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Full Length Research Paper

The effect of replacement of part of dietary crude protein with urea on the performance and carcass characteristics of grasscutters (*Thryonomys swinderianus*) in captivity

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A 24 week feeding trial was conducted to evaluate the effect of replacing a portion of protein requirement of grasscutters with urea on growth performance, carcass characteristics and microbial composition of the caecum. In all, forty grasscutters of age 3- months old were used. There were four dietary treatments with ten replicates in a randomised complete block design. The treatments were; control (U0%-P) which had protein from plant sources only. Treatment 2 (U30%-P) had 70% plant protein and 30% urea, Treatment 3 (U25%-P) had 75% protein from plants and 25% from urea and Treatment 4 (U0%-AP) had 10% protein from animal source and 90% from plant source. Parameters measured included, feed intake, feed wastage, carcass characteristics, caecal pH and caecal microbial composition and meat quality. The data collected was subjected to the analysis of variance with SAS (2008) and significant difference separated at 5% level. The results obtained showed that daily feed intake, feed wastage, and feed conversion ratio were not significantly different ($P > 0.05$) among dietary treatments. However, daily feed wastage was higher than feed intake. Daily weight gain 9.82, 9.70, 9.27 and 10.9 g/day respectively for U0%-P, U30%-P, U25%-P and U0%-AP was not significantly ($P > 0.05$) different among dietary treatments. The protein, fat and moisture content of the meat were influenced by urea supplementation. Dressing percentage was significantly ($P < 0.05$) influenced by dietary treatments but weight of organs to body weight did not differ significantly ($P > 0.05$). Caecal pH ranged from 5.9 - 6.0 and was not significantly ($P > 0.05$) influenced by urea supplementation. Microbes observed in the caecum were mainly *Bacillus* sp. Protein and fat content of the meat was influenced ($P < 0.05$) by dietary treatments but not pH. Urea supplementation of U30%-P and U25%-P reduced the variable cost by 31 to 44% and 36 to 48% respectively making the use of urea economical in the diet of grasscutters. It was concluded that urea can be used in grasscutters diet without any deleterious effects on their general performance or carcass characteristics but renders the production more economical.

Key words: Urea supplementation, grasscutters, plant protein, caecal pH, caecal microbes.

INTRODUCTION

The animal industry plays a very vital role in any country in meeting the protein requirements of the population. The current rate of population growth indicates that the world population might hit 9 billion by the year 2040 of which developing countries are considered the most populous (UNDESA, 2013). There is therefore the need to improve on technology as well as managerial skills to be able to produce enough to feed the rising population. An average Ghanaian consumes 59.8 g of protein per day of which 16.7 g (27.9%) is from animal origin (FAO, 2007). This falls short of the recommended daily protein requirement of 70 to 80 g of which 50% should be of animal origin (FAO, 1990). Malnutrition is therefore prevalent in many communities in Ghana.

The rather low intake of animal protein is mainly attributed to low production of animals which has created a shortfall in the supply of meat, and as a result has led to the influx of imported animal products onto the Ghanaian market to meet this demand (Fialor, 2010). Efforts are being made to increase the production of existing breeds of animals including ruminants. However, increasing the production of the existing breeds of ruminants cannot be achieved rapidly due among other reasons, poor reproductive rate, poor growth rate and poor nutrition (Thrupp, 1998). There is the need for rodents that are tractable and prolific to be domesticated to augment the existing meat supply (Mbah, 1989). The development of the grasscutter or cane rat as an alternative source of meat has gained increasing importance lately in Ghana because of its delicacy. Grasscutter meat contributes considerably towards the alleviation of protein shortages in some parts of Africa (Ntiamoah-Baidu, 1998). However, there are some challenges confronting grasscutter farming in Ghana (Adu et al., 1999). These include the provision of balanced diets to the animals, acquisition of improved genetic breeds and the control of diseases such as Staphylococcosis, Enterotoxaemia and Cestodiasis among others (Adu et al., 1999). Prominent of these is the provision of diets containing adequate nutrients. Work done by Adu and Wallace (2003) and Kusi et al. (2012) indicated that the protein contents of these feeds are often far below the 15 to 18% deemed to be required by the grasscutter for growth and reproduction. However, conventional protein sources such as fish meal and oil seed cakes such as soyabean meal are very expensive (Minson, 1997) and most farmers cannot afford them. There is therefore the need to look for available alternative but suitable cheaper protein sources or use to some limited extent non-protein nitrogenous sources that can equally promote growth and productive performance.

Urea has been used to replace part of the protein in the diet of cattle, sheep and other ruminants because of the micro-organisms (bacteria, protozoa and fungi) present in their rumen (Preston and Leng, 1987). The grasscutter is a non-ruminant herbivore (Akinnusi et al., 2009) and has microbes in part of the gastro intestinal tract (caecum) for fermentation and microbial protein synthesis (McDonald et al., 2010). The microbes are retaken through coprophagy (Pond et al., 1995) and they may benefit from substituting part of the protein in the diet with urea just like ruminants. If urea, a non-protein nitrogen can be utilized by grasscutter as the case is with ruminants then this will cut down cost of protein in feed (Sewell, 1993). The study was therefore undertaken to determine if grasscutters during the growing phase could benefit from substituting part of the protein requirements with urea (NPN).

MATERIALS AND METHODS

Experimental location

The experiment was conducted at the grasscutter Unit of the Department of Animal Science Education of the College of Agriculture Education, University of Education, Winneba, Mampong –Ashanti, Ghana. Geographically, the study area lies on latitude 07° 04'N and longitude 01° 24'W with an altitude of 457 m above sea level. Mampong-Ashanti is found in the North West of the Transitional Zone of the forest and the savannah regions of Ghana. The climate of Mampong is the wet semi-equatorial type, which experiences a bi-modal rainfall pattern with maximum and minimum temperatures of 30.6 and 21.2°C respectively (MSD, 2010).

Experimental animals and design

Forty weaned grasscutters made up of twenty females and twenty males obtained from local farmers in Sunyani- Ghana, were used for the experiment. The grasscutters were put into groups of similar body weights and were randomly allocated to four dietary treatments in a randomized complete block design. There were ten replications of each treatment. Each animal constituted a replicate.

Housing

The grasscutters were housed singly in wooden three tier cages. Each cage had dimension of 60 x 50 x 40 cm. The cages were partitioned with crimped wire mesh. The floor of the cages was covered with wire mesh underneath which was a drawer into which faeces and wasted feed could pass. The cages were placed in a well-ventilated cement block walled house roofed with asbestos sheets to protect the animals from bad environmental conditions such as rainfall and cold conditions.

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Table 1. Percentage composition and calculated values of dietary treatments.

Ingredients	U 0%-P	U30%-P	U25%-P	U0%-AP
Wheat bran	30.35	36.25	34.68	30.28
Dry cassava chips	44.13	50.98	49.67	44.07
Soyabean meal	24.00	9.2	11.92	20.08
Fish meal(Tuna)	-	-	-	4.04
Vitamin mineral premix ²	0.5	0.5	0.5	0.5
Dicalcium phosphate	0.5	0.5	0.5	0.5
Common salt	0.5	0.5	0.5	0.5
Urea	-	2.05	1.73	-
Sodium sulphate	-	0.0426	0.32	-
Calculated analysis in (%)				
Nitrogen	2.88	2.88	2.89	2.88
Calcium	0.23	0.20	0.21	1.06
Phosphorus	0.64	0.55	0.57	0.96
Crude protein	18.00	18.00	18.05	18.00

²Vitamin mineral premix provided the following per kilogram of diet; Vitamin A 8,000 000 u.1, Vitamin D3 1,500 000 u.1, Vitamin E 2500 mg, Vitamin K3 100 mg, Vitamin B2 2000 mg, Vitamin B12 5 mg, Folic acid 500 mg, Nicotinic acid 8000 mg, Calcium Panthotenate 2000 mg, Choline 50000 mg, Magnesium 50000 mg, Zinc 40000 mg, Copper 4500 mg, Cobalt 100 mg, Iodine 1000 mg, Selenium 100 mg.

Experimental diets

Four diets were formulated to contain approximately 18% crude protein. Diet 1 designated as U0%-P had all the protein derived from plant sources. Diet 2 designated as U30%-P had 70% of the protein derived from plant sources while 30% was from urea. Diet 3 designated as U25%-P had 75% of the protein derived from plant sources while 25% was from urea. Diet 4 designated as U0%-AP contained 10% animal protein with the rest from plant sources. Sodium Sulphate was added to the diets that contained urea in order to obtain a nitrogen to sulphur (N:S) ratio of 10:1. The composition of the experimental diets is presented in Table 1.

Data collection

Parameters measured included feed intake, feed wastage, water intake, body weight gain, carcass characteristics, caecal pH and microbial composition and meat quality. Feed and water for the animals were given *ad libitum*.

Chemical assay

The proximate content of the diets were determined according to the procedures of the (AOAC, 1990).

Carcass parameters

Four animals made up of two males and two females were randomly selected and sacrificed at the end of the feeding trial for carcass analysis. Prior to slaughtering, the animals were fasted overnight but had access to water. After slaughter, the carcasses were eviscerated, weighed and chilled at 4°C for 24 h to obtain the cold carcass weight.

Caecal pH

The pH of the digesta from the caecum was measured for the respective replicates with a digital pH meter. Five grams of caecal digesta from the respective replicates was collected in a previously labeled beaker. The probe of the digital pH meter was rinsed with distilled water before inverting into each of the replicate caecal digesta (EUTECH, 1999).

Caecal microbial composition

One gram of caecal digesta of the various experimental animals was taken when the grasscutters were sacrificed for carcass assessment. In the determination of the microbes, an agar solution was prepared. This was done by dissolving six nutrient agar pours in a boiling water bath of 200 ml until they were liquefied and was placed in a 50°C water bath until it was used. The samples containing the caecal digesta of the various treatments were shaken to ensure an even distribution of micro organisms. 10 ml of melted agar was aseptically poured into a previously labeled petri plate that contained the respective samples that had been diluted. The respective petri plates were swirled to mix the sample with the agar while making sure that the agar did not run over the edges of plate. The lid of the respective plates was replaced and was allowed to cool and solidify. The inverted plates were then incubated at 30°C for 24 h. After incubation, the microbial colonies on each plate were stained with Ruthenium, observed under a light microscope which was previously fitted with a camera on the eyepiece. The colonies observed were photographed and the print out was compared with a chart which aided the identification of the observed colonies (Kamra and Pathak, 1996).

Statistical analysis

Data collected was subjected to analysis of variance using SAS (2008) and differences among treatment means isolated at 5%

Table 2. Proximate composition of experimental diets.

Parameter	U 0%-P	U 30%-P	U 25%-P	U0%-AP
Crude protein (%)	18.4	18.2	18.3	18.1
Crude Fibre (%)	4.95	5.98	5.36	4.56
Ether Extract (%)	5.50	4.50	4.00	5.00
Nitrogen free extract (%)	50.12	50.88	50.88	51.46
Ash (%)	8.42	8.42	8.56	8.12
Moisture (%)	12.61	13.36	12.90	12.76

significant level using least significant difference (Table 1).

RESULTS AND DISCUSSION

Proximate composition of diets

The crude protein content of the experimental diets analysed was similar to the calculated values and met the crude protein requirements of growing grasscutters (18%) (Kusi et al., 2012). This indicated that the crude protein content was iso-nitrogenous and therefore no undue advantage was given to any particular treatment. The results of the proximate composition of experimental diets are presented in Table 2.

Effect of urea on growth performance

Feed intake, water intake and feed conversion were not significantly influenced ($P>0.05$) by dietary urea supplementation. Body mass gain was however significantly influenced by urea supplementation (Table 3). Also sex of the grasscutters and time of experiment did not influence these parameters. Daily feed intake ranged from 77.5 to 83.4 g. These similar feed intakes are attributed to similar protein levels of the experimental diets. However, the values of feed intake obtained in this study are higher as compared with 53.8 to 66.2 g reported by Karikari and Nyameasem (2009). Feed wastage by grasscutters was not significantly influenced by dietary treatments, however a high percentage of 60% of feed offered was wasted confirming the observation that grasscutters are wasteful feeders. Water intake of dietary treatments ranged from 167 to 172 ml. Urea supplemented diets had lower water intake as compared to the control but were not significantly different due to similar moisture content of the diets and it is consistent with observation made by Ward (2007). The daily body weight gain of grasscutters fed diet that contained plant and animal protein (U0%-P) and (U 0%-AP) respectively were heavier ($P<0.05$) as compared with the other dietary treatments. This could probably be as a result of the animal protein which is of higher quality in its amino acid profile than both plant and microbial protein (Rahjhan, 1993). Feed conversion ratio ranged from 7.44 to 8.53. However, grasscutters fed (U0%-AP) were most efficient

(7.44) in converting feed to body mass. However, figures obtained in this study are high as compared with 5.1% reported by Karikari and Nyameasem (2009). The relatively higher feed conversion ratio values obtained in this study could be attributed to the wooden cages used in this study which makes grasscutters aggressive in the presence of humans and caretakers which provides a hiding area that allows grasscutters hide from human sight (Karikari and Nyameasem, 2009).

Caecal pH and microbial composition

The pH of the caecum was not significantly affected by dietary urea supplementation. The pH of the caecum ranged from 5.8 to 6.0 (Table 4) which is considered slightly acidic and was therefore not surprising to have bacillus which was able to thrive under these conditions. The caecal pH values obtained in this study are in the range of rumen p^H reported for cattle, sheep and goats by McDonald et al. (2010). This indicated that the caecal environment as influenced by p^H might be similar to the rumen environment of cattle, sheep and goats. The microscopic examination of the digesta obtained from the caecum of grasscutters fed the various diets was indifferent in caecal microbial composition. The microbial colonies observed from the microscopic examination appeared to be the same for all dietary treatments. This indicates that urea supplementation is not likely to affect microbial composition in the caecum. Microbes identified in the caecum were mainly bacteria which were dominated by Bacillus species. No fungi or protozoa were identified in this study. Studies as regards microbial composition in the caecum of grasscutters are limited and therefore this study cannot strictly say that the only microbes in the caecum are bacteria. There is therefore the need to take caecal samples from grasscutters in the wild other than those in captivity and analyse for microbial composition in order to establish the variety of microbes present in the caecum of grasscutters obtained from the natural environment (wild) of the grasscutter.

Carcass characteristics

Dressing percentage was significantly ($P<0.05$) affected by dietary treatments (Table 5). Grasscutters fed diet

Table 3. Effect of experimental diets on the performance of grasscutters.

Fixed effect	Daily feed intake (g)	Daily feed wastage (g)	Initial body weight (g)	Final body weight (g)	Total weight gain (g)	Daily weight gain (g)	Feed conversion efficiency	Daily water intake (ml)
Sex								
Male	80.6±2.3	119.6±2.5	787.5±22.7	2836.6±57.1	2049.1±50.6	9.7±0.24	8.37±0.29	161.6±4.5
Female	78.9±2.3	120±2.5	787.9±22.7	2920.9±57.1	2133.0±50.4	10.1±0.23	8.04±0.29	177.8±4.6
Time of experiment								
18-01-2010	78.06± 2.42	120.90± 2.59	752.91 ± 23.5	3024.25 ±59.31	2271.34±52.50	10.76± 0.25	7.25± 0.31	161.64± 4.93
02-09-2010	81.37± 2.30	118.81± 2.46	822.51 ±22.47	2733.30 ± 56.34	1910.79 ± 49.87	9.06± 0.246	9.17± 0.29	177.76 ± 4.69
Treatment								
U0%-P	79.63 ± 3.30	117.49± 3.54	773.56 ± 32.33	2845.50 ± 81.07 ^a	2071.94 ± 71.75 ^a	9.82± 0.34 ^a	8.42± 0.42	172.21 ± 6.74
U30%-P	78.34 ± 3.36	121.82± 3.59	781.3 ± 32.83	2827.59 ± 82.33 ^a	2046.21 ± 72.87 ^a	9.70± 0.35 ^a	8.16± 0.43	166.58 ± 6.85
U25%-P	77.50 ± 3.29	124.50± 3.52	794.40 ± 32.16	2751.00 ± 80.65 ^a	1956.60 ± 71.38 ^a	9.27± 0.34 ^a	8.53± 0.42	170.70± 6.71
U0%-AP	83.40 ± 3.29	115.60± 3.52	801.50 ± 32.16	3091.00 ± 80.65 ^b	2289.50 ±71.38 ^b	10.9± 0.134 ^b	7.44± 0.42	169.30± 6.71

Means bearing different superscript in the same column are significantly ($P < 0.05$) different.

Table 4. Caecal pH and microbial composition.

Parameter	U0%- P	U30%-P	U25%-P	U0%-AP
Caecal p ^H	5.9± 0.06	6.0± 0.06	5.8± 0.06	6.0± 0.06
Microbial composition				
Bacteria (Bacillus)	√	√	√	√
Fungi	x	x	x	x
Protozoa	x	x	x	x

X=Absent, √=present.

U0%-AP (72.01%) had significantly ($P < 0.05$) higher dressing percentage than those fed diets U30%-P (69.20%) and U25%-P (67.02%) but not those fed diet U0%-P, (71.96%). Grasscutters fed diet U0%- P, (71.96%) had significantly ($P < 0.05$) higher dressing percentage than those fed diet U25%-P (67.02%). Dressing percentage is the live

weight of the animal less the weight of the internal organs, head, legs, blood and fur. Consequently, the significant ($P < 0.05$) difference between grasscutters fed diet U0%-AP (72.02%) and those fed the diets that contained urea U30%-P (69.20%) and U25%-P (67.02%) could probably be attributed to differences in the weight of the

blood fur and feed in the gastro intestinal tract. The mean dressing percentage value of 70% obtained in this study is slightly lower than the mean dressing percentage of 76.98% reported by Omole et al. (2005), when eight grasscutters of mean total body weight of 2.65±0.006 kg were fed with diets which did not contain urea. Trimmable

Table 5. Carcass characteristics of grasscutters fed experimental diets.

Fixed effect	Mean dressing percentage	Trimmmable fat (%)	Liver to body weight (%)	Kidney to body weight (%)	Heart to body weight (%)	Lungs to body weight (%)	Spleen to body weight (%)
Sex							
Male	70.69±0.82	1.60±0.59	2.00±0.56	0.26±0.64	0.54±0.47	0.54±0.87	0.07±0.66
Female	69.39±0.82	1.60±0.59	1.98±0.56	0.27±0.64	0.53±0.47	0.54±0.87	0.07±0.66
Time of experiment							
18-01-2010	66.61±4.04	1.58±0.03	1.97±0.03	0.28±0.01	0.54±0.07	0.55±0.01	0.08±0.00
02-09-2010	73.48±4.04	1.60±0.03	2.02±0.03	0.27±0.01	0.54±0.07	0.53±0.01	0.07±0.00
Treatment							
U0%-P	71.96±5.71 ^{ab}	1.59±0.04	1.98±0.05	0.28±0.21	0.55±0.01	0.53±0.01	0.08±0.01
U30%-P	69.20±5.71 ^{bc}	1.52±0.04	1.98±0.05	0.25±0.21	0.54±0.01	0.55±0.01	0.07±0.01
U25%-P	67.02±5.71 ^c	1.58±0.04	1.96±0.05	0.28±0.21	0.53±0.01	0.53±0.01	0.07±0.01
U0%-AP	72.01±5.71 ^a	1.65±0.04	1.98±0.05	0.26±0.21	0.54±0.01	0.54±0.01	0.08±0.01

Means in a column with different superscripts are significantly ($P < 0.05$) different.

Table 6. Chemical composition and pH of grasscutter meat.

Fixed effect	Protein %	Fat %	Ash %	Moisture %	pH
Sex					
Male	28.43±0.49	4.24±0.09	0.55±0.04	67.08±1.05	5.62±0.02
Female	27.35±0.49	4.23±0.09	0.53±0.04	67.28±1.05	5.64±0.02
Time of experiment					
18-01-2010	27.26±0.48	4.22±0.09	0.53±0.04	65.65±1.05	5.47±0.02
02-09-2010	28.53±0.48	4.26±0.09	0.55±0.04	68.72±1.05	5.80±0.02
Treatment					
U0%-P	27.23±0.68 ^b	4.83±0.13 ^{ab}	0.53±0.05 ^{ab}	61.65±1.49 ^b	5.49±0.03
U30%-P	25.22±0.68 ^{bc}	3.76±0.13 ^{bc}	0.47±0.05 ^{bc}	74.16±1.49 ^a	5.84±0.03
U25%-P	25.28±0.68 ^c	2.80±0.13 ^c	0.45±0.05 ^c	69.33±1.49 ^{ab}	5.72±0.03
U0%-AP	33.85±0.68 ^a	5.58±0.13 ^a	0.72±0.05 ^a	63.61±1.49 ^{ab}	5.49±0.03

Means in a column with different superscripts are significantly ($P < 0.05$) different.

fat was not significantly ($P > 0.05$) affected by dietary treatments. However, grasscutters fed diet U 0%-AP (1.65%) had a numerically higher fat deposition compared with those fed diets U0%-P (1.59%), U30%-P (1.52%) and U25%-P (1.58%). The mean trimmable fat (1.60%) in this study is however, higher than the value of (1.22%) obtained by Omole et al. (2005). The proportions of liver, kidney, heart, lungs and spleen to body weight of the animals were not significantly ($P > 0.05$) affected by dietary treatments. Sex and time of the experiment did not significantly ($P > 0.05$) affect carcass characteristics.

Chemical composition of grasscutter meat

The protein content of the grasscutter meat was

significantly higher (33.85%) for the meat of grasscutters fed U%-AP diet as compared with 27.23% for U 0%-P, 25.22% for U30%-P and 25.28% for U 25%-P (Table 6). The significantly higher protein concentration in the grasscutter meat of those fed the U%-AP diet is attributed to the inclusion of fish meal and soya bean meal which might have supplied amino acids in adequate quantities and proportions which were used for tissue synthesis, which resulted in an increased concentration of protein in the meat (Ranjhan, 1993). The fat content of the grasscutter meat was significantly higher 5.58 and 4.83% for grasscutters that were fed U0%-AP and U0%-P respectively as compared with grasscutters fed urea supplemented diets.

The relatively higher fat deposition is attributed to the

Table 7. Benefit cost analysis.

Description	U0%-P	U30%-P	U25%-P	U0%-AP
Variable cost (Gh¢)	10.98	6.94	7.48	18.51
Fixed cost (Gh¢)	55.1	55.1	55.1	55.1
Cost of grasscutter (Gh¢)	20	20	20	20
Revenue accrued (Gh¢)	56.70	56.54	55.02	61.82
Discounted cost (Gh¢)	122	104.42	102.59	137.4
Discounted revenue (Gh¢)	118.05	117.70	114.35	128.79
Benefit cost ratio (Gh¢)	0.97	1.13	1.12	0.94

faster growth rate as compared with grasscutters fed diets that contained urea. The ash content of the grasscutters meat followed a similar pattern to that of fat and protein of the meat and is attributed to the high phosphorus (0.96%) and calcium (1.06%) of the fish meal. The moisture content of the meat was higher (74.16%) ($P < 0.05$) for the meat of grasscutters fed U25%-P diet as compared to U0%-P but not U30%-P and U 0%-AP. The moisture content of the meat was affected significantly ($P < 0.05$) by the experimental diets. The moisture content of the meat ranged from 61.65% to 74.16%. The moisture content in the meat of grasscutters fed diet U0%-P (61.65%) was significantly ($P < 0.05$) lower than the moisture content of the meat of grasscutters fed diet U30%-P (74.16%) but not different from those fed diets U25%-P (69.33%) and U0%-AP (63.61%). The higher moisture content in the meat of grasscutters fed diet U30%-AP (74.16%) might be attributed to an increase in the size of the spaces between the filaments of the muscles in the meat which retained a lot of moisture. Water occupying this space is referred to as free water and is held there by steric effect and reported that a higher pH goes with higher meat moisture content (Qiao et al., 2001). Therefore, the relatively higher moisture content in the meat of grasscutters fed diet U30%-P (74.16%) could be attributed to a higher pH (5.84) although there were no significant ($P > 0.05$) differences in the pH of the meat of grasscutters fed the various experimental diets.

Economics of production

The variable costs which were labour for feeding animals, cleaning the cages, record keeping and watering, feed, electricity and water amounted to GH¢ 10.98, GH¢ 6.94, GH¢ 7.48 and GH¢ 13.51 for U0%-P, U30%-P, U25%-P and U0%-AP respectively per grasscutter. The fixed costs amounted to GH¢ 55.10 per animal in each treatment. The revenue was obtained by multiplying the final body weight of each grasscutter by the selling price of the grasscutter which was GH¢ 20.00 per kilogram body weight. The following revenue GH¢ 56.70, GH¢ 56.54, GH¢ 55.02 and GH¢ 61.82 were obtained for

U0%-P, U30%-P, U25%-P and U0%-AP respectively. Grasscutters mature and give birth to an average of two offspring at the end of the first year or at the beginning of the second year (4 month) of operation. Their offspring can thus be sold in the second year. Under such circumstances, if three grasscutters are sold, benefits (measured as revenue) which will be GH¢ 118.05, GH¢ 117.70, GH¢ 114.55 and GH¢ 128.71 will be accrued in the second year of operation for U0%-P, U30%-P, U25%-P, and U0%-AP respectively (Table 7). The BCR values were 0.97, 1.13, 1.12 and 0.94 for U0%-P, U30%-P, U25%-P and U0%-AP respectively for the four treatment lines. On the basis of the viability or the worthiness of the project, U30%-P, and U25%-P should be accepted since their values exceed the benchmark of 1.0. U0%-P and U0%-AP should be rejected because their values fall below the benchmark criteria of 1.0.

Conclusion

The results of the studies show that urea can be used in the grasscutters diet without any deleterious effects on their general performance or carcass characteristics. The use of urea in the grasscutters diet to replace part of the protein renders the production more economical and viable

Conflict of Interest

The authors have not declared any conflict of interest.

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Full Length Research Paper

Production practices and constraints of pig farms in N'Djamena area, Chad

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Practices and constraints of pig farming in the area of N'Djamena were submitted to transversal and retrospective and longitudinal investigation. The study concerned a sample of 176 farmers, divided in 4 of the 5 districts where pigs are raised in N'Djamena and 12 surrounding villages. The survey rate was 12% in N'Djamena and 20% in the suburban area. The monitoring concerned 8 farms in the city and 7 at its periphery during one year. Older farmers numbers or ages averaged 43.8 ± 13.7 years were plant producers (52%), employees (24%), small traders, workers and artisans (11%), students and pupils (9%) and retired persons (4%). The constitution of herds by buying pigs was dominant in urban (85%) and suburban (89%) farming systems. Most of the farms (97%) had piggeries but 53% were in defective conditions. The alcohol residues (99%) and artisanal spent grains (67%) were the basic feeds served mostly 2 times a day (67%). Average litter size at farrowing, piglets born-alive and numerical productivity per year per sow were significantly higher ($p < 0.05$) for breeders who used mineral (sodium carbonate and sodium chloride) supplementation. Theft (45%) and mortality (41%) represented the larger part of the 1,350 annual losses of the farms. Respiratory and digestive symptoms dominated (62%) in the monitored farms. These symptoms are related to the bad conditions of piggeries and scavenging pigs. Improvement of reproductive and numerical productivity by mineral supplementation appears interesting; and suggests further studies on this aspect to provide advices to producers. Knowledge of practices and constraints of pig farms are of great importance for the production improvement actions.

Key words: Pig breeding, production practices, constraints, N'Djamena, Chad.

INTRODUCTION

The cities constitute centers of agropastoral productions whose contribution in feeding populations is undeniable (Moustier and De Bon, 2005). The cities represent also sure markets for the agricultural products of the nearby and distant zones from the urban centers (Guerin and

Faye, 1999). Thus, the analysis of dynamic agricultural sector performance and face new opportunities and inherent constraints of proximity of the city is needed to better appreciate them (Broutin et al., 2005). The area of N'Djamena is the second pool of pigs' production in

Chad, after the southern zone (Koussou and Duteurtre, 2002). Pig husbandry is mostly practiced in a traditional way. Feeding is based on the use of local artisanal by-products, kitchen wastes, etc. Animals wander during the days and are kept in a pen at night in the dry season. During the dry season, they are confined in order to avoid damages to cultures in rural areas and in the suburban villages. In urban environment, pigs are systematically confined at night in pigsties made of local materials (Mopaté and Koussou, 2003).

At the end of 2009, N'Djamena population was estimated to be one million city-dwellers and it increases at the rate of 5.4% per year (MEP, 2009). This strong urbanization has consequence on the supply of animal food products for the city-dwellers. Indeed pigs and poultry constitute, as the result of their high productivity, the species of choice in satisfying the fast increase in demand of animal proteins.

In favor of the increase demand of the external and internal demand of pork, a relative development of the production is observed in the two localities during the two last decades (Koussou and Duteurtre, 2002; Mopaté et al., 2006). In N'Djamena, the supply of about 7,000 slaughtered pigs in 2005 comes from urban and suburban farms (Mopaté et al., 2006) whose production practices and constraints remained unknown.

The purpose of the study therefore was to characterize the producers, production practices and constraints of pig farms in the area of N'Djamena.

MATERIALS AND METHODS

Study site

The study was conducted in urban and periurban zones of N'Djamena, Capital of Chad. The geographic coordinates of the city, noted by Global Positioning System (GPS) are 12° 11' 30" north latitude and 15° 04' 91" east longitude.

Sampling and method of data collection

The transversal and retrospective survey was carried out in 4 of the 5 districts where pigs are raised (1st, 3rd, 7th and 9th) in N'Djamena. These districts were drawn randomly. It was the same neighborhoods surveyed: Farcha and Madjorio for the 1st district, Sabangali for 3rd, Chagoua, Dembé, Abena and Atrone for the 7th, Karway and Walia for the 9th. The number of farmers surveyed corresponded to 12% of farmers in urban area. In the suburban area (within 100 km), 12 villages including 9 in the south and 3 in the northern part of N'Djamena were also randomly selected. Because of the smaller number of producers in the suburban sector compared to the urban areas, 20% of farmers were surveyed. In the whole, a total of 176 farmers were sampled and investigated in the two areas.

Factors searched were the characteristics of the breeders (age,

sex, activities and school levels); practices of production (constitution and property of the herds, housing, food, health care and reproduction); losses related to conduct and diseases.

The second phase was the monitoring of 15 pig farms including 8 inside town and 7 on the outside. In total, 287 animals including 168 inside and 119 outside were identified individually with numbered ear tags. The rhythm of visits on the farms was monthly, during one year. According to the availability of the farm, they took place early in the morning before the opening of the pigsty or in the afternoon when all the animals are all present in order to better control their numbers. Data recorded during these visits concerned losses and their causes, sales and purchases of animals and places of transaction.

As for the longitudinal and transversal survey, the explanations have been given to the farmers during the sensibilisation phase. Livestock technicians recruited for this study were trained on the practical and theoretical basis on techniques of approaching the farmers and the protocol of monitoring the farms. In addition, they have been constantly controlled by the person responsible for the study during the information collection phase with the farmers.

Data analysis

Data were treated with MS-Excel, descriptive and variation analysis with SPSS (2009). A simple sorting and cross-tabulation of data is done first. Analysis of variance was performed by ventilation averages over the area factor (urban, periurban) and the practice of mineral supplementation. The threshold signification retained on the differences of average was 5%.

RESULTS

Characteristics of farmers

Regarding 176 surveyed farmers, 59% were in the city and 41% in the suburban area. Their average age was 43.8±13.7 years and were mainly from the Sudanese region of Chad. Breeders were agricultural producers (52%), employees (24%), small traders, workers and artisans (11%), students and pupils (9%) and retired people (4%). On an academic level, 77% of urban farmers were schooled with 25% primary, 42% secondary and 10% higher levels. At the periphery, 71% were schooled and 41% of primary, 23% secondary and 7% higher level. The majority of urban farmers (75% of men and 87% of women) began this activity in 2000 and 16% in the 1990s. In suburban area, they were 56% started in the 2000s and 33% in the 1990s.

Production practices

Herd constitution

The creation of herds by purchase was dominant in urban

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Table 1. Average number of pigs in pig farms according to modes of constitution of the herd in N'Djamena area (Chad).

Constitution mode	Urban area	Periurban area
Heritage	15.1±14.3 (n = 7) ^a	6.3±5.5 (n = 3) ^b
Gift	2.4±1.7 (n = 8) ^a	1.4±0.5 (n = 5) ^a
Purchase	2.2±1.7 (n = 88) ^a	1.9±1.0 (n = 65) ^a
Total	3.1±2.4 (n = 103) ^a	2.0±1.8 (n = 73) ^b

n = number of pig farms; ^{ab} Means along the same line followed by different superscript differ (P<0.05).

Table 2. Types of food distributed in pig farms of N'Djamena area (Chad).

Distribution	Artisanal alcohol residues	Artisanal spent grains	Cereal brans	Kitchen waste and peelings	Forage
Yes	174 (99%)	117 (67%)	73 (41%)	13 (7%)	6 (3%)
Not	2 (1%)	59 (33%)	103 (59%)	163 (93%)	170 (97%)
Total	176 (100%)	176 (100%)	176 (100%)	176 (100%)	176 (100%)

farming (85%) and those in suburban (89%). The gift was by 8% and heritage by 7% in city against 7 and 4% respectively in the periphery. The average herd size at the start of the breeding was 3.1±2.4 pigs in the city and 2.0±1.8 in the periphery (P<0.05). When the constitution is based on the heritage, the different between the city and its periphery was significant (P<0.05) (Table 1).

From 469 pigs identified by the creation of farms, 68% were in urban areas (UA) and 32% in periurban areas (PA). By sex, 28% males and 72% females in UA against 24% males and 74% females in PA. The average age of males was 6.0±0.22 months in the city and 7.14±0.14 months at the periphery. For females, that average age was 7.32±0.43 months in UA and 6.5±0.33 months in PA. Average spending in the purchase of two pigs in the creation of flocks were 16,840 FCFA¹ in the city and 14,460 FCFA in the periphery.

Individual property of the pig herd was dominant (74%) against 26% collective. All farms were mixed (breeders and fatteners).

The presence of other animals in the household was especially noted in the periphery and concerned 85% of 81 cattle, 56% of 153 sheep, 75% of 481 goats and 61% of 1,191 poultrys.

Housing

Piggeries were the boxes with banco walls and roof (BBWR) 76% or with banco walls and straw roof (BBWSR: 11%) or with banco walls and metal sheet roof (BBWMSR: 10%) or similar to simple parking areas (3%). The BBWR were more numerous in the periphery (15/20)

contrary to BBWMSR (13/18) in urban areas. More than half of the piggeries (55%) had their floors, roofs and walls in bad state. This defective state was less important in the city where the BBWR are in majority (82/133) and are in good condition in 47% of the cases. Piggeries were more implanted inside concessions (65%) than on the outside. They were cleaned one time per week (67%); or one time per month (18%) or not at all (15%).

Food

Basic foods were alcohol residues and artisanal spent grains (Table 2) from the indigenous alcohol preparation called locally "Argui" and of local beer "Bili-Bili". These foods were mainly distributed twice daily (67%), three times (18%) or once (15%). They were bought by farmers (85%) so as much in town than at the periphery, produced by themselves (7.5%) or collected (7.5%). The average monthly cost of purchasing food were significantly higher (P<0.001) in town (8,835 FCFA) than at the periphery (5,080 FCFA). The mineral supplementation practiced in 63% of farms was more marked in the city than at the periphery. It was based on sodium carbonate (Na₂CO₃) (50%), sodium chloride (NaCl) (19%) or both (31%). The average expenditures for the purchase of these minerals were higher (P<0.001) in the city (2,450 FCFA) than at the periphery (1,350 F). More than half (56%) of farmers have practiced supplementation with by-products and minerals. It appears that those who used the minerals have higher average herd size (P<0.05) than those who have less. Mean litter size at farrowing by sow and per year were also higher (P<0.05) in the first breeders group than in the second. It was the same for piglets born alive in the two groups of farmers (P<0.05). However, numerical

¹ 1 \$USD = 500 FCFA

Table 3. Variation of reproduction parameters according to the practice of mineral supplementation in pig farms of N'Djamena area (Chad).

Parameter	Mineral complementation	
	Yes	No
Average herd size	21.8±16.8 ^a	14.9±4.8 ^b
Litter size at farrowing /year	16.6±4.9 ^a	14.8±4.8 ^b
Litter size at born-alive /year	15.3±4.5 ^a	13.5±4.6 ^b
Numerical productivity/year	13.5±4.6 ^a	13.4±4.8 ^b

^{ab} Means along the same line followed by different superscript differ (P<0.05).

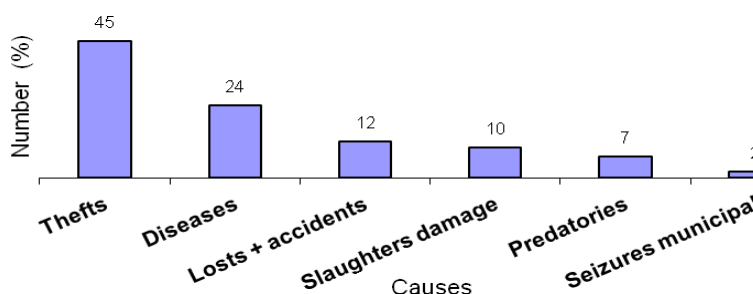


Figure 1. Causes of losses of the pigs (%) in the farms of N'Djamena area (Chad).

productivity by sow per year did not significantly varied in both groups (Table 3).

Activities of collecting (95%), distributing (98%) and food watering (98%) of pigs were performed alternately by members of the family. Employees (5%) were mostly used in the collection of food. The food was served in piggeries (80%). The feeding and watering dishes were mostly (88%) composed of half metal drum (50%) varied basins (29%) cement constructions (9%) or recycled materials which were wheels and vehicle used tires (12%).

Health care and reproduction

The majority of farmers (61%) had used decided to treat sick pigs against 13% who used slaughtering, 6% practiced isolation and 20% were undecided. They used the most modern care than the traditional one. The treatments concerned mainly injections (60%), deworming (31%) or both (9%). The products used were from veterinary clinics, pharmacies and veterinary posts (46%), from market (36%) or from medicinal plants (18%). In 51% of farms, pregnant sows were isolated from the herd before parturition, 28% after parturition and 21% paid no attention to these females. The average numerical productivity per year according to these practices did not show significant differences.

Production constraints

For 1,350 losses of heads in mortality in 81% of farms in one year, 71% were in 85% of urban farms and 29% in 74% of farms in suburban area. These losses represented overall 39.8% of the pigs' population. They were higher in urban farmers (P<0.05) (11 pigs) than those in the suburban area (7 heads). Theft and mortality due to diseases represented the two main causes of pig losses in the farms (Figure 1).

For 113 farmers (64%) who have pathological problems, 65 were in the city and 48 at the periphery. Respiratory symptoms (cough for dyspnea) and gastrointestinal (diarrhea, vomiting, intoxication, parasitosis) dominated in 62% of herds tracking followed by skin diseases, edemas and wounds (18%), weight loss (13%) and foot diseases (7%). Respiratory and gastrointestinal symptoms were more marked in peripheral farms (Figure 2).

In monitored farms, 211 pigs were removed including 47% in urban and 53% in the periphery. Males were 59% and females 41%. More than half of the exits of the farms (52%) took place in the dry season and 48% during the rainy season. The exits caused by mortality with all confused causes have been more significant in the zone (52%). Mortality was higher in peripheral areas (74%) than in urban (26%). Deaths by diseases (mainly pneumonia) constituted 37%, accidents 32% and slaughter

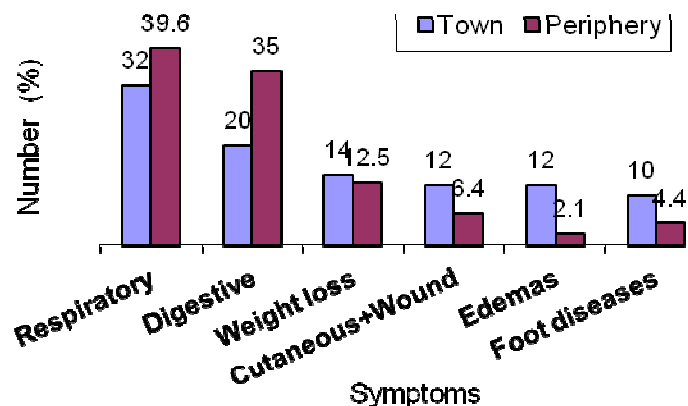


Figure 2. Symptoms of the diseases related by pig farmers in N'Djamena area.

Table 4. Number and average age of pigs having left the monitored farms according to causes in N'Djamena area, Chad.

Cause	Number	Percentage	Age average
Mortality	110	52	5.7±4.6
Sale	64	30	17.1±6.5
Theft	32	15	8.7±2.0
Gift	05	03	8.0±4.8
Total	211	100	10.0±7.2

all causes 31%. Mean age by cause of exit showed that mortality was concentrated in young animals from 5 to 6 months, thefts and gifts of animals from 8 to 9 months and selling of older pigs (Table 4). These mean ages were significantly different ($P < 0.05$).

The majority of pigs (24/34) were slaughtered at the periphery for damage to crops and only 10 out of 34 for receptions, ceremonies and sacrifices, including 6 in the city. The majority of thefts (69%) and sales (70%) took place in the city. However, accidents were higher (66%) in peripheral areas than in the city (34%). Apart from the farrowing, the other entries concerned only the purchase of 6 pigs including 4 female of about 8 months. For all breeders, sales and purchases of alive pigs took place on the farm. There is no special market of pigs in N'Djamena area.

DISCUSSION

The study allowed to characterize farmers, production practices and to identify constraints of pig farms in the area of N'Djamena. The proportion of farm producers and employees in our area was close to that observed in Basse-Casamance in Senegal, respectively 52.6 and 22.8%. However, retirees are three times higher in this region. Persons exercising small trades, pupils and students have not been reported in Basse-Casamance

(Niang, 1997). The majority of educated breeders is an asset for a development program. Technical topics to diffuse will be better assimilated by these producers. In southern Chad (Mopaté and Koussou, 2003) and in northern Cameroon (N'joya et al., 1996), 56% of farmers were educated. The proportion of educated producers will develop in the future because young people in school failure situation will practice more and more agricultural activities. However, the lack of management structure in pig production in the area of N'Djamena does not argue for its rational development. This situation is also reported on pig farms of Cameroon (Ndébi et al., 2009).

Regarding production practices, the proportion of farmers who buy pigs constitute herds for themselves was more than that observed in Basse-Casamance in Senegal with 60% (Missohou et al., 2001). This situation is characteristic for the relatively speculative suburban agricultural production (Moustier and De Bon, 2005). In rural areas of southern Chad, the constitution of pig farms remains dominated by donations, heritage, and especially the "fosterlings²" (Mopaté and Koussou, 2003). Fosterling of pigs is also a practice of dominant constituting of herd under village conditions in Basse-Casamance (Missohou et al., 2001). The closer social links in villages and the lack of financial resources contribute to the maintenance of this practice.

Farmers' preference for females with an average age of 6.5 months in suburban area and 7 months in urban area is a strategic approach to have females ready to enter reproductive phase. Indeed, the average age at first pregnancy in the surveyed area is 7 months (Mopaté et al., 2011). In Basse-Casamance, it is the just weaned pairs of piglets (5 months) which are bought for the constitution of the herds. The prices are lower (5,000 FCFA) for the local race and twice more for that improved (Missohou et al., 2001). In the Groundnut Basin of Senegal (Buldgen et al., 1994), well-differentiated farms are observed: piglet production (48%), feedlot (20%) and mixed (32%). This is also the case in Vietnam, where 86% are feedlot 10%, piglet production and 4% boar production (Froelich, 1991). However, 93% of pig farms in Basse-Casamance, Senegal (Missohou et al., 2001), 75% in Cameroon (Ndébi et al., 2009) and almost all of our area farms were mixed (piglet production and feedlot). This practice is characteristic of a still traditional production, marked by the absence of allotment of animals and specialized workshops of production.

Our results show that farmers who have piggeries seems to have increased compared to the observations made by Sana in 1997 (87%) conducted 10 years ago in a concentration area that includes N'Djamena. This evolution is specific to livestock production in urban and periurban environments to ensure relative protection of animals. The use of unconventional feed resources in traditional pig breeding is a current practice in N'Djamena

² Form of mutual aid consisting in giving a female to a friend or a relative and sharing with him the products of the births.

area. This practice is also observed in other Sub-Saharan Africa countries to lower the production costs (Ikani et al., 2001; Lekule et al., 2003; Mashatise et al., 2005; Chiduwa et al., 2008; Olasunkanmi, 2008; Ndébi et al., 2009; Kagira et al., 2010; Orbert et al., 2013; Kiendrébeogo et al., 2014). The frequency of feed distributions twice a day in the majority of the pig farms seems acceptable. But the amounts served and the nutritional values of different by-products used would have to be known for a better and efficient utilisation of the available feed resources (Lumu et al., 2013). The use of minerals (sodium carbonate and/or sodium chloride) in the diet should be reported by farmers, as a desire to neutralize the acidity of residual alcohol remaining in the ration fed to pigs. The residues from indigenous alcohol making is often used in the pig feeding and become acid after 24 to 48 h during conservation. Minerals are also the subject of treatment of pigs carrying cysticercus kysts. On pig farms of villages in southern Chad, urban and periurban farms of the cities of Pala (Chad), Garoua (Cameroon) and Bangui (Central Africa Republic), the mixture of these minerals in feeds is a common practice (Mopaté and Koussou, 2003; Mopaté et al., 2010). The use of these minerals in pig feed including sodium chloride is recommended because of their deficiency in cereals (Gaudré and Quiniou, 2009). These minerals seem to affect litter size at farrowing and the number piglets born alive that was higher among farmers who use them. But similar practices on farms and bad behavior have not allowed these farmers to keep this advantage. Indeed, the annual numerical productivity of the two groups showed no significant differences. These facts suggest further studies with a larger sample size on this aspect, to provide advice to farmers in order to increase productivity of their farms. In general, the practices of herd constitution by purchasing at the creation of farms, of housing by use of unsustainable materials and using local food by-products were also observed in Nigeria (Ajala et al., 2007; Ironkwe et al., 2008), Kenya (Mutua et al., 2011) and Burkina Faso (Kiendrébeogo et al., 2014). However, complementation of pigs with minerals (sodium chloride and sodium carbonate) observed in this study not noted in these countries. The liquid nature of the alcohol residues with a high proportion of water leads the fact that some farmers do not give water to their animals. In urban and rural pig farming in Senegal, the basic diet composed of kitchen waste mixed with 4 L of water distributed regularly (Buldgen et al., 1994). In Busia District (Kenya), rural farmers provide pigs with water separately from the feeds (Mutua et al., 2012). This lack of watering is held responsible for losses of young piglets, according to this source. In Cambodia, the unbalanced rations, the early sale and bad transport conditions are incriminated in the high mortality rate (30-40%) of piglets after weaning, significantly constraining the development of this production (Sevin, 1994).

The analysis of production constraints reveals mostly

losses related to control (theft, slaughter for damage, traffic accidents and seizures) and diseases. These losses are the constraints to which most breeders of the urban, periurban and rural areas are confronted (N'joya et al., 1996; Youssouf et al., 2008; Ndebi et al., 2009; Mopaté et al., 2010). Moreover, bad practices and lack of access to adequate framing structures were identified as constraints in pig production (Obonyo et al., 2013). Nevertheless, it should be noted that in addition to pathological problems to which farmers have referred to the African porcine pest represented as permanent major constraints of pig production in many African countries (Penrith, 2013; Penrith and Vosloo, 2009; Penrith et al., 2013). In Chad, this disease has appeared recently (Bambo et al., 2012). The availability of pigs ready for market could be improved by reduction of important losses caused by thefts and mortalities. Observations on rustic local races in France show that a good control improves productivity of farms (Lebroue et al., 2000). For pigs of the local breed of Benin, improvement of feed and health monitoring increase significantly litter size from 5.33 to 8.8 piglets (Koutinhouin et al., 2009). The increase in food transformation and consumption of pork in towns (Mopaté et al., 2006) would be responsible for the increase number of theft cases. The stolen pigs are most often sold to transformers who slaughter them immediately so that owners can not recognize them by specific marks made on the ears. For pathologies, bad conditions of more than half piggeries and the diurnal free range pigs have probably affected the pig health with dominant respiratory and digestive symptoms in most farms.

Conclusion

Knowledge of practices and constraints of pig farming provide a better understanding of pig production in N'Djamena and its suburban area. This is of great importance for the orientation of support actions to producers by development agencies. Breeders have a school level of education allowing the diffusion of the technical topics. The axes of intervention will be controlled of constraints related to livestock management and diseases which affect pigs. Improvement of litter size at farrowing by supplementation with sodium carbonate and sodium chloride observed in this study appears interesting. It suggests further studies on this aspect to provide advices to producers.

Conflict of Interest

The authors have not declared any conflict of interest.

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