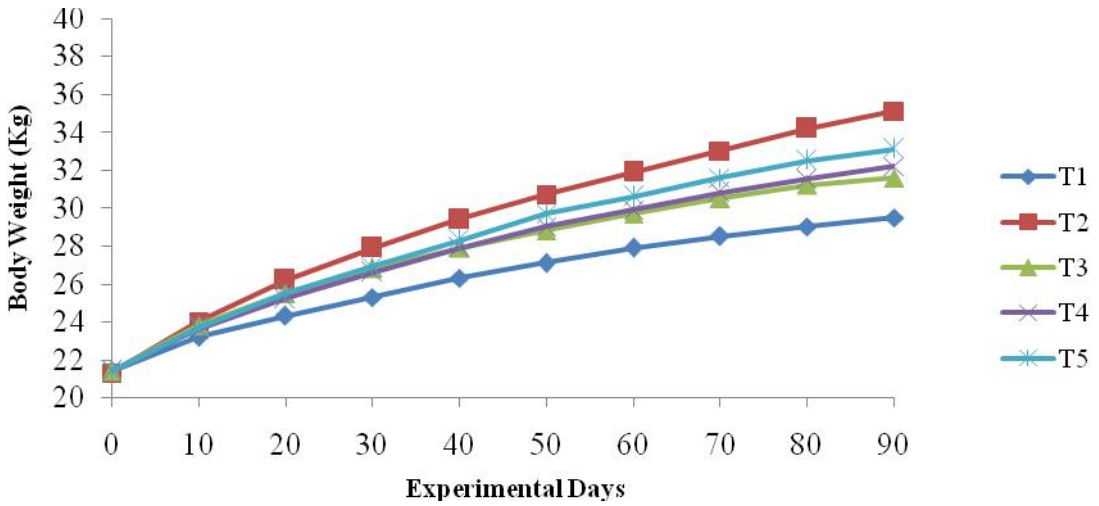

Fig 2 Trends in body weight change of sheep fed a basal diet of fodder oat hay and supplemented with different varieties of vetch hay

4. Discussion

4.1. Chemical composition of experimental feeds and refused feed

The 8.9% CP content of fodder oat hay used in this study was slightly lower than the 11.5% CP content of the same variety reported by Dawit and Teklu (2011) and 10.6% reported by SARC (2015). Although the CP content of fodder oat hay used in this study was lower than previous reports, it was higher than the 7% CP required for microbial protein synthesis in the rumen that can support at least the maintenance requirement of ruminants (Van Soest, 1994). The CP content of Abdeta and Lalisa vetch varieties was also lower than the 24.8% and 24.1% CP content of the same varieties, respectively reported by Dawit *et al.* (2011). The lower CP content of experimental feeds registered in this study might be due to losses of the leaf fractions containing high CP while curing the experimental forages in the field. The lower CP and higher NDF, ADF and Cellulose contents of fodder oat hay refusal than the offered fodder oat hay indicates the selective nature of sheep in feeding more nutritious and palatable portion (leafy part) of the hay than the lignified parts.

4.2. Dry matter and nutrient intake

The highest ($P<0.001$) intake of fodder oat hay in the un-supplemented group than the supplemented ones could be due to an effort of sheep in that group to satisfy their nutrient requirements. The higher ($P<0.05$) total DM intake of sheep in T2 than sheep in T1, T3 and T4 was attributed to higher oat hay intake by those sheep in T2 as the level of supplementation on DM basis was the same for all supplemented treatments. According to Adugna *et al*. (2002) feed that is high in protein and low in fiber content results in high digestibility and voluntary feed intake. Therefore, the higher total DM intake by the sheep in T2 might be due to the higher CP and lower NDF, ADF, HC and Cell concentration of Gebisa vetch variety compared to other varieties (Table 2). The increment of total DM intake as a result of supplementation might be due to supplementation of vetches increased the nitrogen content of the total diet, which in turn was likely increased feed intake and the rate of degradation of the basal diet in the rumen (Topps, 1997). The result of total DM intake in this study was by far higher than the DM intake previously reported for Arsi-Bale sheep by different authors (Dawit and Solomon, 2009; Ermias *et al.,* 2013; Teklu *et al.,* 2018). This could be attributed to better palatability of the basal and supplementary feeds used in this study.

The highest CP intake (154.5 g/day) in sheep supplemented with Gebisa vetch variety (T2) could be attributed to highest DM intake in T2 and the highest CP content of Gebisa compared to other vetch varieties (Table 2; Table 3). The lowest CP intake (99.9 g/day) recorded for the non-supplemented group could be because of the lowest DM intake and absence of high protein feed supplementation. When the overall CP intake in this study was observed, it was by far higher than the CP intake previously reported for Arsi-Bale sheep by different authors (Dawit and Solomon, 2009; Ermias *et al.*, 2013; Biruk, 2017). This might be attributed to high DM intake of experimental animals in this study and better CP concentration of the basal diet used for this experiment as it was improved forage with better CP content, lower fiber content and better digestibility than natural grass hay or straw as it was the case in most of the earlier studies.

4.3. Body Weight Change and Feed Conversion Efficiency

The improvement in body weight parameters and feed conversion efficiency observed in the supplemented groups over un-supplemented could be associated with the vetches supplementation which increased DM and nutrient intake as well as DM and nutrient digestibility. Chumpawadee *et al*. (2009) noted that when animals are fed relatively higher dietary protein, nutrient digestibility is improved leading to high nutrient uptake that promotes ADG. Ermias *et al.*, 2013; Hunegnaw and Berhan, 2016; Biruk, 2017 also reported that increasing protein and energy levels

in the diet improved ADG and FCE of animals. The body weight gained by feeding sole fodder oat hay (T1) itself was higher than earlier reports for Arsi-Bale sheep under different feeding regimes (Ermias *et al.*, 2013; Alem, 2014; Biruk, 2017). This indicates that sole fodder oat hay can be used without any supplementation to bring moderate animal productivity if harvested at appropriate stage and well conserved. It also shows the importance of the quality of basal diet to enhance animal productivity. The best performance of sheep supplemented with Gebisa vetch variety (T2) could be attributed to relatively higher DM and nutrient intake.

The body weight parameters and feed conversion efficiency obtained in the current study by T2 were very high when compared with the experiments previously conducted on Ethiopian sheep breeds using different supplement feeds from forage and concentrate sources. Based on the current findings Gebisa can be recommended as best performing variety for use as supplementary feed in ruminants fed roughage based diets. The very high body weight parameters and feed conversion efficiency obtained in this study might be attributed to the very high CP intake (Table 3) and important nutrients such as vitamins and minerals found in green feeds like fodder oat and vetch, though this study did not addressed such parameters. Therefore, this study showed that fodder oat and vetch hay based feeding is a very high potential feeding strategy that should be given due attention by producers and policy makers as well as livestock professionals in order to particularly enhance productivity of sheep under small holder production system, where these feeds can be relatively easily produced.

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Competing Interests

The authors declare no competing interests.

Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Berhanu Tassew. The first draft of the manuscript was written by Berhanu Tassew and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Ethics approval

The national guidelines for the care and use of animals have been followed.

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