World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 6.129

INFLUENCE OF DIFFERENT DIETARY PROTEIN CONCENTRATION ON GROWTH AND REPRODUCTIVE PERFORMANCE OF THE GRASSCUTTER (*THRYONOMYS SWINDERIANUS*)

Korankye Okyere[1], Clement Gyeabour Kyere[2]*, Asamoa-Bonsu Afua Sarpong[3] and Patrick Atta Poku Jnr[2]

[1]Department of Animal Science Education, Faculty of Agriculture Education, University of Education, Winneba, P.O. Box 40, Mampong-Ashanti, Ghana.
[2]Department of Science Education, Seventh-day Adventist College of Education, Affiliated to University of Cape Coast, Post Office Box 29, Agona-Ashanti Region, Ghana.
[3]Department of Animal Science Education, Faculty of Vocational Education, University of Education, Winneba, P.O. Box 1277, Kumasi, Ghana.

Corresponding Author: Clement Gyeabour Kyere
Department of Science Education, Seventh-day Adventist College of Education, Affiliated to University of Cape Coast, Post Office Box 29, Agona-Ashanti Region, Ghana.

Article Received on 15/03/2021 **Article Revised on 05/04/2021** **Article Accepted on 05/04/2021**

ABSTRACT

This study was conducted to investigate the influence of different dietary protein concentration on growth and reproductive performance of the grasscutter (*Thryonomys swinderianus*) for a period of 17 months. Thirty-six (36) dams, 12 bucks and their 115 offspring fed six different dietary protein concentrations (10%, 12%, 14%, 16%, 18% and 20% CP). The animals were assessed for growth, body weight reproductive performance. The dams and the bucks were mated in six groups of three females to a male in two batches in concrete cages. Completely randomized design was used and data collected was analysed using Generalised Linear Model (GLM) Type II procedure of SAS (2008). Increasing dietary protein concentration increased birth and weaning weights, preweaning growth rate, litter size at birth (P<0.01), but not sex ratio (P>0.05). Pregnancy rate, litter weight at birth, litter size at weaning, kid survival rate, number of days of exposure of male to female and dam weight loss at lactation were significantly influenced by the treatment(P<0.01). This study concludes that adequate dietary protein concentration (10%-18%) is required for optimum reproductive performance of captive grasscutters.

KEYWORDS: Grasscutter, dietary protein, weaning weight, litter size, litter weight, sex ratio.

INTRODUCTION

The grasscutter (*Thryonomys swinderianus*) is a wild hystricomorphic rodent found only in West Africa. Grasscutters are widely distributed and exploited in most areas.[1] The grasscutter is desirable for domestication because of its excellent taste, comparatively higher nutritional value.[2] and meat yield than most species of livestock. [1] Grasscutters in captivity are commonly fed on elephant grass (*Pennisetum purpureum*) and guinea grass *(Panicum maximum)* which have crude protein (CP) content of 10.44% and 7.77% when cut at 90 and 120 days respectively. [3] With age crude protein content and digestibility of these grasses reduce. Protein content, in particular, constantly reduces to as low as between 3.0%-7.7% at 120 days and beyond in the dry seasons.[4] The protein requirement of the adult grasscutter for optimum growth has been reported to be 12-18.5 % by Mensah and Okeyo.[5]

The relationship between nutrition and reproduction is a topic of increasing importance and concern among animal producers, nutritionists and animal input dealers.[3] This interest resulted from the fact that animals survive on poor quality roughage and crop residues which are deficient in many essential nutrients. The major constraint in such feeds is protein deficiency because the digestible crude protein content of these roughages is very low. [1] Protein has important biological functions and its requirement in animal nutrition need to be met for optimum growth and reproductive performance.[6] The effect of different dietary protein levels on reproductive performance (ovulation, mating, pregnancy rate, litter size, neonatal weight, and subsequent neonatal development) and histology of reproductive organs of cattle, sheep and goats have been the subject of numerous studies and reports.[6]

The major hindrances to the domestication of the grasscutter are the lack of improved breeding stock and nutrition,[1] lack of technical know-how, lack of proper management practices for efficient production, housing design and poor reproductive performance.[3] The grasscutter has a gestation length of 152-154 days [7] and average litter size of 3.8-5.7 and produces 1.6 to 1.9 litters per female per year.[8] In Benin and Togo, litter sizes up to eleven or twelve have been reported. [9] This indicates that there is great potential in increasing the reproductive performance of grasscutter. This requires critical assessment and research into the biology of the rodent, especially, nutrition and reproduction interaction. These interaction effects could be assessed by measuring the effects of nutrition on the reproductive parameters of the rodent. The aim of the study was to investigate the influence of different dietary protein concentration on growth and reproductive performance of the grasscutter (*Thryonomys swinderianus*).

MATERIALS AND METHODS

Study Location

The experiment was conducted at the Grasscutter Section of the Department of Animal Science Education, University of Education, Winneba, Mampong Campus. Mampong- Asante is the capital town of the Mampong Municipality of the Ashanti Region. Mampong is located 60 km North-East of Kumasi on the Kumasi- Ejura road. The Municipality lies between latitude 07 04^{0}" degrees North and longitude 01 24" degrees west with altitude 457.1 m above sea level in the Transitional Zone between the Guinea Savanna Zone of the north and Tropical Rain Forest of the south of Ghana. The climatic condition is wet semi-equatorial type, with a bi-modal rainfall of 1224mm per annum and temperature range of 22.3^{o}C-30.6^{0}C. Rainfall occurs in April to July (Major Raining Season), August to November (Minor Rainy Season) and December to March (Dry Season).[10]

Experimental Animals and Mating

Thirty-six (36) adult female grasscutters (8-20 months old) raised at the grasscutter section of the Department of Animal Science of the University of Education, Winneba, Mampong were used in the experiment. The females weighed 1.5-3.5kg. Twelve (12) male grasscutters (bucks) aged between 10 and 20 months were selected from the same colony as the females. The males weighed between 2.3 and 3.7kg. Mating of the animals was done in concrete cages in a ratio of one male to three females. The date and time of mating were recorded. Males and females were left together for six (6) weeks. The females were examined for successful pregnancy by palpation at 6 weeks after separation. Non pregnant females were re-mated. All the kids born to the does in the experiment were selected and their growth, body weights, survival and reproductive characteristics were studied. One hundred and fifteen (115) kids were involved.

Housing of the Experimental Animals

The experimental grasscutters were housed in three-tier wooden (Plate 2) and concrete cages. Each wooden cage measured 90×40×60 cm. The wooden cages were one-chambered. The concrete cages were two with a passage at the centre. Each chamber measured 80×50×70 cm.

Experimental Design and Treatment

The Completely Randomized Design (CRD) was used. The female grasscutters were randomly grouped into three (3) in a cage. Each group received one male for mating. The bucks and the does were kept and fed together for six weeks after which the males were separated from the females. The treatments for all the experimental animals were the six diets containing 10% (T1), 12% (T2) 14% (T3) 16% (T4) 18% T5) and 20% (T6) levels of crude protein, respectively. Before the start of the experiment the grasscutter colony at the University farm were fed a basal diet of elephant grass and concentrates that contained 10% crude protein. The 10% (T1) crude protein diet served as the control of the experiment.

Experimental Diet

Six different diets containing different protein levels were formulated (Table 1) and fed to the animals as supplements to grass. The diets contained 10%, 12%, 14%, 16%, 18% and 20% crude protein. Elephant grass (*Pennisetum purpureum*) was fed as the basal diet. The grasscutters were provided with fresh and clean drinking water *ad libitum*in twice daily.

Table 1: Proportions of feed ingredient in formulated diet.

Ingredients	10%CP	12%CP	14%CP	16%CP	18%CP	20%CP
Maize	67	47.50	43.00	39.00	33.50	31.50
Wheatbran	24	42.50	41.20	39.50	39.50	35.00
Soybean meal	1.00	2.00	7.80	13.50	19.00	25.50
Oyster shell	7.00	7.00	7.00	7.00	7.00	7.00
Salt (NaCl)	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin Premix	0.50	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100	100

Vitamin and Mineral Premix Composition

Vit. A (8.000UI), Vit. D (1.500UI), Vit. E (2.5000UI), Vit. K_3 (1.000mg), Vit. B_2 (2.000mg), Vit. B_{12} (5mg), Nicotinimic acid (3mg), Calcium Panthotenate (2mg), Antioxidant (10mg), Folic acid (500mg), Chlorine Cloruro (50mg), Manganese (50mg), Zinc (40mg), Copper (4.50mg), Cobalt (100mg), Iodine (1mg) and Selenium (100mg).

Analysis of Ingredients and feeds

Chemical analysis of samples of elephant grass and formulated diets were carried out in the Nutrition Laboratory of the Department of Animal Science of the Kwame Nkrumah University Science and Technology, Kumasi according to the procedures outlined by Association of Agricultural Chemist. [10] The results are presented in Tables 2.

Table 2: Chemical Composition of Diets.

Variables	%Dry Matter	%Crude Protein	%Crude Fibre	%Ether Extract	%Ash
Protein Diet					
10%	86.39	9.90	5.95	2.99	6.29
12%	86.03	11.65	5.98	2.99	3.19
14%	87.24	13.70	5.36	2.99	8.05
16%	87.10	16.30	4.56	1.99	8.81
18%	86.98	17.90	5.07	1.99	9.74
20%	87.46	19.70	5.32	2.99	10.54
Elephant Grass ***(Pennisetum purpureum)***					
Major Rains	34.30	9.25	31.00	1.17	9.80
Minor Rains	89.77	7.90	32.79	1.00	6.25
Dry	92.5	5.1	58.62	1.50	5.21

Health Management of Experimental Animals

The selected males and females were flushed with the formulated diet. The animals were observed everyday for possible occurrences of diseases and sicknesses. Sick and wounded animals were isolated and treated. Disinfectant (Dettol) and fly repellant (Raid Insecticide Spray) made by Johnson Family Company were used to prevent pathogens and flies' infestations. Visitors were restricted from entering the grasscutter house to avoid animals being traumatized. Post mortem was conducted on dead animals and findings of possible causes of death were recorded.

Parameters Measured

Weight at mating

Weight of does and bucks were determined by weighing the animals at selection before mating. AR series precision electronic balance made by Guangzhou Yihouzin Electronic Instrument Company of China was used to record individual weights of the animal in grammes.

Number of days from mating to conception and to parturition

Interval between first day of joining buck and dam and day of conception. It was calculated as: *Days of joining to conception=Days from joining to parturition -150 days of gestation*

Pregnancy Rate (PR%)**:** Number of pregnant animals was counted after animals were diagnosed to be pregnant and pregnancy rate was calculated as:

$$PR\ (\%) = \frac{Number\ of\ pregnant\ animals}{Number\ of\ animals\ mated} \times 100$$

Birth and weaning weight

Kids were weighed within 24 hours after birth and again at weaning with an electronic balance. Birth and weaning weights were recorded (g).

Litter size at birth and weaning

Live kids born to the dams were counted and recorded immediately after parturition. The kids were identified with the use of metal tags. Kids surviving up to preweaning were also counted.

Litter weight at birth and weaning

Total weights (g) of the kids in a litter at birth and at weaning were computed from individual weights at birth and at weaning, respectively.

Preweaning growth rate

Preweaning growth rate of the kids was calculated as:

$$Preweaning\ growth\ rate\ (\frac{g}{day}) = \frac{Weaning\ weight - Birth\ weight}{Number\ of\ days\ from\ birth\ to\ weaning}$$

Problems of gestation, parturition weight loss

Incidences of abortions, difficulty in parturition and still births were observed and recorded. Postmortem was carried out by the Department's Veterinary Officer on dead mothers at labour and dead kids. Weights of does were taken and recorded at parturition and at weaning of the kids with the use of digital electronic balance.

Preweaning Survival rates

Preweaning mortality resulting from different ailments and incidences were recorded. The preweaning mortality and survival rates were calculated as:

1.
$$Preweaning\ mortality\ (\%) = \frac{Number\ of\ dead\ kids}{Number\ of\ kids\ born} \times 100$$

$$Preweaning\ Survival\ (\%) = \frac{Number\ of\ kids\ alive\ at\ weaning}{Number\ of\ kids\ born} \times 100$$

2.

Data Analysis
The data collected were subjected to Least Square Analysis using Generalised Linear Model (GLM) Type II procedure of SAS. Differences between means of significant effects were separated by using the probability of difference (PDIFF) procedure of SAS.[12]

RESULTS

Growth rate and Birth and Weaning Weights
Highest birth weight was obtained by kids whose dams were on 10-14% CP while the lowest was recorded by kids whose dams were fed 16-20% CP (P<0.01). Kids on 10, 12 and 14% also had similar birth weights (Table 6). Weaning weights increased with increasing dietary protein up to 18% and started decreasing at 20% (P<0.01) (Table 6). The highest preweaning growth rate was attained by kids born and maintained by dams fed 12, 14 and 16% dietary protein while the lowest preweaning growth rate was recorded by kids born and maintained by dams fed 20% dietary protein (P<0.05). Generally, preweaning growth rate increased with increasing dietary protein concentration up to 16% and started declining to 20% (Table 6).

Table 6: Treatment effect on growth and body weight.

Variables	BirthWeight(g)	Weaning Weight(g)	Preweaning Growth Rate(g/day)
10% CP	140.93 ± 8.57[a]	552.177 ± 54.33[a]	7.19 ± 0.79[a]
12% CP	149.52 ± 10.37[a]	633.499 ± 57.39[b]	8.39 ± 0.84[ab]
14% CP	147.55 ± 8.13[a]	673.22 ± 41.56[b]	8.91 ± 0.61[b]
16% CP	107.52 ± 11.93[b]	669.84 ± 67.01[b]	9.02 ± 0.98[b]
18% CP	129.99± 10.86[b]	631.30 ± 62.45[b]	8.26 ± 0.92[a]
20% CP	114.67 ± 8.25[b]	440.41 ± 45.67[c]	5.62 ± 0.67[c]
P-value	0.001	0.0002	0.0003
Mean	129.56±19.64	588.25±98.97	7.67±1.45

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

Litter size and weight at birth and at weaning
Dams fed 14% and 16% dietary protein concentration recorded highest litter size at birth (P<0.01). Litter size at birth increased with increasing dietary protein concentration up to 16% and started declining (Table 7). Similarly, litter size at weaning was highest (P<0.01) at kids born and raised on 16% and 18% dietary protein concentration. Increasing dietary protein concentration resulted in increasing litter size at weaning up to 18% and declined again at 20% dietary protein concentration (Table 7).

The highest (P<0.01) litter weight at birth was obtained by kids whose dams were fed on 10, 12 and 14% while lowest was obtained by kids whose dams were fed on 16, 18 and 20%. Kids born by dams fed 10, 12 and 14% crude protein diets had similar litter weight while those fed 16, 18 and 20% dietary protein had similar weights. Highest litter weight at weaning was obtained by animals born on 14 and 16% crude protein. Litter weight at weaning increased with an increasing dietary protein concentration up to 16% and started decreasing to the lowest at 20% (Table 7). Litter weight at weaning was highest (P<0.05) at 16%.

Table 7: Treatment effects on litter size and litter weight at birth and weaning.

Variables	Litter size		Litter weight (g)	
	Birth	Weaning	Birth	Weaning
10% CP	3.41 ± 0.4[a]	1.53 ± 0.4[a]	543.35± 32.7[a]	1651.71± 226.3[a]
12% CP	4.25 ± 0.5[a]	1.91 ± 0.48[a]	584.33± 40.8[a]	1830.60± 230.3[b]
14% CP	5.33 ± 0.3[b]	2.77 ± 0.4[b]	543.54± 31.5[a]	2385.17 ± 167.4[cd]
16% CP	4.56 ± 0.6[ab]	4.48 ± 0.6[c]	343.62± 46.3[b]	2488.04 ± 270.2[c]
18% CP	3.36 ± 0.5[a]	3.31 ± 0.5[c]	474.14± 42.4[b]	2220.56 ± 262.62[d]
20% CP	4.13 ± 0.3[a]	1.27 ± 0.3[a]	424.72± 29.2[b]	1299.55 ± 166.5[e]
P-value	<.0001	<.0001	0.0001	<.0001
Mean	4.44±1.05	3.50±0.90	556.98±74.37	2241.68±307.31

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

Number of Days from mating to conception, Pregnancy Rate Dam weight loss during lactation

The effect of treatment on the number of days from joining to conception was significant (P<0.05). Dams fed on 12, 14, 18 and 20%dietary protein concentration conceived earlier than those on 10 and 16% (Table 8). Pregnancy rate was highly influenced by the treatment (P<0.01) (Table 8). The highest pregnancy rate was recorded by dams fed 10 and 12% dietary protein concentration while dams fed diets containing 16, 18 and 20% crude protein recorded the lowest (Table 8). The highest (P<0.01)dam weight loss was recorded by dams fed 12% dietary protein followed by those fed 10% (Table 8) and the lowest was 14% dietary protein.

Preweaning survival was highly influenced by dietary protein concentration (P<0.01). The overall preweaning survival rate was 90.65 %. The lowest preweaning survival rate was recorded by kids fed 20 % dietary protein. Animals from the other treatments had highest survival rate and were similar (Table 8).

Table 8: Treatment effects on pregnancy rate, number of days from mating to conception, dam weight at loss lactation and *Preweaning survival rate (%).*

Variables	PR (%)	DMC	DMLL	PSR
10% CP	100.00±3.07 [a]	21.00 ± 2.16[a]	-726.76 ± 117.23[a]	86.60±6.13 [a]
12% CP	98.99±3.72[a]	15.38 ± 2.31[b]	-1238.96 ± 133.13[b]	90.60±6.57 [a]
14% CP	95.05±2.91[b]	15.21 ± 1.61[b]	-361.07 ± 94.26[c]	96.03±4.60 [a]
16% CP	76.85±4.27[c]	18.47 ± 2.68[a]	-584.45 ± 153.46[d]	95.56±7.63 [a]
18% CP	80.77±3.89[c]	15.51 ± 2.27[b]	-585.89 ± 144.44[d]	98.07±6.46 [a]
20% CP	83.46±2.66[c]	14.95 ± 1.65[b]	-556.80 ± 93.08[d]	75.08±4.69 [b]
P-value	0.0001	0.02	<.0001	0.0001
Mean	90.03	12.02±4.68	-479±238.60	

Means bearing different superscripts in the same column are significantly different (P<0.05).
PR-Pregnancy rate (%); DMC- Days from mating to conception; DWLL- Dam weight Loss at lactation (g); PSR-Preweaning survival rate (%)

DISCUSSION

Birth weight, Weaning weight and Growth rate

The mean birth weight of 129.56±19.64 (Table 8) was higher than 120g and 120.5g reported earlier. [2] This could be attributed to the availability of protein in the serum of the dam to speed up cell growth of fetuses.[13] The means were similar to birth weight of 133.3 and 132.3g in grasscutter fed 20% and 22% of crude protein respectively as main diet. [14] The mean birth weight of 16%, 18% and 20% (Table 8) dietary protein were similar to those reported earlier.[2] This suggests that higher protein concentration during gestation period may have negative effect on birth weight.

Increase in weaning weight was similar to earlier reports [15] that kids fed higher protein achieved increased weaning weight. The overall mean weaning weight of 588g was comparable to earlier report by Addo *et al.*[2] of 450.9g and 429g for males and females respectively. This weight gain at weaning may be as a result of the availability and utilization of nitrogen in the diet of both the dams and the kids. This observation suggests that sufficient dietary protein consumption influence better weaning weight than low protein diet.[15] However, the results indicate that dams fed 20% dietary protein resulted in lower weaning weight than the control and this indicates that toxic effect of excess protein yields excess plasma ammonia to inhibit gluconeogenesis which impedes cell growth and development, thereby reducing weight gain.[16] Increased growth rate shows that growth rate is influenced by maternal and postnatal protein nutritional status and that maternal protein restriction during pregnancy and lactation result in stunted preweaning growth.[17]

Litter size and weight at birth and weaning

The range of litter size obtained in this study (3.36-5.33) similar to earlier study of Kusi *et al.*[3] which reported a litter size of between 3 and 5 and those reported earlier by Lameed and Ogundipe.[18] who also reported a litter size of between 3 and 5 of grasscutter dams fed 18% to 24% as main diet. It is also similar to the study of Addo *et al.*[2] which reported a litter size of 2-6 and also litter size range of 3.8–5.7 reported by Kusi.[3] This result could be explained as that improved dietary protein increased ovulation rate, thereby, increasing litter size at birth.[16] Dams fed 14% dietary protein had the highest litter size after which increasing dietary protein showed a decline. This shows that 14% dietary protein will be adequate to influence ovulation rate (number of ova released during ovulation).[15] and enhance implantation and maintain pregnancy.[13]

Adequate dietary protein resulted in birth of heavy kids and increased litter size. [15] The product of these (birth weight and litter size) is increased litter weight at birth and weaning. Increasing dietary protein also enhanced growth rate and survivability of kids therefore increasing litter weight at weaning from 10%-16% dietary protein. The reduced litter weight at weaning of kids fed 18% and 20% dietary protein was as a result of low litter size and litter weight at birth and also reduced growth rate.

Number of days from mating to conception and pregnancy rate

Mating which resulted in conception were within three weeks of exposure to the male. This confirms the earlier study by Addo *et al.* [2] which reported that the first two weeks of exposure of the female to the male resulted in 80% receptivity and recorded about 79% pregnancies. This study showed that the lowest dietary protein level recorded longer days of exposure to conception. Excess dietary protein reduced pregnancy and this suggests its negative impact on conception. Kusi [3] explained that a reduction in fertility due to increased intake of protein could be caused by direct toxic effect of protein breakdown product such as ammonia which reduces energy because it requires additional energy to metabolize the extra nitrogenous waste, thus, reducing the available energy.

Dam weight loss at lactation and Preweaning survival rate

This study indicates that lactation had effect on the bodies of the dams and resulted in significant reduction in maternal weights from parturition to weaning as lactation had negative impact on maternal weight.[15] Much weight was lost to the dams fed 10% and 12% dietary protein. This effect was as a result of the dam's inability to meet nutritional demand for lactation. [1] Muscle myofibre breakdown rate was high in dams fed 10% and 12% dietary protein and this resulted in maternal mobilization of proteinaceous tissues resulting in reduced weight gain.[19]

Kids born and raised by dams fed 18% dietary protein had highest preweaning survival rate of 98% while kids born and raised by dams fed 10% had 86% survival rate. Dietary protein restriction reduced the milk protein concentration and the ability of the dam to initiate and maintain flow of milk to alleviate starvation of kids and improve the immune system.[6] Poku Jnr *et al.*[15] reported that inadequate dietary protein resulted in decreased kid survival. However, Lameed and Ogundipe.[18] recorded no significant difference in the survival rates of grasscutters kids fed varied dietary protein.

CONCLUSIONS

The study concludes that feeding different levels of dietary protein concentration enhanced body weights, growth, reproductive characteristics and preweaning survival rate and not sex ration. It is recommended that dietary protein concentration for enhanced reproductive performance should range between 14% and 18%.

Disclosure of conflict of interest

Authors have declared that, no conflict of interests exist.

REFERENCES

1. Annor, S.Y., Djang-Fordjour, K.T. From the Rearing of Large and Small ruminants to a relatively tiny grasscutter (*Thryonomys swinderianus*): Problems and prospects of grasscutter rearing in Ghana. Proceedings of Sunyani Polytechnic Lecture Series, September 24-27. Sunyani Polytechnic Conference Hall, Sunyani, Ghana, 2006; 49-58.
2. Addo, P.G., Awumbila, B., Awotwi, E., Ankrah, N.A. Reproductive characteristics of the female grasscutter (*Thryonomys swinderianus*) and formulation of colony breeding strategies. *Livestock Research for Rural Development*, 2007; 19(4): 1-16.
3. Kusi, C., Tuah, A.K., Annor, S.Y., Djang-Fordjour, K.T. Determination of dietary crude protein level required for optimum growth of the grasscutter in captivity. *Livestock Research for Rural Development*, 2012; 24: 176.
4. Bayble, T., Melaku, S., Prasad, N.K. Effects of cutting dates on nutritive value of Napier (*Pennisetum purpureum*) grass planted sole and in association with desmodium (*Desmodium intortum*) or lablab (*Lablab purpureus*). *Livestock Research for Rural Development*, 2007; 19(1): 11.
5. Mensah, G.A., Okeyo, A.M. continued harvest of the diverse African Animal Genetic Resources from the wild through domestication as a strategy for sustainable use. A case of the larger grasscutter (*Thryonomys swinderianus*). International Livestick Research Institute, Nairobi, Kenya, 2005.
6. Korankye, O. The influence of dietary protein supplement on the reproduction performance of captive grasscutter (*Thryonomys swinderianus*). Master of Philosophy Thesis, University of Education, Winneba, Ghana, 2011.
7. Adu, E.K, Wallace, P.A., Ocloo, T.O. Efficacy of sex determination in the greater cane rat, Thryonomys swinderianus, Temminck. *Journal of Tropical Animal Health Production*, 2002; 34(1): 27-33
8. Kusi, C. Determination of dietary crude protein requirement for optimum growth and carcass quality of grasscutters (Thryonomys swinderianus) in captivity. M.Phil Thesis, University of Education, Winneba, Ghana, 2010; 62-78.
9. National Research Council (NRC). Grasscutter In: Microlivestock: little known small animals with a promising economic future. National Academy Press, Washington D.C, 1991; 449.
10. Meteorological Service Division (MSD). Annual Report for 2008. Sekyere West District, Mampong-Ashanti, Ghana, 2008.
11. Association of Official Agricultural Chemists (AOAC). Official Method of Analysis (15th Edition). Association of Official Agricultural Chemists, Arlington Virginia, USA, 1990; 807-809.
12. Statistical Analysis System (SAS). SAS/SAT User's Guide, Release 6.03 Edition. Carry, NC: SAS Institute Inc., 2008; 1023.
13. Obi O.O., Omole, A.J., Ajasin F.O., Tewe, O.O. (2008). Nutritive potentials of four conventional forages fed to growing grasscutters (*Thryonomys swinderianus*). Livestock Research for Rural Development, 2008; 20: 11.

14. Pine, A.P., Jessop, N.S., Oldham, J. Maternal protein reserves and their influence on lactational performance in rats. *British Journal of Nutrition*, 1995; 72(6): 815-30.
15. Poku Jnr, P.A. Annor, S.Y., Djang-Fordjour, K.T. Growth, Reproduction and Carcass Characteristics of Grasscutters (*Thryonomys swinderianus*) Fed on Different Levels of Protein Supplement. *World Journal of Zoology*, 2013; 8(2): 175-184.
16. Wogar, G.S.I. Performance of Gestating Grasscutters (T*hryonomys swinderianus*) Fed Cassava-based Diets with Graded Protein Levels. *Asian Journal of Animal Sciences*, 2011; 5: 373-380.
17. Annor, S.Y., E.K. Adu, J. Donkor, H.R. Otsyina and J. Ahiaba, Grasscutter Production: A Handbook. Qualitype Ltd, Accra, Ghana, 2009; 23-49.
18. Lameed, G.A., Ogundijo, O.O. Effect of varied dietary protein levels on the reproductive performance of grasscutter in captive. Journal of animal and veterinary advances, 2006; 5(5): 361-363.
19. Boateng, P. Reaching the Poor with Marketable Products. In: Proceedings of the International Forum on Grasscutter held at the Institute of Local Government Studies, Accra, Ghana from, 2005; 12-16.