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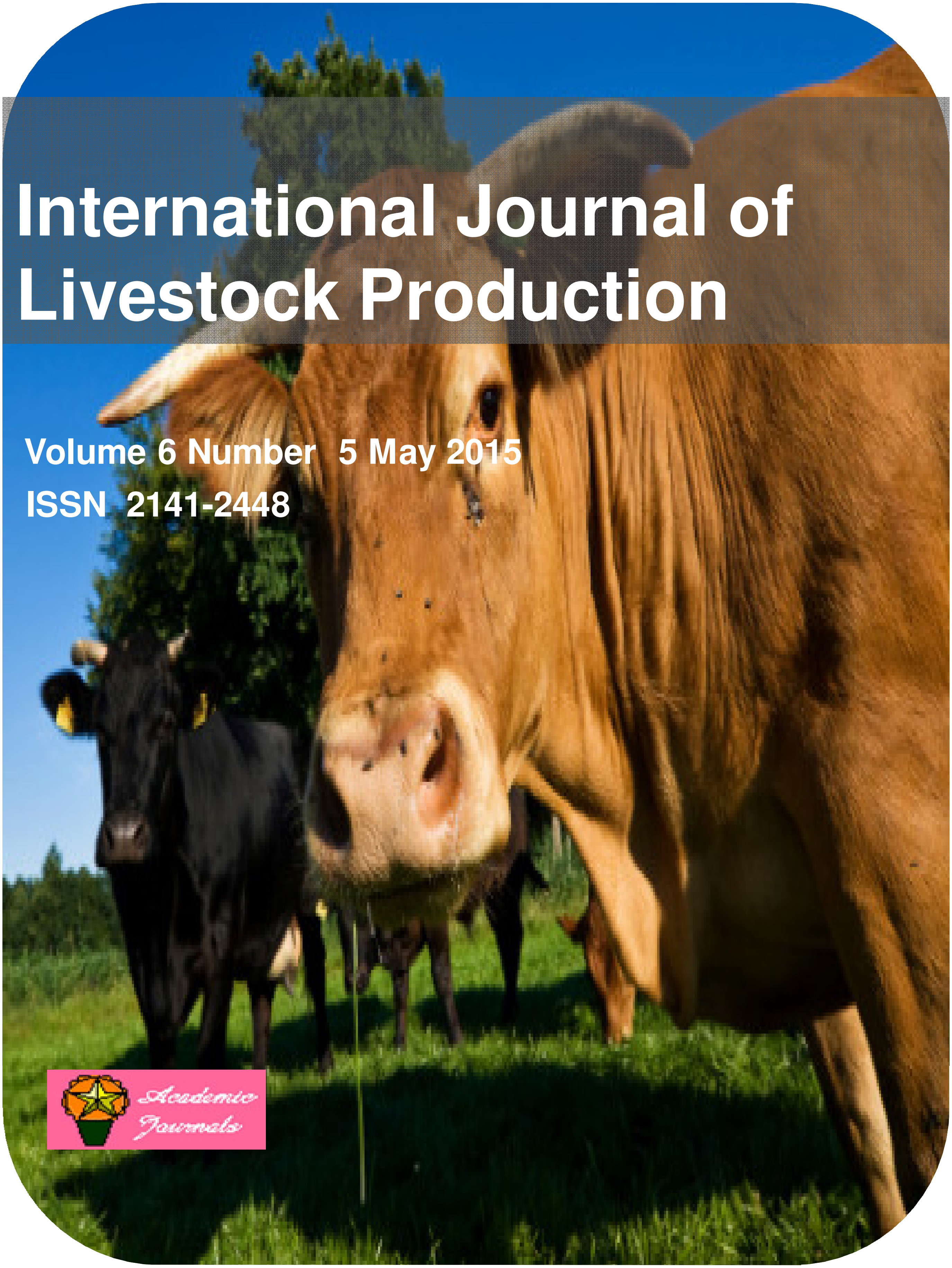

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International Journal of Livestock Production

Full Length Research Paper

Effects of water exchange on water quality parameters, nutrient utilization and growth of African catfish (*Clarias gariepinus*)

Adebola Oluyinka Ajiboye, Adeniyi Adediran Awogbade and Oluseun Adebola Babalola

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Received 3 March 2015; Accepted 12 May, 2015

This experiment investigated the effects of water exchange on water quality parameters and growth of *Clarias gariepinus*. 225 *C. gariepinus* of mean weight 2.60 ± 0.01 g were stocked at 15 fish per treatment in three replicates. Water quality and growth parameters such as mean weight gain (MWG), specific growth rate (SGR), food conversion ratio (FCR) and protein efficiency ratio (PER) were calculated using standard procedures. pH of T3 (9.15) was significantly higher p<0.05 than other treatments. Dissolved oxygen indicated that T5 (3.45 mg/l) was significantly lower than other treatments. The ammonia values revealed that T5 (0.08 mg/l) was significantly higher p < 0.05 than other treatments. MWG of T1 (29.43 g) and T2 (27.77 g) were significantly higher p < 0.05 than T3, T4 and T5. SGR and PER of T1 (2.26%), (5.74) and T2 (2.22%) (5.31) increased significantly p < 0.05 than other treatments. The FCR of T1 (0.40) and T2 (0.42) were significantly lower than other treatments. It was evident in this study that exchange of water has an increase or decrease in the state of water quality parameters and growth of a fish.

Key words: Water exchange, water quality parameters, fish carcass, growth parameters, *Clarias gariepinus*.

INTRODUCTION

The present trend of global food security in aquaculture which is focused on increasing the protein intake of every individual can only be attained through proper water management. In ensuring optimum nutrient utilization of diets and growth of tropical freshwater fishes, fish culturists must endeavour to monitor water quality parameters. The optimum production in fisheries sector is majorly dependent on the physical, chemical and biological qualities of water (Bhatnagar and Devi, 2013). It is very apparent that the health and subsequent growth of fish are directly related to the quality of water in which the fish are raised (Viadero, 2005). Fish metabolites produced as a result of biological activities and decomposition of uneaten feeds have adverse effects on the quality of water, health status and growth of the fish. Water quality parameters like dissolved oxygen, pH, turbidity, alkalinity, ammonia, temperature and other factors such as biological oxygen demand and chemical oxygen demand indicate the pollution level of given water body (Ehiagbonare and Ogundiran, 2010). It is therefore very important to note that, successful pond management requires an understanding of water quality (Bhatnagar and Devi, 2013). Water is the home of the fish and its quality has been overlooked in fish management

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Table 1. Water quality parameters' values.

Parameter	T1	T2	T3	T4	T5
pH	6.60 ± 0.62^{c}	8.05 ± 1.83^{ba}	9.15 ± 1.00^{a}	7.58 ± 1.38^{b}	8.76 ± 1.07^{ba}
Dissolved oxygen	4.33 ± 1.49	5.32 ± 2.50	4.57 ± 1.05	4.03 ± 1.28	3.47 ± 0.50
Ammonia	0.01 ± 0.01^{a}	0.03 ± 0.02^{a}	0.05 ± 0.01^{a}	0.06 ± 0.02^{b}	0.08 ± 0.02^{b}

Means ± S.E. with same superscript were not significantly different ($p > 0.05$).

(Keremah et al., 2014). The role of water quality parameters cannot be overlooked for maintaining a healthy aquatic environment and for the production of sufficient food organisms in ponds for increasing fish production (Bhatnagar and Devi, 2013). Aquaculture productivity is determined by physic-chemical characteristics of water body (Huct, 1986). The determination of physicochemical parameters of waters in the effluents discharged from fish farms and their environmental impacts will go a long way to help fish farmers to manage and develop their waste water systems (Pulatsu et al., 2004). The production of aquatic organisms in water bodies has faced many challenges because knowledge of water quality parameters has been neglected by fish culturists.

The objective of this study was to investigate the effects of water exchange on water quality parameters (such as pH, water temperature, dissolved oxygen, ammonia) nutrients utilization and growth of *Clarias gariepinus.*

MATERIALS AND METHODS

A total number of 225 *C. gariepinus* of mean weight 2.60 ± 0.01 g were purchased from a reputable farm in Ibadan, Oyo State, Nigeria. The fish samples were transported inside 50 L container. The fish samples were acclimatized before the commencement of the experiment for a period of two weeks in the laboratory. The fish samples were randomly assigned to five treatments and stocked at 15 fish per treatment in three replicates inside 50 L experimental bowls. The allotted fish samples were daily fed for a period of 12 weeks at 5% biomass.

The fish samples were fed three times daily (7.00 am, 12.00 noon and 6.00 pm) with 2 mm Duratee pelleted feeds. Fish feeding rates were adjusted every week after measuring the total biomass of each treatment. Water was changed every day in T1 and was allotted as control while in other treatments water was changed every 2, 3, 4 and 5 days and the treatments were allotted T2, T3, 4 T4 and T5, respectively. Water samples were collected fortnightly to determine water quality parameters. The pH of the water was determined using a digital pH meter Suntex (model TS-2). Dissolved oxygen was determined using dissolved oxygen meter (model Jenway DO 9071). The dissolved oxygen meter was standardized by using saturated potassium chloride and zero solutions. The analytical determination of ammonia was determined according to the standard methods of American Public Health Association APHA (1992).

After the feeding trial experiment, the following nutrient utilization and growth parameters were determined: Mean weight gain was calculated according to Ishwata (1969), by subtracting mean final weight (g) from mean initial weight (g). SGR = (LnW2 – LnW1) / T2−T1 × 100 (Brown, 1957). Where LnW2 and LnW1 are mean final weight and mean initial weight. T2 and T0 are final day of the experiment and initial day of the experiment, respectively. FCR was determined as described by Hepher (1988). FCR = Total feed consumed (g)/Weight gain by fish (g). PER was calculated according to the method of Zeiotoun et al. (1973). PER = Weight gain (g)/Protein intake

Statistical analysis

The data collected were analyzed using Statistical Package for Social Sciences (SPSS), Version 11, 2001 and Statistical Analysis Software (SAS), Version 8, 2001. Duncan's Multiple Range Test was used to compare the differences among the means. The significant level was set at 5%.

RESULTS

The water quality parameters results are presented in Table 1. The pH values ranged between 6.60 and 9.15. The pH value of T1 (6.60) was significantly lower compared to other treatments, while T3 (9.15) was significantly higher $p < 0.05$ than other treatments. The values recorded for dissolved oxygen indicated that T5 (3.47 mg/l) was significantly lower than other treatments. The ammonia values in this study revealed that T5 (0.08 mg/l) was significantly higher $p < 0.05$ and T1 was significantly lower than other treatments. The effects of water exchange on nutrient utilization and growth of *C. gariepinus* are shown in Table 2. The MWG values ranged between 21.30 g and 29.43 g. The MWG of T1 (29.43 g) and T2 (27.77 g) were significantly higher ($p < 0.05$) compared to other values recorded in T3 (21.30 g), T4 (21.67 g) and T5 (21.80 g). The SGR ranged between 1.99 and 2.26%. The values recorded for SGR in T1 (2.26%) and T2 (2. 22%) increased significantly $p < 0.05$ compared to other treatments. The FCR recorded in this experiment ranged between 0.40 and 0.52. The FCR of T3 (0.52), T4 (0.51) and T5 (0.51) increased significantly $p < 0.05$ than T1 (0.40) and T2 (0.42). The PER values ranged between 4.36 and 5.74. The PER of T1 (5.74) and T2 (5.31) were significantly higher $p < 0.05$ than other treatments.

DISCUSSION

pH is an indicator that determines the quality of water

Table 2. Nutrient utilization and growth of *Clarias gariepinus*.

Parameter	T1	T2	T3	T4	T5
Mean initial weight	2.60 ± 0.01	2.60 ± 0.01	2.60 ± 0.01	2.60 ± 0.01	2.60 ± 0.01
Mean final weight	3 2.03 ± 6.25	30.37 ± 4.71	23.90 ± 4.55	24.27 ± 4.28	24.40 ± 6.16
Mean weight gain	29.43 ± 6.25^{a}	27.77 ± 4.71^{a}	21.67 ± 4.28^{b}	21.30 ± 4.55^{b}	21.80 ± 6.16^{b}
Specific growth rate	2.26 ± 1.16^{a}	2.22 ± 0.13^{a}	2.01 ± 0.16^{ab}	1.99 ± 0.18^{b}	2.04 ± 0.24^{ab}
Feed conversion ratio	0.40 ± 0.08^{b}	0.42 ± 0.06^{b}	0.51 ± 0.10^{a}	0.52 ± 0.13^{a}	0.51 ± 0.16^{a}
Protein efficiency ratio	5.74 ± 0.05^{a}	5.31 ± 0.03^{a}	4.36 ± 0.06^{b}	4.37 ± 0.08^{b}	4.57 ± 0.07^{b}

Means ± S.E. with same superscripts were not significantly different ($p > 0.05$).

required for aquaculture production. The range of pH values obtained in this study agreed with studies of Wurts and Durborow (1992) and Bhatnagar and Devi (2004). They recommended that optimum pH level in ponds should be between 6.5 and 9. The significant value recorded in T1 could be attributed to regular change of water which ensures optimum level of hydrogen ions and hydroxyl anions in the culture media. Similarly, the dissolved oxygen values are within the range (3.30 to 12 mgl^{-1}) reported by Moogouel et al., (2010). The lowest value of dissolved oxygen reported in T5 could be attributed to the fact that, there was no regular exchange of water in the culture media. The available dissolved oxygen had been utilized by the fish. Dissolved oxygen required by aquatic organisms in any culture media could be determined by constant water exchange in the culture media at optimal levels. The ammonia values in this experiment were extremely low compared to the values (1.25 to 4.63 mgl^{-1}) recorded by Moogouel et al. (2010). This report could be traced to drastic reduction of dissolved oxygen in T5 which might have culminated to stress in the fish.

In this experiment, the specific growth rate did not agreed with the range recorded by Kasi et al. (2011) and Jalili et al. (2013) who recorded a range of 1.42 and 6.59 for Cobia (*Rachycentron canadum*). In any experiment, the specific growth rate of any fish is subjected to various factors like weight gain, average feed intake, condition factor and water quality parameters of the culture media. The FCR recorded in this experiment did not corroborate with the findings of Kasi et al. (2011) and Nadir et al. (2007) who reported values that ranged between 1.00 and 1.35 and 1.45 and 1.77, respectively. The major aim of an experiment could affect the FCR value of the fish. Since water exchange was the main objective of this experiment, water exchange and water quality parameters are critical factors that determines how much of the diets are converted to fish flesh. It is evident that problems encountered as a result of poor water quality parameters may result to low appetite which eventually affects conversion of the feeds into flesh. The PER values (0.4 to 0.8) reported by Gaber et al. (2012) in Tiger shrimp (*Penaeus semisulcatus*) was considerably lower than values recorded in this study.

The culture media of any experiment determines the quality of the water which also affects how efficient the protein in the diet is adequately utilized by the fish. Whenever there is poor water quality parameters, the fish species are stressed and this affect the utilization of the protein in the diet. The disparity of these values could be attributed to the fact that the controlled water exchange rate in the laboratory in this experiment gave a higher PER values than the water exchange for the Tiger shrimps carried out in the earthen ponds.

The results recorded in this study indicate that water exchange is a critical factor that should be considered in ensuring good water quality parameters, nutrient utilization of diets and growth of fish.

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Full Length Research Paper

Productive performance evaluation of Dorper sheep crosses (50% Dorper × pure Adilo indigenous sheep breed) under farmer conditions in different agro ecological zones

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A case history based study was conducted in Wolaita and Siltie zones, with the objectives of evaluating the productive performance of Dorper sheep crosses. The study woreda were purposively selected from two zones, on the basis of Dorper sheep breed distribution with purposive sampling techniques. Households of all farmers who received the Dorper sheep breed were monitored by establishing sample frame. Production data were subjected to GLM procedure of Statistical Analysis System. Dorper lambs gained from 0.30 to 0.43 kg per day under different environmental conditions. Mean market age for Dorper sheep crosses were 12.87±0.70 and 12.05±0.76 in Siltie and Wolaita, respectively. Market weight is higher in Wolaita (31.29 kg) than Siltie zone (30.47 kg). It was concluded that the breed consume all types of feed stuffs that helps to adapts well to a wide variety of environmental conditions. Market problem was identified in Wolaita zone because of the breed lack tail. Crossbreeding Dorper sheep blood level with Adilo indigenous sheep reduces market problem in Wolaita zone. Further study is needed to show value chain on Dorper sheep production to increase production level in different climatic conditions.

Key words: Agro ecological, crosses, Dorper, farmer condition, productive performance.

INTRODUCTION

In Ethiopia, indigenous sheep has advantageous (CSA, 2011; Kosgey et al., 2008) that support regular income in both tangible and/or intangible manners to a large human population through the sale of live animals and skins (Abebe et al., 2010). Despite all these advantages at farmer and national level the production from indigenous sheep remained very low because of low genetic makeup. Due to these reasons tropical countries have been implementing crossbreed of indigenous animals with improved exotic genotypes to improve the genetic

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potential of indigenous animals (Belete et al., 2014). The main breeding objective for the majority of Ethiopian sheep farmers is meat, rather than wool production, and is driven by market demands and agro-ecology (ESGPIP, 2007). A national sheep-breeding program was therefore initiated to address farmers' objectives with the introduction of a specialized meat breed, the Dorper sheep is also reputed for its reproductive performance (Székely, 2011). The Southern Agricultural Research Institute (SARI) was established by the regional Government in 2001 and re-established in 2005 with a mission of providing improved agricultural technologies and information, policy proposals for agricultural development and natural resources management as well as multiplication and distribution of improved agricultural technologies (AARC, 2012). Dozens of poor farmers have already been benefited from this initiative by crossing and selling Dorper sheep for use as breeding stock in some zones of the region with selling prices ranging from 3000 to 5000 Birr per animal. Even though, the productivity, adaptability, market value and meat characteristic of these sheep breeds has not been studied in the area.

The Dorper improved exotic sheep breed well perform and thrive in all agro ecological climates and have high fertility, short generation interval, adaptation in harsh environment and their ability to produce in limited feed resource (Belete et al., 2014). Dorper crossbreeding currently focuses on village monitoring studies (Mekonen, 2012), with evaluation of the comparative performance of purebred and different grades of crosses. Performance recording is an important tool to suggest the breeding policy for a given area (Belete et al., 2014). As a result, there is a need to assess agro ecological zone differences and define the present performance of Dorper sheep breed; has until now not been evaluated under Ethiopia production systems in different agro ecological zones. Therefore, the objectives of this paper were to evaluate the productive performance of Dorper sheep and to identify factors influencing the performances under farmers' management conditions in different agro ecology.

MATERIALS AND METHODS

Description of the study areas

Wolaita zone is located at 330 km to the south-west of Addis Ababa and 160 km from Hawassa, Regional capital city. Its altitude ranges from 1200 to 2950 masl. It has twelve woreda of which two woreda (Damot Gale and Damot Sore) were purposively selected based on Dorper sheep distribution. Damot Gale and Damot Sore woredas are located in between 6°51" and 7°35" North Longitude; and 37°46" and 38°1", respectively. Agro ecology of the areas is 62% highland (Dega), 38% midland (Weina Dega) and 58% highland (Dega), 42% midland (Weina Dega), respectively.

The average temperature varies from minimum 13.6°C to maximum 25.1°C and 14°C to maximum 21°C, respectively. The annual average rainfall in Damot Gale and Damot Sore is 1175 mm and 1200 mm, respectively. In a bimodal pattern with three distinct seasons; dry (November to February), small rains from March to June and big rains from July to October in both districts (NMA, 2013, WZFED, 2013).

Siltie zone is one of the 14 zones of the Southern nation nationality and people's regional government. It is located at 173 km from Addis Ababa, the capital city of Ethiopia and 177 km from the regional town Hawassa. It has eight woreda of which Mirab Azernet was purposively selected based on Dorper sheep distribution. The Woreda is located in 2889 masl, 7.43-7.66°N latitude and 37.86-37.90°E longitudes. It has two different agro-climatic conditions, Dega and Woina-dega and consisting 37% and 63%, respectively. The annual average minimum and maximum temperature range from 14 to 17°C, respectively and the average annual rainfall ranges from 1200 mm (Melesse et al., 2013). There are three distinct seasons; big rainy season (June, July, August and September); dry season (January, February and March); small rainy season (October, November and December) (MAWAO, 2013; NMA, 2013). Geographical location of the study areas are indicated in Figure 1.

Sampling technique

All farmers who received improved breed (Dorper) sheep were sample frame. A total of 65 households (48 from Mirab Azernet district, Siltie zone, 9 from Damot Gale and 8 from Damot Sore district, Wolaita zone) were monitored and considered purposively for the household survey in the current study based on Dorper sheep breed distribution. Sampling frame was established in a purposive sampling procedure selected to administer the questionnaire for production system and socio-economic study based on distribution of Dorper sheep and study Kebeles or Peasant Associations (PA), were selected which can represent number of 50% Dorper sheep distributions (Table 1).

Data collection procedure

A structured questionnaire, group discussion, field monitoring and secondary sources were used to gather qualitative and quantitative data on sheep production system in general and Dorper sheep breed in particular and husbandry practices. Discussion were focused on the origin and history of the Dorper sheep population, chain of Dorper sheep market, current status and major constraints of Dorper sheep production system.

Flock monitoring

Flocks of 65 households were monitored between November 2013 and April 2014. Prior to sampling, previous survey results and secondary data from the Office of Agriculture and Rural Development (OoARD) on overall agricultural production, socioeconomics and crop-livestock integrations were reviewed, and experts of animal husbandry consulted. Field visit was also made to gather pre-information and select the study Kebeles, villages and thereby the households.

For each Kebele, flock density of one enumerator was recruited from the respective locality (5 for the whole study (2 enumerators for Wolaita zone and 3 enumerators for Silte zone). All animals were identified and numbered at the start of the study. Production performance (birth weight and weaning weight) and mortality data were recorded (Appendix 1 and 2). Within 24 h of the new born; date of birth, birth weight, type of birth, sex of lamb and ewe/dam parity were taken. Weaning weight was recorded on 90th day. Market age was taken through records and market weight was recorded by six months. Weights were taken by using balance

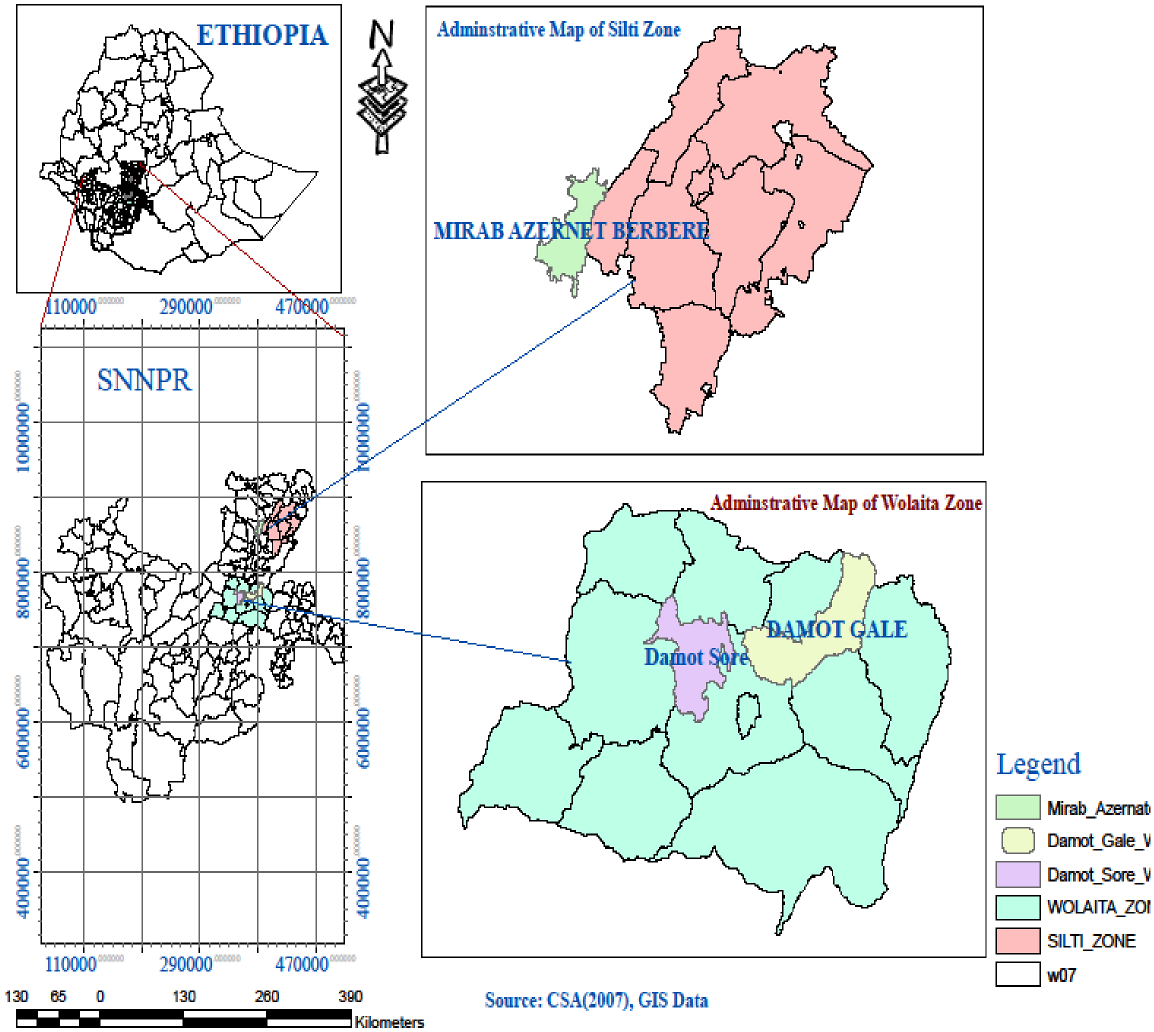

Figure 1. Location of study area.

Table 1. Selected kebeles and its agro ecological zones

District	Agro ecological zones			
	Kolla	Woyne dega	Dega	Sampled villages
Damot Gale	-	2	1	3
Damot Sore	-	-	2	2
Mirab Azernet	6	1	2	10

scale.

Case histories

To grasp adequate information on the parameters like age at first lambing, lambing interval, lamb mortality, litter size, case histories of breeding females was taken according to Kaufmann (2005, Appendix 1, 2 and 3). This is because the monitoring time was still short to record these events. The breeding females whose histories were recorded were those that gave birth at least once. Case histories were done giving priority for older females assuming that they were more informative. Twenty-seven case histories were recorded on breeding ewes.

Data management and statistical analysis

Growth data were subjected to GLM procedure of Statistical Analysis System SAS (SAS (2003). Fixed effects fitted in the model

Table 2. Productive performance of Dorper sheep crosses.

Source	N	Bw LSM(± SE)	Ww LSM(± SE)	Wa LSM(± SE)	Ma LSM(± SE)	Mw LSM(±SE)
Overall	65	2.25±1.72	17.30 ±0.98	3.16±0.55	12.66±1.39	30.68±3.26
Location		NS		NS		NS
Siltie	48	2.34±0.87	17.72±0.49[a]	3.18±0.28	12.87±0.70[a]	30.47±1.65
Wolaita	17	2.00±0.94	16.11±0.53[b]	3.11±0.30	12.05±0.76[b]	31.29±1.78
Season		NS			NS	
Dry season	15	2.88±0.68	16.40±0.39[b]	3.13±0.22[ab]	12.40±0.55	28.51±1.29[b]
Small rainy	12	2.03±0.58	17.29±0.33[a]	3.50±0.19[a]	12.50±0.47	31.75±1.11[a]
Big rainy	38	2.07± 0.51	17.65±0.35[a]	3.07±0.25[b]	12.81±0.40	31.21±1.02[a]
Birth type		NS		NS		
Single	40	2.07±0.77	18.20±0.44[a]	3.20±0.24	12.30±0.62[b]	32.05±1.45[a]
Twins	17	2.78±0.76	16.30±0.43[b]	3.05±0.24	12.94±0.62[ab]	27.97±1.45[ab]
Multiple	8	2.00±0.75	14.93±0.41[c]	3.25±0.23	13.87±0.61[a]	29.65±1.40[b]
Parity		NS		NS		NS
1	12	1.96±0.65	15.79±0.37[c]	3.08±0.21	13.66±0.53[a]	30.00±1.24
2	20	2.70±0.51	16.70±0.29[b]	3.05±0.16	12.90±0.41[ab]	29.83±0.96
3	33	2.08±0.64	18.21±0.25[a]	3.27±0.30	12.15±0.36[b]	31.45±1.18
Sex		NS		NS	NS	NS
Male	38	2.47±0.47	17.62±0.27[a]	3.26±0.15	12.68±0.38	31.36±0.89
Female	27	2.09±0.56	16.85±0.21[b]	3.03±0.04	12.62±0.32	29.74±0.78
Blood group		NS		NS		
50% cross	37	2.20±0.47	19.00±0.27[a]	3.24±0.15	11.21±0.38[b]	31.85±0.89[a]
25% cross	28	2.31±0.43	15.05± 0.29[b]	3.07±0.08	14.57±0.42[a]	29.14±0.78[b]

Means within each subclass with different superscript (a, b, c) letters differ significantly (P<0.05); NS- non significant. Bw; birth weight, Ww; weaning weight, Wa; weaning age, Ma: market age and Mw; market weight.

included the effects of location (2); sex (2); parity (1- >3); birth type (Single, twin, triple, multiple) and season of birth (dry, small rainy and big rainy season). The statistical model is explained as follows:

$Y_{inlmjyo} = \mu + L_i + X_j + P_l + B_m + S_n + B_y + e_{ijlmnyo}$; Y_{inlmjo} = *Weights and weaning of the* n^{th} *lamb*; μ = *the overall mean*; L_i = *the fixed effect of the* i^{th} *location*; X_j = *the fixed effect of* j^{th} *sex*; P_l = *the fixed effect of* l^{th} *parity*; *Bm = the fixed effect of* m^{th} *type of birth*; S_n = *the fixed effect of* n^{th} *season*; B_y = *the fixed effect of* y^{th} *blood level* and ei_{nlmjo} = *the random error.*

RESULTS

In this study, productive performance results of Dorper sheep crosses are given in Table 2. Factors affecting Dorper sheep production are given in Table 3.

DISCUSSION

Market weight and age

In the entire studied area, the Dorper had high adaptation, 75.5% (Belete et al., 2014). Similarly, Cloete et al. (2000) and Gavojdian et al. (2013) reported the Dorper sheep breed performed well under semi-intensive management conditions, proving to be an adaptable breed to new rearing conditions. Unlike other improved sheep breed, Dorper sheep breed has good adaptation under different climatic conditions.

Market weight and market age were affected by birth type and blood group. Parity and location also had significant on market age of lamb. Season had significant on market weight. In Siltie zone, Dorper lamb reached market age at 12.87 months, which was significantly higher (p<0.05) than those in Wolaita zone, 12.05 months. Feed is more available in Mirab Azernet area as discussed earlier and housing separately their sheep. Because of better feeding and management, ewes become in heat within shorter time after lambing. Dorper sheep lamb in Wolaita had significantly lower weaning weight 16.62 kg (p<0.05) than Siltie (Table 2).

Constraints

In the present study areas, market problem was reported as first major problem in Wolaita zone and water and feed shortage in Siltie zone. Market problem as major problem in Wolaita zone reflects, lack of awareness on

Table 3. Factors affecting Dorper sheep production.

Constraints	Wolaita				Siltie	
	Damot Gale		Damot Sore		Mirab Azernet	
	N	%	N	%	N	%
Diseases	1	11.1	2	25.0	5	10.4
Water shortage	1	11.1	1	12.5	17	35.4
Feed shortage	0	0	1	12.5	13	27.1
Market problem	4	44.4	4	50.0	5	10.4
Lack of extension support	2	22.2	0	0	3	6.3
Lack of technology	1	11.1	0	0	5	10.4

Dorper breed and its products, besides advantages rather than Siltie zone, Mirab Azernet woreda. Market problems in Wolaita zone is lack of tail. On other hand, water and feed shortage at village level, pronounced particularly in dry season and none harvesting season, respectively. Lack of technology transfer knowledge through extension service and training was the other constraint in three districts as it was reported by Tsedeke et al. (2011).

As an option getting 50% improved Dorper sheep by affordable price, training on awareness creation and organizing farmers as cooperatives were raised through group discussion. Majority of the respondents in three districts purchased Dorper sheep with 100 birr/kg from Areka Agriculture Research Center at high cost based on the degree of blood group of the breed, with respect to this they seek to get improved breed at affordable price. Some other respondents consider training on awareness creation and organizing farmers as cooperatives as an important option to enhance sheep productivity.

CONCLUSIONS AND RECOMMENDATIONS

Considerable differences were seen among the two studied zones regarding to location (agro ecologies), management systems, production performances and market information on the breed Dorper sheep. Agro ecology had significant effect on market age and weight. Market problem was identified in Wolaita zone. Market weight is higher than Siltie zones. In view of the above, the following recommendations were suggested:

i. Facilitating market opportunities by connecting the marketing route of this locality with big market players (traders, wholesalers, processors or exporters) and establishing big and standardized livestock market in nearby areas should be encouraged;
ii. Extension support should be needed by research institute and Agricultural office to improve institutional arrangements and management aspects;
iii. Market problem in Wolaita zone should be solved by cross breeding with Adilo indigenous sheep to appear tail in next generations.
iv. Further study is needed to show value chain on Dorper sheep production to increase production level in different climatic conditions.

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Appendix

Appendix 1. Flock monitoring and dynamics.

Flock dynamics follow-up format									
Breed/class	**Inventory (Number)**	**Monitoring 1 Date**						**Mon. 2 date**	**Mon. 3 date**
		Birth			**Purchased**	**Sold**	**Died**		
		Single	**Twin**	**Triple**					
Local									
Ewe									
Pregnant									
Suckling									
Dry									
Ram									
Lambs									
<3 month									
3-6 month									
7-12 month									
Exotic									
Ewe									
Pregnant									
Suckling									
Dry									
Ram									
Lambs									
<3 month									
3-6 month									
7-12 month									
Crosses 50/75%									
Ewe									
Pregnant									
Suckling									
Dry									
Ram									
Lambs									
<3 month									
3-6 month									
7-12 month									

Appendix 2: Lamb weight.

Lamb weight monitoring format

Farmer name: ____

Wereda:____

Zone: ____

Ewe name	**Breed**	**Parity**	**Lambing date**	**Birth Type**	**Sex**	**Weight**							
						Date	**kg**	**Date**	**kg**	**Date**	**kg**	**Date**	**kg**
Ewe #1													
Ewe #2													
Ewe #3													
Ewe #4													
Ewe #5													
Ewe #6													
Ewe #7													
Ewe #8													
Ewe #9													

Birth type : single, twin, triple

Appendix 3: Life histories questionnaires for breeding female.

1. Name of the owner
2. Name of the ewe
3. Does she have ID?
4. Tag No. of the ewe
5. When did you get? How (purchased, from research centers)?
6. Age of the ewe when acquired
7. Was she born in your flock or did you get from somewhere else?
8. How many lambs did this ewe deliver up to now? (The complete number, alive as well as dead ones)
 a) At the first______________________ b) At the second____________________
c) At the third_____________________
9. At what age did she give birth for the first time? (Age in months)
10. The month and year of first lambing, second, third_____________________________

11. Does the animal have any problems like udder abnormalities, mastitis, poor milk let down of else? If yes, for which problem you could account for?
12. Does this animal have any abortions?
a. If yes, how many and before which lamb did they occur
b. Where those early or late abortions?
13. Did this animal ever show difficulties to conceive? a. yes b. no
14. If yes, what do you think was the reason?
15. Is the ewe now pregnant and since how many months?

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Full Length Research Paper

Effect of a liquid extract of *Moringa oleifera* on body weight gain and overall body weight of weaning pigs

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Weaning piglets were continuously delivered a fermented extract of *Moringa oleifera* at a dilution of 1/250 in the drinking water beginning at 21 or 28 days of age. Weekly body weight and weight gain were measured for 5 consecutive weeks in the fermented extract treated and the control group. There was no significant difference between those groups (P<0.05), except the body weight gain in the period 21-28 days (P<0.05), as fermented extract treated piglets were heavier (1.16 kg) than the control group (0.61 kg). The data indicate that *M. oleifera* extract has a positive growth promoting effect on the animals.

Key words: *Moringa oleifera,* additive, weight gain, weaning, piglets.

INTRODUCTION

Antibiotics have been successfully used to control bacterial infections and as growth promoters in domesticated animals. In modern meat production, especially in pigs, the use of antibiotics improved the efficiency of feed conversion, resulting in faster weight gain and economic benefits (Niewold, 2007). Nevertheless, the abuse and misuse of antibiotic agents in meat production has led to antibiotic resistance of zoonotic bacteria including *Salmonella enterica, Escherichia coli, Campylobacter jejuni* and *Clostridium perfringens* in pig and poultry populations (Sridevi Dhanarani et al., 2009; Furtula et al., 2010).

The continuous use of antimicrobial agents may lead to a weakening of the immune system and to an imbalance of the intestinal microbiota. For example, a decrease in the IgM and IgA concentration was observed when macrolide, cycline and β-lactam antibiotics were added to the feed of weaning pigs (Bosi et al., 2011). Furthermore, an animal with a weakened immune system is susceptible to infection by pathogenic microorganisms including bacteria and viruses, which can reduce production performance. In order to maintain and enhance animal body weight, the scientific community and the industry are continuously searching for reliable and appropriate alternatives to antibiotics, for both growth promotion and therapeutic applications (Hume, 2009). Alternatives to antibiotics include natural herbal extracts known as essential oils from different plants such as citrus fruits, oregano, pepper, onion, thyme, eucalyptus and *Moringa oleifera* to stimulate the immune system and develop the gastrointestinal tract to improve the overall production performance (Hume, 2009; Amad et al.,

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Table 1. Chemical Composition of the *Moringa oleifera* liquid extract supplied in the experiments.

Element	Units	Results
Organic matter	%	+/- 6.0
Crude protein	%	+/-3.5
Ashes	%	+/-0.2
Fats	%	+/-0.3
Nitrogen	%	+/-0.06
Organic carbon	%	+/-3.4
Potassium	%	+/-0.12
Calcium	%	+/-0.35
Magnesium	%	+/-0.03
Density	kg/m³	1.025
pH		Between 4.2-5.4
EC	Mmhos/cm	97
Color		Yellowish brown
Smell		Characteristic

EC = Electric conductivity. Source: Nutritional Laboratory of Junta Agroempresarial Dominicana (JAD), Santo Domingo, Dominican Republic.

2011; Jamroz and Kamel, 2002; Hernandez et al., 2004).

M. oleifera is used to supplement the feed of ruminants, especially in tropical regions and leads to a positive performance enhancing effect (Sanchez et al., 2006; Mendieta-Araica et al., 2010). But *M. oleifera* is also well known as an immune stimulating and performance enhancing natural product, both in humans and in animals (Fahey, 2005; Garima et al., 2011). Further, studies were done showing the growth enhancing effects of a liquid extract on plants (Foidl et al., 2001); It is typically used as a dried leave powder or as a methanol leaf extract added as a supplement to the animal feed and has demonstrated positive effects (Foidl et al., 2001; Ly et al., 2001; Sudha et al., 2010). However, to the best of our knowledge, there are few scientific reports regarding the direct effect of liquid fermented extracts of *M. oleifera* added to the drinking water of weaning pigs. For these reasons, we conducted a field study to evaluate the performance of weaning pigs consuming drinking water treated with a liquid and fermented extract of *M. oleifera.*

MATERIALS AND METHODS

Location

The study was conducted in a commercial pig farm in the city of Moca, Espaillat Province, Dominican Republic. The Geo-climatic conditions were subtropical with an average temperature of 24°C, and 70% of humidity. The water supplied for the experiment came from a farm-owned well treated with chloride and softened with a filter to reduce the salts and heavy metals content.

Liquid extraction procedure

A commercial liquid extract of *M. oleifera* was used in this study, which is produced from 250 kg of mashed leaves and twigs in 1100 L of water (Immunobiol, produced by Green Miracle, Moca, Espalliat province. The characteristic chemical and physical values of the extract were measured and are stated in Table 1.

Experimental animals

A total of 400 pigs were used in two replicated experiments, two hundred per experiment. A total of ten floor cages housed 20 pigs each per experiment. Out of these ten cages, five received drinking water enriched with a fermented extract made from *M. Oleifera* and 5 were considered as control groups. From each one of the five treated and the five non-treated cages, three pigs were matched having the same sex and the same weight and were identified with earmarks.

The same procedure was conducted in each experiment. These three selected marked pigs per box were weighed individually weekly. The test boxes had an individual water supply separated from the control group so that the water for the test group could be handled separately. The extract was added for the duration of the experiment to the drinking water of the pigs in the test group at a concentration of 1 gallon to 250 gallons of drinking water. The pigs of the first experiment (five *M. oleifera* groups and five control groups) started receiving the extract at 21 and 28 days of age and in the first and second experiment, respectively.

The feed supply and consumption throughout the study was continuous and the feed was formulated with corn, soybean, digestible protein sources such as spray dried plasma, potato meal, fish meal and dry whey powder, which meet or exceeded the National Research Council (NRC, 2012). The exact feed consumption and the feed conversion could not be measured in this experiment due to local performance technical issues.

The weekly weight was measured for five weeks in pigs. All piglets received the same treatment and feed formulation with the exception of the extract treated delivered in the drinking water. The variables evaluated were the body weight and body weight gain. The body weight was measured by weighing the piglets in a scale graduated in grams and the body weight gain was calculated by subtracting the initial from the final weight per period.

Statistical analysis

The statistical analysis was conducted using the General Lineal Model (GLM) of the Statistical Analysis System (SAS, 2002) with a

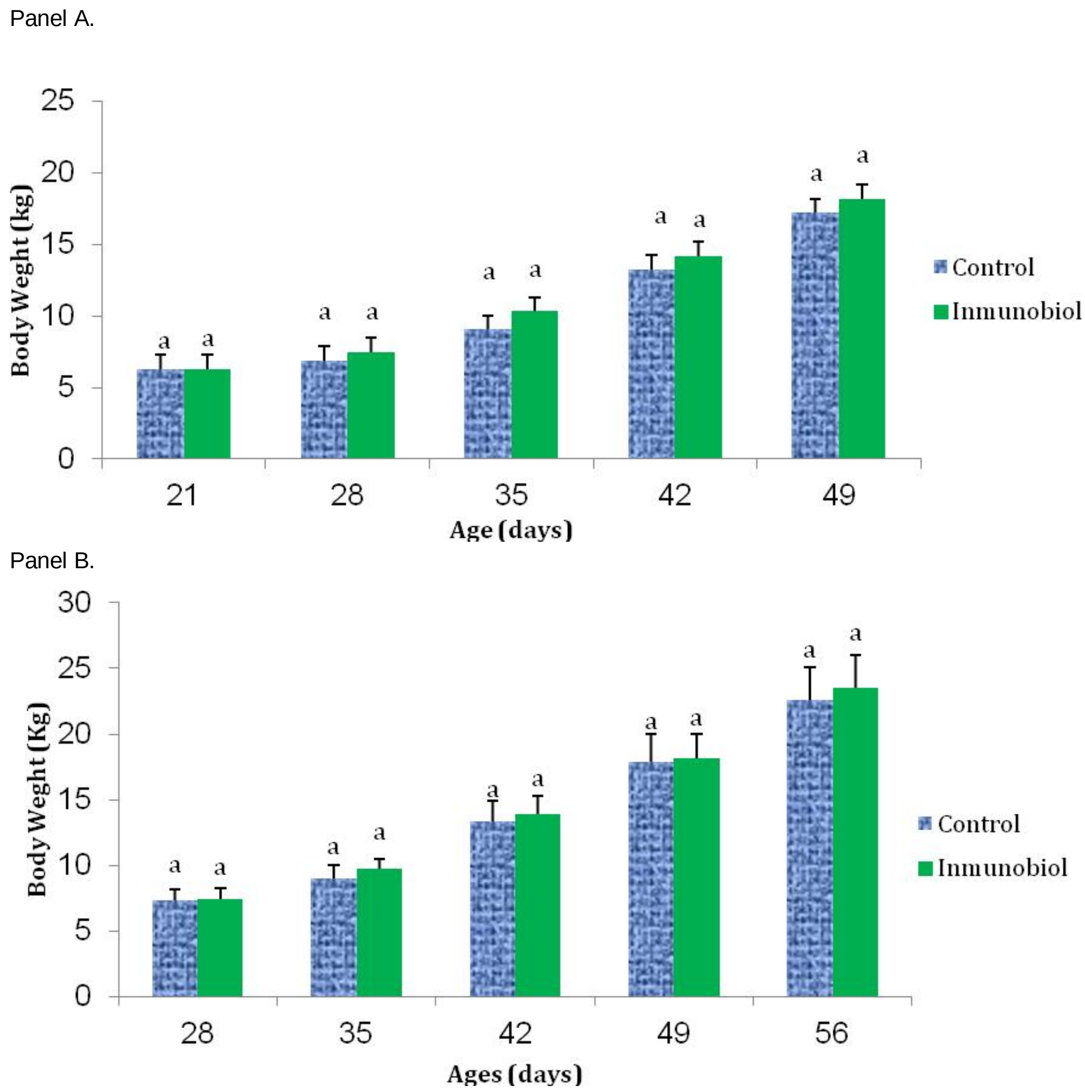

Figure 1. Body weight measured weekly for 5 consecutive weeks in piglets consuming drinking water or the same water treated with fermented *Moringa oleifera* extracts beginning at 21 (Panel A) or 28 (Panel B) days of age.

probability of 95%. The mean separation was done with Duncan of SAS with a probability of error not more than 5%.

RESULTS

In the first and second week, body weight gain was significantly increased in the group of pigs receiving the *M. oleifera* supplement ($P<0.05$; Figure 1A; Table 2). For the remaining time points in the experiment, body weight was not significantly different between the treatment and control groups in any other of the time periods evaluated. However, pigs receiving the extract of *M. oleifera* in the drinking water did have a higher body numerical body weight throughout all periods of the experiment.

At the beginning of the study on Day 21, the piglets in the control and treatment groups weighed an average of 6.28 and 6.32 kg, respectively. On Day 28, the control and treated pigs averaged 6.89 and 7.48 kg, respectively, which was significantly different between the two groups ($P<0.05$). On day 35, 42 and 49, the average body weights of the pigs treated with *M. oleifera* were always higher than the average body weights of the control groups, but not statistically significant ($P>0.05$). The final average body weight gain of the *M. oleifera* group was 11.85 kg, while the control group only gained 10.92 kg.

At the beginning of Experiment 2, there was no significant difference in the average body weight of the *M. oleifera* treated piglets (7.4 kg) and control group (7.38 kg) (Figure 1B). However, after 1 week of treatment at Day 35, *M. oleifera* treated piglets averaged 9.70 kg which was 0.68 kg more than the control animals with

Table 2. Body weight gain measured weekly for 5 consecutive weeks in piglets consuming drinking water or the same water treated with fermented *M. oleifera* extracts beginning at 21 (Panel A) or 28 (Panel B) days of age*.

Periods (days)	21-28	29-35	36-42	43-49	21-49
Group 1					
Control**	0.61±0.27[a]	2.17±0.80[a]	4.17±0.51[a]	3.97±0.49[a]	10.92±1.93[a]
Inmunobiol**	1.16±0.41[b]	2.84±0.34[a]	3.86±0.38[a]	3.99±0.52[a]	11.85±0.77[a]
Group 2					
Control*	1.63±0.37[a]	4.35±0.81[a]	4.55±0.59[a]	4.69±0.62[a]	15.22±1.65[a]
Inmunobiol**	2.30±0.42[a]	4.24±0.89[a]	4.25±0.67[a]	5.30±1.35[a]	16.09±1.94[a]

*Data represent the Means±SEM of 15 pigs per treatment. **Means±SEM in the same column with similar letters no differ statistically (P>0.05).

9.02 kg. The same trend was observed at 42, 49, and 56 days of age, where the piglets fed with the *M. oleifera* extract were heavier than the piglets of the control group. At the termination of the experiment, the piglets consuming water containing the *M. oleifera* extract, gained an average of 0.89 kg (3.9%) more than the piglets of the control group. Furthermore, the overall averaged body weight of the *M. oleifera* fed group was 16.09 kg, whereas the control group only gained 15.22 kg.

DISCUSSION

M. oleifera is a hardy tree that can grow in nutrient poor soil and is well adapted to drought conditions. In recent studies, the effects of supplementing proteins and fatty acids with *M. oleifera* dried leave flour was shown in pigs (Mukumbo et al., 2014). Moringa leaves have also been reported to provide a suitable protein source for ruminant and monogastric livestock (Soliva et al., 2005).

Extracts from the leaves and pods have been reported to have numerous health benefits and seed extracts have been shown to be antimicrobial (Atawodi et al., 2010). Raw Moringa components may contain certain amounts of antinutritional factors including tannins and saponins that could interfere with nutritional beneifts, although the concentrations are quite low (Foidl et al., 2001). Further, it has been demonstrated that fermentation of *M. oleifera* leaf extract by *Lactobacillus plantarum* increases protein content, pepsic digestibility of protein and availability of iron in the extract which can be considered as a prebiotic enhancement of its effectively (Thierry et al., 2013).

Olufunsho Awodele et al. (2011) reported decreased food consumption and no toxic effects in rats consuming *M. oleifera* extract. Further, treated rats had the same weight as rats that did not consume the extract, which provides some evidence of improved feed conversion. Like the rat study, the author did not observe any evidence of toxicity using a 0.4% final concentration. However, it was not possible to measure feed conversion in these experiments.

Supplementation of the piglet diet with these fermented compounds may have supplied some nutrient benefits. However, given the low dosage that the piglets received, the weight gain seen in these experiments was probably not due to the nutrient content of the extracts, but more likely due to the performance enhancing effects of a number of detected phyto-components in the plant (Garima Mishra et al., 2011).

The data presented here indicate that the piglets consuming water treated with *M. oleifera* extract showed an increased weight gain, and this weight gain was more noticeable in the first experiment where piglets started the treatment at an earlier age. This might indicate that the effect of the liquid extract of *M. oleifera* is more effective at a younger age. Previous studies indicate that other antibiotic alternatives (feed additives, botanicals, probiotics) are also more effective in young animals with a naïve immune system and under developed gastrointestinal tract (Uni et al., 1999; Uni et al., 2003; Solis de los Santos et al., 2003). It appears that some prebiotics and plant extracts can impact the developing gastrointestinal morphology and the associated immune system in a positive manner (Uni and Ferket, 2004). Solis de los Santos et al. (2005) reported that the villus height and the intestinal surface area were significantly increased in chicks fed a prebiotic supplement. Similarly, phytogenic feed additives have also been demonstrated to alter intestinal villi structure which impacts weight gain (Namkung et al., 2004; Nofrarias et al., 2006; Oetting et al., 2006). Accordingly, the piglet weight gain observed in these experiments may be partly explained by taller villi as a result of the *M. oleifera,* which would result in a larger surface for nutrient absorption (Gartner and Hiatt, 2001). However, no intestinal samples were obtained, and thus, this hypothesis remains to be validated.

In conclusion, the results presented here indicate that fermented extracts of *M. oleifera* are promising growth promoter alternatives for use in swine production. The extracts of these trees are available and can be made at a relatively low cost which also facilitates their use. The data collected here indicate that efficacy is related to age, which may be related to development of immature immune and gastrointestinal systems. Further research should be conducted to understand how this extract impacts the immune system and gastrointestinal tract architecture in order to optimize the use of *M. oleifera* extracts.

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