ENDOGENOUS NITROGEN AND AMINO ACID SECRETIONS IN MONOGASTRIC ANIMALS - A REVIEW

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ABSTRACT

The characterisation and measurement of endogenous ileal nitrogen and amino acid excretion of simple-stomached animals, including pigs and poultry, is important to an understanding of gastro-intestinal physiology, as having practical application in the determination of amino acid requirements by the factorial method and the determination of dietary true amino acid digestibility. Studies indicate that the amount of endogenous nitrogen entering the mammalian gastro-intestinal tract is considerable.

Traditionally, the net endogenous loss of protein from the ileum has been determined by feeding animals a protein-free diet, although the regression technique has been applied also. However, the protein-free method may lead to considerable underestimation of the physiologically normal level of endogenous excretion. The regression technique seems to give rise to endogenous loss values similar to those obtained after feeding animals a protein-free diet and therefore the use of this approach may also lead to error. Moreover, the homoarginine (guanidination) method, in which intact protein is given to the animal, allows direct measurement only for the endogenous loss of lysine. An alternative and more general approach is the isotope (either a radioactively labelled amino acid or the stable isotope: ^{15}N) dilution method. Central to this method is choice of a suitable precursor pool for the endogenous nitrogen-containing material. However, because the nature and origin of these nitrogen-containing compounds is not fully resolved, it is not possible to specify a precursor pool with confidence. A new method for determining endogenous ileal amino acid excretion that involves feeding the animal peptides followed by ultrafiltration of the ileal digesta, has been proposed and evaluated. The enzyme hydrolysed protein approach is not subject to the criticisms of the protein-free or regression methods. Given the unphysiological nature of the protein-free dietary state and the problems associated with the other methods, the enzyme hydrolysed protein method may give rise to more meaningful estimates of basal endogenous nitrogen and amino acid loss.

Keywords: Endogenous nitrogen, protein-free, regression, homoarginine, isotope dilution, hydrolysed casein

INTRODUCTION

Food is the major item of expenditure in pig and poultry production and rate and composition of animal growth the major determinants of product value. Consequently, any decision regarding the feeding strategy to be adopted for growing pigs and chickens, is a key one influencing long term profitability. It is important to minimise feed cost and increase the efficiency of feed conversion to animal protein.

In this respect, there has been much interest over recent years in developing technologies to assist in the formulation of diets for pigs and poultry. Linear programming has become an extensively used procedure and computerised mathematical models simulating pig and poultry growth are becoming increasingly important tools for specifying dietary nutrient requirements. These approaches require that

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consideration be given not only to the gross amino acid composition of the dietary ingredients but also to determination of the bioavailability of the amino acids.

Bioavailabilty refers to the amount of each amino acid in a feedstuff which can potentially be utilised for body protein synthesis and other anabolic processes, following the successive steps of digestion, absorption and metabolism. Despite considerable research effort having been devoted to the development of techniques for the routine assessment of the amino acid availability of pigs and poultry feedstuffs, a satisfactory method has yet to emerge [1]. In the absence of a routine measure of amino acid availability, methodology has concentrated on the measurement of amino acid disappearance from the gut, i.e. digestibility. There is now general agreement that digestibility measurements made at the end of the ileum of the pig and poultry are superior to the traditional faecal approach [2,3,4].

Accepting that amino acid digestibility should be based on measurements made at the terminal ileum of monogastric animals, it needs to be recognised that ileal digesta are derived both from dietary and endogenous sources. Endogenous amino acid loss is used to correct apparent digestibility coefficients to true values. True amino acid digestibility has the advantage over apparent digestibility in that it is a fundamental property of a feed ingredient regardless of the dietary conditions under which the ingredient is fed [5]. For a given amino acid, apparent digestibility increases exponentially with the ingested quantity because endogenous excretion, as a percent of total excretion, decreases proportionally [6,7]. By contrast, several studies [6,8,9,10] indicate that true rather than apparent digestibility, is not affected by the level of dietary protein intake. Therefore, using true rather than apparent digestibility allows raw materials to be accurately compared, even if they are ingested in different quantities. Also, with increasing interest in the use of computer models to simulate biological aspects of growth in animals such as the pig and chicken, an accurate account of the animal's metabolism of protein is required, including the estimation of endogenous protein excretions in the terminal ileum.

Although the importance of endogenous excretion in simple-stomached animals is recognised, there are problems in attempting to apportion amino acids appearing in ileal digesta to dietary or endogenous origin. This paper therefore considers the secretion of endogenous nitrogen into the gastro-intestinal tract of monogastric animals and further evaluates different approaches which have been employed to estimate endogenous amino acids.

ENDOGENOUS PROTEIN SECRETION INTO THE GASTRO-INTESTINAL TRACT

Exogenous dietary proteins provide over half the peptides and amino acids eventually absorbed from the gastro-intestinal tract of the monogastric animal [11]. The contents of the gastro-intestinal tract are composed not only of undigested residues from the ingested protein, but also of products of endogenous origin (digestive enzymes, mucoproteins, desquamated epithelial cells, urea, amino acids produced by cellular catabolism and albumin) and other non-dietary, but not strictly endogenous materials such as bacteria and ingested hair, which dilute the exogenous residues [12]. The endogenous N secretion into the porcine digestive tract in relation to N intake is shown in Table 1.

Table 1. Endogenous nitrogen secretion into the digestive tract of the growing pig, as a percentage of food nitrogen intake

Source	Percentage
Saliva + Gastric Secretion	3.0 - 8.0
Pancreatic Secretion	4.0 - 15.6
Bile Secretion	4.5 - 6.5
Small Intestine Secretion	22.0 - 26.5
Sloughed Cells	2.5 - 3.5
Entire Endogenous Secretion	38.0 - 60.1

Adapted from Auclair [13]

The data in Table 1 indicate that the total endogenous nitrogen (N) secretion to the end of the ileum is 38 – 60% of the total N intake, with secretion from the small intestine accounting for 22 – 27% of total N intake. The N from sloughed cells was 3 – 4% of total N intake. In contrast to the latter values, Potten [14] observed that approximately half of the total endogenous protein entering the small intestine comes from replacement of epithelial cells lining the intestinal lumen (10^{9} cells weighing 1 g and being produced every 16 min in the human, and 4.5 days in the mouse intestine). This high rate of cell turnover is presumably needed in order to maintain the barrier function of the epithelium and enable the intestine to adapt rapidly to changes in the local environment [11].

The composition of endogenous ileal digesta from the pig determined under dietary protein-free conditions was determined by Taverner et al. [15]. The four most abundant amino acids in endogenous ileal digesta were identified as proline, glycine, glutamic acid and aspartic acid in order of decreasing abundance, with serine and threonine being the next most abundant. These six amino acids are also reported to occur most abundantly in mucin protein [16]. Taverner [17] and Zebrowska [18] have also shown that amino acid composition of the endogenous protein at the terminal ileum is similar to that of the muco-proteins. Hashimoto et al. [19] found that muco-proteins are moderately resistant to proteolytic enzymes. Thus, it appears likely that muco-proteins, such as those present in the mucosal secretions, are a major source of endogenous protein N appearing in the ileum. This was supported by Fauconneau and Michel [20] who reported that 75% of endogenous excretion was likely derived from intestinal mucus in the form of muco-protein and the protein present in the sloughed-off epithelial cells.

Digestion of the endogenous protein secretions occurs along the entire length of the intestine and is probably a continuous process. All of these proteins are assumed to be digested and absorbed in a similar way to those arriving from the diet, though, it is realised that the digestibility of individual proteins varies widely [21]. Fauconneau and Michel [20] and Zebrowska and Buraczewska [22] considered the digestion of endogenous protein to be much slower than that of exogenous protein, with the majority of endogenous protein digestion occurring in the ileum and caecum by the joint action of bacterial and endogenous enzymes. In contrast, other workers [23] have shown endogenous and exogenous proteins to be digested and absorbed at similar rates. Taverner [17] considered after reviewing the available literature, that most of the digestive enzymes secreted into the gut would be digested and reabsorbed without contributing significantly to the overall net endogenous excretion of protein from the gut.

Estimates of the quantity of endogenous protein digested and reabsorbed, reported in the literature, vary markedly. According to Souffrant [24], data on the total amount of N secreted into the digestive tract during the passage of digesta vary between 16 and 33 g depending on the literature consulted. This endogenous N is reabsorbed, at least partially. Rerat [25] using a number of different techniques calculated that 46 g of endogenous amino acids were digested and absorbed from a total secretion of 54 g (i.e. 85% of total N secreted is recycled). The estimates of Rerat et al. [12] and Low [26] indicate that approximately half (54%) of the total endogenous nitrogen is digested and absorbed after secretion into the gastro-intestinal tract.

Using the estimates of Rerat et al. [12] and (Low [26], Butts [27] calculated that approximately 8 g of endogenous N and 38 g of endogenous amino acids secreted into the gastro-intestinal tract remained undigested and unabsorbed at the end of the ileum, while using the estimate of Rerat [25] gave 2.8 g of endogenous N and 12 g of endogenous amino acids remaining undigested and unabsorbed at the end of the ileum. The values of 3 – 6 and 0.7 – 7.3 g of N per day leaving the terminal ileum of the pig reported by Low and Zebrowska [28] and Souffrant [24].

respectively, are in agreement with the latter estimate.

DETERMINATION OF THE ENDOGENOUS EXCRETION OF PROTEIN

Various approaches to the estimation of endogenous amino acids have been employed. These include:

THE PROTEIN-FREE METHOD

The traditional method for determining endogenous N and amino acid excretion involves feeding the animals a protein-free diet and then measuring the N and amino acids in digesta collected at the terminal ileum [29,30,31]. Literature values for the endogenous N and amino acid excretion from the terminal ileum of the growing pig given protein-free diets and containing 3 – 6% dietary fibre, indicate they are highly variable between studies, particularly for proline. Serine, threonine, proline, glycine, aspartic acid and glutamic acids are predominant in endogenous ileal amino acid excretions determined under protein-free alimentation. These amino acids constitute a large proportion of the mucus glycoproteins [32]. De Lange et al. [33] cited evidence for the proline secretion under protein-free alimentation being the result of large quantities of glutamine from muscle breakdown being metabolised to proline in the intestinal tract. This may be enhanced by the reduction of intestinal transport of proline and other amino acids under protein-free alimentation [34]. Taverner et al [15] suggested that the high levels of proline and glycine in endogenous ileal excretion following protein-free feeding were the result of their absorption as constituents of small peptides and their reflux back into the lumen as free amino acids, following intracellular digestion. Sauer [35] interpreted true digestibility coefficients determined using a protein-free diet of greater than unity, in particular for proline and glycine, to be due to an overestimation of these amino acids under protein-free alimentation.

The protein-free method has been criticised [35] due to the possible influence the addition of fibre, often added to protein-free diets, has on excretion and due to the absence of dietary protein. It is not possible to investigate quantitatively or qualitatively relations between protein feeding and endogenous losses.

The protein-free method has also been criticised because of the possible inducement of physiologically abnormal metabolism with unknown consequences on endogenous protein excretion. When animals are deprived of dietary protein and enter negative body N balance, their rate of whole-body protein synthesis fall [36]. Therefore, the overall endogenous excretion of protein into the gut would be expected to decrease, probably by way of reduced pancreatic secretions and mucus production. Given that N-free feeding is not physiologically normal and could evoke specific reactions in the animal body, it is not clear if data obtained with this method can be extrapolated to protein feeding.

The validity of determining endogenous amino acid excretion following protein-free alimentation has, however, received support from studies where the endogenous ileal amino acid flows of protein-free fed animals were similar to those found in animals given either a synthetic amino acid diet devoid of certain non-essential amino acids [37] or a protein-free diet with simultaneous intravenous infusion of amino acids [33]. From the results of these two studies, it does not appear that the protein-deplete state *per se* affects endogenous amino acid loss at the distal ileum of animals. It remains possible, however, that dietary peptides exert a direct stimulatory effect on gut endogenous protein secretion. It has been demonstrated with the growing pig [38] and the rat [39] that the presence of dietary protein or peptides in the gut lumen increases endogenous excretion of amino acids at the distal ileum. Therefore, an alternative technique for determining endogenous amino acid flows is needed whereby the endogenous excretion of protein into the digestive tract can be measured under conditions of peptide and protein alimentation.

THE REGRESSION METHOD

Another traditional method for determining endogenous N and amino acid excretion, adopting protein-containing diets, is the regression method. The regression procedure adopted by several workers [6,31,40] involves feeding a range of diets containing graded levels of protein source, measuring the ileal protein flow for each diet and extrapolating back to zero protein intake by linear regression, to give an estimate of the endogenous protein excretion. This technique has an advantage in that the influence of dietary protein and fibre is accounted for. Also the regression method makes it possible to assess the effects of protein quality and specific protein components, for example, antinutritional factors [24]. However, the linear regression method for estimating endogenous excretion has been criticised, because the estimation of endogenous loss is constrained by a mathematical function which may not be a suitable descriptor of the real biological phenomenon. The increase in amino acid flow with increasing protein intake is attributed entirely to increased amount of undigested food protein, assuming that there is no change in the amount of endogenous amino acid excretions. There is evidence, however, that the rate of excretion into the intestine does vary with the amount of protein given [41]. Consequently, some of the increase in amino acid flow with increased dietary protein intake is probably the result of enhanced secretion of endogenous proteins. Souffrant [24] also reported that it is unlikely that a linear relation exists between feed intake and endogenous N or amino acids in digesta or faeces. An increase in the protein level of the feed used with the regression method is always associated with changes in the composition of other crude nutrients and other feed ingredients, therefore hindering the interpretation of the results regarding causes and effects.

Literature values indicate some variations across the different studies probably due to differences in digesta collection methods and animal liveweights. The values, determined by the regression method, are similar to those found for animals given a protein-free diet. These can be seen more clearly in those studies where both methods have been used to determine the flow of amino acids at the terminal ileum for animals [6]. Also, different proteins do not appear to significantly affect the determined endogenous amino acid flows [6,15]. The regression method was used by Moughan et al. [42] for rats and pigs fed barley meal, but the majority of the intercepts were not significantly different from zero. Skilton [43] in reviewing the previous authors' results, noted that the coefficients of determination, particularly for the pigs, were low ($R^2 = 0.18 - 0.62$, $n = 11$). The low correlations exemplify the problems associated with the variability of endogenous protein excretion and the large number of animals required to obtain meaningful results.
Philosophically, the regression method would appear to be better than the protein-free method for endogenous N and amino acids in ileal digesta. This, however, does not appear to be the case in practice.

HOMOARGININE (GUANIDINATION) METHOD

The homoarginine method which allows a more definitive study of the effect of peptides and protein on endogenous amino acid loss, has been developed [44,45,46,47]. This approach is able to distinguish between exogenous and endogenous protein and allows the determination of endogenous lysine flow in the small intestine of mammals and birds. The method involves transforming lysine units in dietary protein to homoarginine units by the guanidination reaction with O-methylisourea (MIU). Body proteins do not contain homoarginine, therefore, any unabsorbed homoarginine must have come from the diet rather than the endogenous secretions. In contrast with other markers (^{15}N, ^{13}C, ^{14}C), it is not incorporated into endogenous protein, so intestinal scales and pancreatic protein are free of homoarginine. After absorption, the homoarginine is partially reconverted into lysine by arginase, an enzyme mainly found in the liver, with subsequent release of urea. With regard to the latter assumption, Schuttert et al. [48] in an *in vitro* experiment, did not detect any arginase activity in the small intestine of the growing rat. Provided that guanidinated protein and native protein are broken down enzymatically at similar rates in the digestive tract, and that homoarginine is absorbed in a similar manner as the other protein-bound feed amino acids, the endogenous proportion of N in ileal chyme can be calculated on the basis of the amount of homoarginine that disappears during the chyme's passage up to the terminal ileum.

Rutherfurd and Moughan [49] who studied the effect of pH and protein level on the extent of guanidination of casein, gelatin and soya protein isolate, reported that complete conversion of lysine to homoarginine was not achieved for any of the proteins studied. Nevertheless, with gelatin, which has a low natural lysine content, a maximum conversion of lysine to homoarginine of 95% was achieved, indicating that guanidinated gelatin is a suitable protein source for directly determining the endogenous excretion of lysine in the mammalian gut.

Hagemeister and Erbersdobler [44] used the homoarginine method to investigate the ileal digestibility of casein and soya isolate in pigs and found that the true digestibility for both feed N and endogenous N was 99.5% and that more than 90% of the ileal N was of an endogenous origin. Siriwan and Bryden [45] and Siriwan et al. [46] who used the homoarginine technique with chickens fed guanidinated casein, reported that 90% of the amino acids appearing in the ileum were of endogenous origin. Moughan and Rutherfurd [47] completely guanidinated gelatin protein and in a study with growing rats demonstrated that when protein is present in the gut, endogenous lysine loss from the terminal ileum is considerably enhanced above that found with protein-free alimentation.

Souffrant [24] concluded that the homoarginine method is an appropriate method available to estimate proportions of endogenous protein and amino acids in ileal chyme. The method makes it easy to assess the effects of protein content and quality on endogenous N and amino acid levels in the chyme at the terminal ileum. The major disadvantage of the method, however, is that it provides direct information only for endogenous lysine flow. Further disadvantages include the possible accumulation of homoarginine in the body over time due to the slow rate of conversion of homoarginine to lysine. Again, homoarginine may interfere with the urea cycle leading to an accumulation of ammonia in the body.

RADIOACTIVE ISOTOPE OR TRACER TECHNIQUE

The use of radioactive isotopes or tracers (^{15}N, ^{14}C, ^{13}C, ^{35}S, ^{75}Se) to label dietary protein or the whole animal body protein prior to the trial, in order to distinguish between the exogenous and endogenous amino acids appearing in the terminal ileum after feeding a protein-containing diet, has been carried out by other workers [50,51]. The most successful application to date has been the ^{15}N tracer.

Using the technique of labelling the animal's body protein with radioactive or ^{15}N stable isotopes, De Lange et al. [50] showed that endogenous N flow at the terminal ileum is considerably enhanced when natural protein-containing feeds are given as opposed to protein-free diets.

Souffrant [24] has reviewed the use of the ^{15}N dilution technique and outlined some of the difficulties with this method. The practical aspects of the technique which require further critical analysis include the method of labelling the animal's N pool, and the selection of the pool with a labelling level equal to that of total endogenous nitrogen. Choice of precursor pool has a significant effect on the dilution factor [52]. The ^{15}N method can be used to determine the endogenous N in digesta and faeces, but not the proportions of endogenous amino acids. The latter means that a constant assumed endogenous amino acid composition is used to determine true amino acid digestibility coefficients. This constant amino acid composition is usually that determined following feeding of the animal a protein-free diet, which as discussed earlier has its own inherent difficulties. Although the use of labelled dietary protein and animal body protein may give a good measure of endogenous protein excretion, the technique involves considerable expense and specialised equipment, which may limit its use even as a baseline measurement. More work needs to be done on the suitability of alternative precursor pools.

PEPTIDE ALIMENTATION METHOD

Studies [39,53,54] indicate that endogenous amino acid loss from the rat's small intestine is higher under peptide alimentation than under protein-free or synthetic free amino acid feeding. Further, Moughan and Rutherfurd [47] have shown that the endogenous flow of lysine at the terminal ileum of rats fed a diet containing guanidinated protein was significantly higher than that of rats fed a protein-free diet.

The approach of Darragh et al. [53], however, in which endogenous ileal amino acid excretion was determined after feeding rats an hydrolysed casein based diet, relied on the assumption that dietary amino acids were completely absorbed. The enzymically hydrolysed casein (EHC), a mixture of free amino acids and oligopeptides, was assumed to be completely digested and absorbed by the end of the small intestine of the rat.

Although the latter seems likely, it is difficult to establish unequivocally. Consequently, a method for determining endogenous loss has been proposed [55] which removes the need to make assumptions concerning the completeness of absorption of the dietary amino acids. In this method the animal is fed a semi-synthetic diet containing EHC as its sole N source. Ileal digesta are collected and nitrogenous fraction separated physically using large volume disposable Centriprep -10 ultrafiltration devices (Amicon, W.R. Grace and Co., Danvers, Massachussetts). The high molecular weight (M.W. >10,000 Daltons) fraction resulting from the ultrafiltration provides a measure of endogenous amino acid flow. If some of the dietary amino acids and small peptides are not absorbed, they will be removed in the low molecular weight fraction. In addition to the unabsorbed dietary amino acids and peptides, the low molecular weight fraction will contain non-protein N and may contain endogenous free amino acids and small peptides. The latter if present, are expected to be at a low concentration [39]. Nevertheless, their removal in the low molecular weight fraction may lead to some underestimation of the actual endogenous loss of amino acids. Donkoh and Moughan [31] applied this new method with growing pigs, and their results some of which are presented in Table 2, provide further evidence that dietary peptides have a stimulatory effect on endogenous amino acid secretion and loss from the small intestine.

Table 2. Endogenous amino acid flow at the terminal ileum of the growing pig using the enzymically hydrolysed casein/ultrafiltration (EHC), protein-free (PF) or regression methods (mg/kg freeze dry matter intake; no = 6)

	Endogenous amino acid flow		
Amino acid	*EHC*	*Protein-Free*	*Regression*
Lysine	464 ± 9.2	271 ± 6.8	259 ± 17.5
Histidine	360 ± 6.5	190 ± 5.9	198 ± 5.1
Threonine	879 ± 9.0	469 ± 8.4	438 ± 14.4
Valine	612 ± 4.8	351 ± 3.9	338 ± 8.1
Isoleucine	348 ± 12.2	253 ± 6.3	236 ± 7.7

The EHC endogenous flows were significantly (P < 0.05) higher than for the protein-free treatment and the regression methods
Adapted from Donkoh and Moughan [31]

CONCLUSION

Further research into methods for determining ileal endogenous amino acid excretion is required, but the hydrolysed protein method may give rise to more meaningful estimates of basal endogenous and amino acid loss, which may be used to generate digestibility coefficients for practical application.

REFERENCES

1. Sibbald, I.R. Estimation of bioavailable amino acids in feedingstuffs for poultry and pigs: a review with emphasis on balance experiments. Can. J. Anim. Sci. 67: 221 – 300, 1987.
2. Laplace, J.P., Darcy-Vrillon, B. and Picard, M. Evaluation de la disponbilite des acides amines: choix raisonne d'une methode. J. Rech. France 17: 353 – 370, 1985.
3. Sauer, W.C. and Ozimek, L. Digestibility of amino acids in swine: results and their practical applications. A review. Livestock Prod. Sci. 15: 367 – 388, 1986.
4. Donkoh, A., Moughan, P.J. and Smith, W.C. The laboratory rat as a model animal for determining ileal amino acid digestibility in meat and bone meal for the growing pig. Animal Feed Sci. Technol. 49: 57 – 71, 1994.
5. McNab, J.M. Factors affecting digestibility of foodstuffs. In: Digestion in the Fowl. Proceedings of the 11th Poultry Science Symposium, Edinburgh, 1975. K.N. Boorman and B.M. Freeman, editors. British Poultry Science Limited, Edinburgh, pp. 261 – 263, 1976.
6. Furuya, S. and Kaji, Y. Estimation of the true ileal digestibility of amino acids and nitrogen from apparent values for growing pigs. Animal Feed Sci. Technol. 26: 271 – 285, 1989.
7. Keith, M.O. and Bell, J.M. Composition and digestibility of canola press cake as a feedstuff for use in swine diets. Can. J. Anim. Sci. 71: 879 – 885, 1991.
8. McNab, J.M. Measuring availability of amino acids from digestibiity experiments. 7th European Symposium on Poultry Nutrition, 19-21 June, Girona, Spain, pp. 285 – 286, 1989.
9. Zuprizal, Larbier, M., Chagneau, A.M. and Lessire, M. Effect of protein intake on true digestibility of amino acids in rapeseed meals for adult roosters force fed with moistened feed. Animal Feed Sci. Technol. 34: 255 – 260, 1991.
10. Donkoh, A. and Moughan, P.J. The effect of dietary crude protein content on apparent and true ileal nitrogen and amino acid digestibilities. Br. J. Nutr. 72: 59 – 68, 1994.
11. Smith, W.M. Peptide and amino absorption in the small intestine. In: Animal Nutrition and Transport Processes. 1. Nutrition in Wild and Domestic Animals. Comparative Physiology. Vol. 5. J. Mellinger, editor. Karger, Basel, pp. 146 – 155, 1990.
12. Rerat, A., Corring, T. and Laplace, J.P. Protein digestion and absorption. In: Protein Metabolism and Nutrition. Proceedings of a Symposium Held at the University of Nottingham, 1974, European Association for Animal Production Publication No. 16. D.J.A. Cole, K.N. Boorman, P.J. Buttery, D. Lewis, R.J. Neale and H. Swan, editors. Butterworths, London, pp. 97 – 138, 1976.
13. Auclair, E. Etude des Pertes Azotes D'origine Endogene dans le Tube le Porc, le Coq et le Rat. Dissertation, University of Clermont, France, 1986.
14. Potten, C.S. Clonogenic, stem and carcinogen-target cells in small intestine. In: Diseases of the Gut. J.M. Polak, S.R. Bloom, N.A. Wright and A.G. Butler, editors. Page Bros., Norwich, pp. 3 – 14, 1986.
15. Taverner, M.R., Hume, I.D. and Farrell, D.J. Availability to pigs of amino acids in cereal grains. 1. Endogenous levels of amino acids in ileal digesta and faeces of pigs given cereal diets. Br. J. Nutr. 46: 149 – 158, 1981.
16. Horowitz, M.I. Macromolecules of the gastrointestinal tract. Annals N.Y. Acad. Sci. 106: 278 – 287, 1963.
17. Taverner, M.R. Ileal Availability for Pigs of Amino Acids in Cereal Grains. PhD. Thesis. University of New England, Armidale, Australia, 1979.
18. Zebrowska, T. Nitrogen digestion in the large intestine. In: Physiologie Digestive Chez le Porc. 2e Seminaire International Jouy-en-Josas-Versailles, France, 1982. Les Colloques l'INRA no. 12. J.P. Laplace, T. Corring and A. Rerat, editors. Institut National de la Recherche Agronomique, Paris, pp. 226 – 236, 1982.

19. Hashimoto, Y., Tsuiki, S., Nisizawa, K. and Pigman, W. Action of proteolytic enzymes on purified bovine submaxillary mucin. Annals N. Y. Acad. Sci. 106: 233 – 246, 1963.

20. Fauconneau, G. and Michel, M.C. The role of the gastrointestinal tract in the regulation of protein metabolism. In: Mammalian Protein Metabolism, Vol. 4. H.N. Munro and J.B. Allison, editors. Academic Press, New York, pp. 481 – 522, 1970.

21. Alpers, D.H. Digestion and absorption of carbohydrates and proteins. In: Physiology of the Gastrointestinal Tract, Vol. II, 2nd edition, L.R. Johnson, editor. Raven Press, New York, pp. 1469 – 1487, 1987.

22. Zebrowska, T. and Buraczewska, L. Influence of dietary protein level on the rate of digestion in the small intestine of pigs. I. Amount and cor position of digesta. Roczniki Nauk Roln. 94B (1): 82 – 96, 1972.

23. Romero, J.J. and Canolty, N.L. A method for determining the relative rates of intestinal absorption of endogenous and exogenous protein. Nutr. Rep. Int. 19: 275 – 280, 1979.

24. Souffrant, W.B. Endogenous losses during digestion in pigs. In: Digestive Physiology in Pigs. Proceedings of the Vth International Symposium on Digestive Physiology in Pigs. EAAP Publication No. 54. M.W.A. Verstegen, J. Huisman and L.A. den Hartog, editors. Pudoc. Wageningen, pp. 147 – 166, 1991.

25. Rerat, A. Absorption of nitrogen and amino acids from exogenous (fish meal proteins) or endogenous sources in the pig. Pig News and Info. 11: 173 – 180, 1990.

26. Low, A.G. Endogenous nitrogen evaluation from absorption studies. In: Physiologie Digestive Chez le Porc. 2e Seminaire International Jouy-en-Josas-Versailles, France, 1982. Les Colliques l'INRA No. 12. J. P. Laplace, T. Corring and A. Rerat, editors. Institut National de la Recherche Agronomique, Paris, pp. 189 – 198, 1982.

27. Butts, C.A. Endogenous Ileal Amino Acid Excretion in Monogastric Animals. PhD Thesis. Massey University, Palmerson North, New Zealand, 1991.

28. Low, A.G. and Zebrowska, T. Digestion in pigs. In: Protein Metabolism in Farm Animals. H.D. Bock, B.O. Eggum, A.G. Low, O. Simon and T. Zebrowska, editors. University Press, Oxford, pp. 53 – 121, 1989.

29. Leterme, P., Thewis, A., Beckers, Y. and Baudart, E. Apparent and true ileal digestibility of amino acids and nitrogen balance measured in pigs with ileo-rectal anastomosis or T-cannulas, given a diet containing peas. J.Sci. Food Agric. 52: 485 – 497, 1990.

30. Furuya, S. and Kaji, Y. Additivity of the apparent and true ileal digestible amino acid supply in barley, maize, wheat or soya-bean meal based diets for growing pigs. Animal Feed Sci. Technol. 32: 321 – 331, 1991.

31. Donkoh, A. and Moughan, P.J. Endogenous ileal nitrogen and amino acid flows in the growing pig receiving a protein-free diet and diets containing enzymically hydrolysed casein or graded levels of meat and bone meal. Anim. Sci. 68: 511 – 518, 1999.

32. Cetta, G., Pallavicini, G., Calatroni, A. and Castellani, A.A. Glycoproteins from bovine duodenal mucosa. Italian J. Biochem. 21: 275 – 288, 1972.

33. De Lange, C.F.M., Sauer, W.C. and Souffrant, W.B. The effect of protein status of the pig on the recovery and amino acid composition of endogenous protein in digesta collected from the distal ileum. J. Anim. Sci. 67: 755 – 762, 1989.

34. Karasov, W.H., Solsberg, D.H. and Diamond, J.M. Dependence of intestinal amino acid uptake on dietary protein or amino acid levels. Am. J. Physiol. 252: G614 – G625, 1987.

35. Sauer, W.C. Endogenous nitrogen in balance studies. In: Physiologie Digestive Chez le Porc. 2e Seminaire International Jouy-en-Josas-Versailles, France, 1982. Les Colliques l'INRA No. 12. J.P. Laplace, T. Corring and A. Rerat, editors. Institut National de la Recherche Agronomique, Paris, pp. 199 – 204, 1982.

36. Millward, D.J., Garlick, P.J., James, W.P.T., Sender, P.M. and Waterlow, J.C. Protein turnover. In: Protein Metabolism and Nutrition. Proceedings of a Symposium Held

at the University of Nottingham, 1974. EAAP Publication No. 16. D.J.A. Cole, K.N. Boorman, P.J. Buttery, D. Lewis, R.J. Neale and H. Swan, editors. Butterworths, London, pp. 49 – 69, 1976.

37. Skilton, G.A., Moughan, P.J. and Smith, W.C. Determination of endogenous amino acid flow at the terminal ileum of the rat. J. Sci. Food Agric. 44: 227 – 235, 1988.

38. Buraczewska, L. Secretion of nitrogenous compounds in the small intestine of pigs. Acta Physiol. Polonica, 30: 319 – 326, 1979.

39. Butts, C.A., Moughan, P.J. and Smith, W.C. Endogenous amino acid flow at the terminal ileum of the rat determined under conditions of peptide alimentation. J. Sci. Food Agric. 55: 175 – 187, 1991.

40. Fan, M.Z., Sauer, W.C. and McBurney, M.I. Estimation by regression analysis of endogenous amino acid levels in digesta collected from the distal ileum of pigs. J. Anim. Sci. 73: 2319 – 2328, 1995.

41. Ozimek, L., Sauer, W.C., Ozimek, G. and Conway, D. Effect of diet on the qualitative and quantitative adaptation of exocrine pancreatic secretions. 63rd Annual Feeders' Day Report. Agriculture and Forestry Bulletin Special Issue, pp. 16 – 19, 1984.

42. Moughan, P.J., Smith, W.C., Kies, A.K. and James, K.A.C. Comparison of the ileal digestibility of amino acids in ground barley for the growing rat and pig. N.Z. J. Agric. Res. 30: 59 – 66, 1987.

43. Skilton, G.A. Aspects of True Ileal Protein Digestibility Assay in the Growing Rat. Honours Disseration, Massey University, Palmetston North, New Zealand, 1986.

44. Hagemeister, H. and Erbersdobler, H. Messung der prazakalen Verdaulichkeit von Protein mit der Homoargin-Methode. Arch. Anim. Nutr. 37: 451 – 452, 1987.

45. Siriwan, P. and Bryden, W.L. Determination of endogenous amino acids using homoarginine. In: Proceedings of the Poultry Husbandry Research Foundation Symposium. University of Sydney, Australia, p 9, 1987.

46. Siriwan, P., Bryden, W.L. and Annison, E.F. The use of homoarginine to correct ileal digestibility values for endogenous amino acids. Proc. Nutr. Soc. Australia, 12: 102, 1987.

47. Moughan, P.J. and Rutherfurd, S.M. Endogenous flow of total lysine and other amino acids at the distal ileum of the protein- or peptide-fed rat. The chemical labelling of gelatin protein by transformation of lysine to homoarginine. J.Sci. Food Agric. 52: 179 – 192, 1990.

48. Schuttert, G., Moughan, P.J. and Jackson, F. *In vitro* determination of the extent of hydrolysis of homoarginine by arginase in the small intestine of the growing rat. J. Agric. Food Chem. 39: 511 – 513, 1991.

49. Rutherfurd, S.M. and Moughan, P.J. Guanidination of lysine in selected dietary proteins. J. Agric. Food Chem. 38: 209 – 211, 1990.

50. De Lange, C.F.M., Souffrant, W.B. and Sauer, W.C. Real ileal protein and amino acid digestibilities in feedstuffs for growing pigs as determined with the ^{15}N-isotope dilution technique. J. Anim. Sci. 68: 409 – 418, 1990.

51. Krawielitzki, K., Zebrowska, T., Schadereit, R., Kowalczyk, J., Wunsche, J. and Herrmann, U. Determination of nitrogen absorption and secretion in different sections of the pig's intestine by digesta exchange between ^{15}N labelled and unlabelled animals. Arch. Anim. Nutr. 40: 25 – 37, 1990.

52. Moughan, P.J., Buttery, P.J., Essex, C.P. and Soar, J.B. Evaluation of the isotope dilution technique for determining ileal endogenous nitrogen excretion in the rat. J. Sci. Food Agric. 58: 165 – 172, 1992.

53. Darragh, A.J., Moughan, P.J. and Smith, W.C. The effect of amino acid and peptide alimentation on the determination of endogenous amino acid flow at the terminal ileum of the rat. J. Sci. Food Agric. 51: 47 – 56, 1990.

54. Donkoh, A., Moughan, P.J. and Morel, P.C.H. Comparison of methods to determine the endogenous amino acid flow at the terminal ileum of the growing rat. J. Sci. Food Agric. 67: 359 – 366, 1995.

PERCEPTION OF FARMERS AND NON-FARMERS AROUND BUI NATIONAL PARK TOWARD THE MANAGEMENT OF PROBLEM WILDLIFE

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ABSTRACT

Farmers and non-farmers in 10 fringe communities around Bui National Park were surveyed to examine perceptions of human-wildlife conflicts and their management. Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) tools were used to gather information. The response groups tended to attribute different degrees of depredation to certain wildlife species. In choosing control methods to manage wildlife conflicts, both farmer and non-farmer groups tended to prefer lethal methods.

Most farmers (84.0%) and non-farmers (68.3%) believed baboons were the most severe or frequent source of crop depredation followed by bush fowl and patas monkey in descending order of severity of depredation. Approximately 86.0% of farmers and 72.0% of non- farmers felt hunting reduced depredation-related problems, but non-farmers were approximately three times as likely as farmers to prefer non-lethal control techniques for warthogs. The fact that there is no disparity in perceptions of crop depredation wildlife makes it easier for development of a management plan for the park.

On the contrary, the existence of disparities in perceptions of control techniques for depredation wildlife is a potential source of conflict in the development of a management plan for Bui National Park. However, residents of fringe communities of the park, agreed to suggested use of non-lethal means of control only if they would be compensated for crop and livestock losses. Local people also suggested their involvement in the protection and management of the park.

Keywords: *agricultural-wildlife conflicts, vertebrate pest management, wildlife damage, depredation, wildlife-human dimensions, fringe communities.*

INTRODUCTION

Farmers around protected areas must contend with economic impacts from a variety of depredating wildlife species. These animals physically damage crops, fishing nets, farms, vegetation and soil. Besides they plunder livestock and some serve as reservoir host or vectors for human and domestic animal diseases. Above all others attack humans directly. Oduro and Sarfo-Mensah [1] reported an increase in the incidence of conflict between wildlife and agriculture in fringe communities of Mole National Park.

Aggravating this situation is the increasing human densities around parks due to population growth. Consequently, croplands have also become scarce while the numbers of many animal species within the protected areas have increased tremendously creating man-wildlife conflicts as the animals search for food, cover and water. This is more serious around protected areas like the Bui National Park. Elephant depredation on field crops can be substantial in some range areas [2].

Although the Wildlife conservation regulations [3] permit killing without a permit in defense of one's self or any other person (Regulation 17), it does not in defense of crops or livestock. Nei-

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ther these Wildlife Conservation Regulations [4] nor the Wildlife Reserves Regulations [4] make any provision for compensation for damage caused by wild animals from the reserves.

Protected areas management demands the co-operation of people living around them. Without it, conflicts over wildlife damage to crops and livestock, and illegal use of resources from within the reserves are inevitable. The 1994 Forest and Wildlife Policy [5] gave an emphasis to rural people's participation in resource management and protection. Furthermore at least three of the six principal elements listed under the "strategy and medium-term programme objectives' of the Wildlife Development plan [6] relate to people's involvement in wildlife management activities. Again one of the major areas of concern under programme IV of the Wildlife Development Plan [6] is to resolve existing conflicts with people living in protected areas, thereby minimizing their impact on the reserve's ecology. Also under "Risks and Uncertainties" it is stated that successful implementation of the Wildlife Development Plan [6] requires widespread public support and underscored that there is a risk this will be lacking. In addition, the Wildlife Development Plan [6] gives prominence to the fact that in many rural areas, wildlife is regarded primarily as a problem because of crop and livestock losses.

However, farmers and wildlife managers are increasingly asked to incorporate evolving societal values into management decisions; their values often call for the application of non-lethal wildlife control methods [7,8,9]. Wildlife management is an expensive business and consequently, needs political and donor support. In sum, wildlife management requires the involvement of fringe communities in protected area management decisions, which is the most harmonious and cost effective method of managing forest and wildlife reserves.

Because farmers in many fringe communities of protected areas are major land holders and influence depredation-related management decisions, understanding their attitudes and how they differ from non-farmers may be critical to managing wildlife damage problems on private lands [8]. Likewise, some segments of the fringe communities of wildlife and forest reserves may vociferously oppose wildlife damage management decisions, so their perceptions are equally important [10].

METHODS

Ten out of twenty-one fringe villages of Bui National Park were sampled at random. From each village, lists of farmers and non-farmers were compiled with the help of the chief, chief's secretary and elders. Twenty percent of farmers and non-farmers from each village were randomly selected for interview using a checklist/questionnaire. One hundred farmers and sixty non-farmers in all were interviewed. The farmers' checklist/survey consisted of forty questions while non-farmers were asked thirty-one questions.

The two surveys had 25 questions in common. Additional questions posed to farmers solicited information about the types of commodities produced and the degree of depredation experienced according to type of commodity.

Both groups received a list of 12 local wildlife species ranked and compiled from earlier interview: baboon [*Papio anubis*], patas monkey [*Erythrocebus patas*], ground squirrel [*Xeru erythropus*], green parrot [*Psittacidae sp*], bush-fowl [*Francolinus bicalcaratus*], wartho [*Phacochoerus aethiopicus*], green monkey [*Cercopithecus aethiops*], bushbuck [*Tragelaphus scriptus*], grey kestre [*Falconidae v*], black cobra [*Naja melanoleuca*], dwarf *mongoose [Herpestes sanguineus]*, grasscutter [*Thryonomys swinderianus*] and were asked to rate the severity o damage caused by each on a Likert scale.

For farmers, this question referenced damag experienced on each respondent's operatio Non-farmers were asked to estimate the level o damage inflicted by each species in their are A mean for each response was calculated an species ranked according to the severity of damage attributed to it. Each respondent was ve bally presented with a list, accompanied b black and white pictures, of potentially depredating species and asked whether, given options among control techniques, they will prefer lethal methods, non-lethal methods, or whichever method works best. Because farmers work closely with the land it was assumed that wildlife contact was an integral part of their duties and led to some wildlife awareness. To ascertain levels of awareness among non-farmers, a series of questions were asked to gauge their wildlife - related behaviour.

Analyses were conducted using a chi-square statistic to determine significance. The null hypothesis that responses from farmers and non-farmers did not differ ($P > 0.05$) was tested.

RESULTS

Demography

Average age in 10-year intervals of both farmers and non-farmers was calculated to be 32 - 43 years old. The mean education level of farmers and non-farmers was middle school. Farmers ($\bar{x}$ = 25 year resident) tended to be long-term occupants of their villages compared to non-farmers ($\bar{x}$ = 22 years resident).

All the farmers interviewed raised 2 different crops; 54% raised grains (rice, guinea corn, maize, and millet). Twelve percent (12%) cultivated food legumes (bambara beans, groundnut, cowpea and water melon). About 87% produced roots and tubers (yam and cassava). Only 3% raised fleshy vegetables (pepper, Okro, tomato and garden eggs).

The farming system practiced was mixed cropping with crop rotation. Most (80%) produced livestock including: Chicken (80%), sheep (71.9%), goats (87.3%), cattle (28.0%), guinea fowl (10.0%), turkeys (2.0%) and pigs (8.0%); all the farmers interviewed produced 2 types of livestock.

Magnitude and Source of Losses

During 1986, 87% of farmers in our survey experienced some level of damage from wildlife, while 79.6% experienced damage between 1993 and 1994. When asked to estimate the most recent year's loss, 32% reported losses < ¢20,000, 29% reported losses from ¢20,000 - ¢40,000 and 33% estimated losses > ¢40,000.

In rating the severity of damage associated with 12 species of wildlife, responses of farmers differed from non-farmers for 7 species (Table 1). While there was some agreement on the rank of depredation sources (e.g. bush fowl, baboon and patas monkey constitute the greatest source of damage and the dwarf mongoose the least), farmers rated levels of damage by particular wildlife species as most severe than non-farmers. For example, more farmers than non-farmers reported damage from bush fowl, baboon, and patas monkey as most severe.

When asked to designate the control technique ("lethal", "non-lethal", or "whichever works best") to be applied in cases of species specific depredation, responses from farmers and non-farmers differed in each case (Table 2). There was no significant difference between farmers and non-farmers in the preference of control techniques for problem wildlife. Both farmer and non-farmer designated lethal technique for control of depredation wildlife. However, both farmer and non-farmer preferred using non-lethal technique to control warthog. The black cobra was an exception to this pattern; responses from both farmer and non-farmer indicated a lethal control technique. In the case of grasscutters, although not protected by any law, 94% of farmers preferred lethal methods, 1% preferred non-lethal and 5% opted for whichever method works best. Similarly, 88.3% of non-farmers preferred lethal methods 3.3% preferred non-lethal, and 8.3% designated whichever method works best. With respect to warthog, 14.0% of farmers preferred lethal method, 82.0% preferred non-lethal and only 4.0% opted for whichever works best. Likewise, only 2.0% of non-farmers preferred lethal method 90% preferred non-lethal, and 8.0% designated whichever works best.

Levels of Participation

Both groups were asked, if they hunted during 1993-94 (Table 3), and response did not differ by response group ($P>0.05$) with 58.0% of farmers and 45.0% of non-farmers participating. When respondents who hunted were asked, if they chose to hunt a particular type of animal specifically to alleviate depredation, responses did not differ by group ($P>0.05$); almost equal numbers of both farmers (57.60%) and non-farmers (45.0%) intentionally pursued a depredating species.

Management Perceptions

A series of questions were pósed to investigate the perceptions of management techniques currently practiced in the study area (Table 3). Eighty-six percent (86%) of the farmers and 71.7% of the non-farmers believed that hunting helped reduce damage caused by wild animals, but none of the response groups was uncertain of hunting's efficacy. To focus on hunting baboons, it was asked, if this particular species should be hunted to control damage. Responses differed by group ($P<0.05$), with more farmers than non-farmers approving of this management approach. In preserving a possible alternative to hunting, it was asked, if payment for damages attributed to baboons would be acceptable. Again responses differed by group ($P<0.05$), with (83.0%) farmers and 71.7% (non-farmers) expressing support for this alternative. In response to what percentage of losses farmers should be reimbursed (Table 4) answers differed by group ($P<0.05$) with non-farmers expressing less support for comprehensive depredation payments than farmers.

DISCUSSION

There have been many reports in daily- newspapers about farmers' perceptions of wildlife damage management issues but there has not been any reported in-depth scientific studies on these issues. Oduro and Volta-Tineh (7) have reported similar interesting findings at Mole National Park. Their report revealed that respondents who identified themselves as farmers expressed attitudes and opinions distinct from non-farmers.

In this study, non- farmers are actually composed of a mosaic of consumptive and non-consumptive resource users and individuals from diverse economic and educational backgrounds. This amalgamating of groups may explain some of the overlap in response between farmers and the broadly classified non-farmers, though generally the two groups were statistically different in their responses. Both farmers and non-farmers were equally likely to have hunted during 1991, and both groups shared perceptions regarding hunting usefulness for controlling depredation. In the case of warthog, green monkey, bushbuck and grey kestrel and black cobra, the two response groups concurred on the degree of depredation attributable to each species; apart from warthog the distribution of the rest of the species tended towards between severe and least severe damage.

Responses did differ ($p< 0.05$) between groups for severity of damage attributable to baboon, patas monkey, Geoffroy's ground squirrel, green parrot, bush-fowl, dwarf mongoose and grass-cutter. These responses were distributed at extreme ends of the scale with bushbuck and dwarf mongoose towards least severe damage while baboon, bush-fowl, and patas monkey were at the most severe end of the scale.

Reasons for perceptual differences between farmers and non-farmers are numerous. Certainly expdriential differences underlie the two response groups. Farmers may interact directly with wildlife on a daily basis in the context of their small scale or commercial-agricultural interest.

Direct interactions among non-farmers, in contrast, may occur less frequently than farmer-wildlife contacts and perhaps in more urban settings perceptions of the same species of wildlife encountered in different settings may lead to disparate opinions about its activities and impacts on human economic interests.

Both response groups ranked bush fowl, patas monkey and baboon in the order of severity as the greatest source of wildlife - caused damage. This ranking reflects the trend of increasing bush-fowl, patas monkey and baboon - human conflicts at Mole National Park [7]. In the study area, bush fowl, patas monkey and baboon appear to be coming into increasing contact and conflict on farm lands and also at home. This may be responsible for the agreement both farmers and non-farmers had on their severity of damage.

In this study, strong opposition to hunt marauding baboons was not reflected in the survey result. Responses between the groups surveyed were significantly different ($p < 0.05$) though they were not polarised in their distribution. Only 30% of non-farmers and 11% of farmers opposed baboon hunting, most farmers (89%) and non-farmers (79%) agreed to baboon hunting. Both response groups were certain that hunting baboons to control crop and livestock damage was appropriate.

Farmer and non-farmer respondents expressed high support (83.0% and 71.7%) respectively for paying for baboon depredation in lieu of hunting, and farmers were more supportive of this idea than were non-farmers. The appropriate level of compensation was a source of disparity. More farmers (23.0%) than non-farmers (10.0%) felt that compensation should be paid for 75 - 100% of losses. Again, more non-farmers (28.3%) felt that compensation should be paid even where there is no record of loss, whereas only 5% of farmers preferred this level of compensation.

In the absence of information regarding stakeholders' perceptions and experiences with wildlife depredation, wildlife agencies may institute controversial management decisions. Knuth *et al.*, [4], proposed the application of risk management theory to integrate the perceived and actual risks and benefit of a particular wildlife species expressed by stakeholders into the management process. With regard to the baboon, such an approach might help farmers put the risk they experience in perspective and help non-farmers understand what managers must consider when making population management decisions.

The extent to which the results of this study can be extrapolated is not clear. It has been observed that studies indicating wildlife attitudes, knowledge and perceptions may vary according to protected area [7], and therefore warrant a cautionary approach.

CONCLUSION

The farmers and non-farmers in fringe communities around Bui National Park seem to associate different levels of depredation to certain wildlife species. The respondents ranked baboon, bush-fowl, and patas monkey as the greatest source of damage and dwarf mongoose as the least. Both farmers and non-farmers preferred lethal control method for the management of wildlife conflicts. However they opted for non-lethal technique for the control of wart-hog. Farmers and non-farmers, who hunted, intentionally targeted depredating species. More than 70% of both farmer and non-farmer groups felt that hunting as a management technique reduced depredation related problems but they differed in hunting baboons to control damage. When asked if payment for damages attributed to baboons would be acceptable, they also differed. Such disparities in perceptions of damage caused by a species are a potential source of conflict in the development of management plans. Information gathered indicated that animals that stray into farms and homes stood the risk of being killed by lethal means. However, they welcome the suggestion that they will use non-lethal means of control only if they are compensated for crop and livestock losses. It was also clear that the local communities supported the idea of being involved in the management of the park.

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REFERENCE

Oduro W., P. Sarfo-Mensah. 1997. Local Community Involvement in the Protection and Management of Mole National Park. Protected Areas Management and Conservation Project/Japan Government, Ghana Wildlife Department, Ministry of Lands and Forestry.

2. Oduro, W., B. Volta-Tineh. 1997. (Unpublished). Perception of farmers and non-farmers around Mole National Park toward management of Problem Wildlife.

3. Wildlife conservation regulations, 1971, L.I. 685. Government of Ghana.

4. Wildlife Reserve Regulations, 1971, L.I. 710. Government of Ghana.

5. Forest and Wildlife Policy, 1994. Government of Ghana.

6. Wildlife development plan 1998-2003. Overview and Summary, Vol I. Wildlife Department, Accra. July 1998.

7. Arthur, L.M., R.L. Gum, E.H. Carpenter, and W.W. Shaw. 1997. Predator Control; the public viewpoint. Trans. Am Wildl. and Nat. Resource. Conf. 42: 137-145.

8. Kellert, S.R. 1980. Americans' attitudes and knowledge of animals. Trans North Am. Wildl. Conf. 45:111-124.

9. Kellert, S.R. 1983. Affective, cognitive, and evaluative perceptions of animals. Pages 241-267 In I. Altman and J.F. Wohlwill (eds)., Behaviour and the natural environment. Plenum Press, New York.

10. Peyton, R. B. 1984. A typology of natural resource issues with implications for resource management and education. Mich. Acad. 17: 49-58.

11. Knuth, B.A., R.I. Stout, W.F. Siemer, D.J. Decker, and R.C. Stedman. 1992. Risk management concepts for improving wildlife population decisions and public communication strategies. Trans. North Am. Wildlife and Nat. Resource. 57:63-74.

Table 1: Response by farmers and non-farmers asked to rank depredation problem associated with 12 wildlife species around Bui National Park, 1995.

Depredation Source	Respondent	Number	Most Severe	More Severe	Severe	Least Severe	Relative[a] $P < 0.05$	X^2
Baboon	Farmer	100	65.00	35.00	0.00	0.00	1.35	118.0[b]
	Non-Farmer	60	38.33	48.33	11.67	1.67	1.72	202.93
Patas Monkey	Farmer	100	80.00	19.00	1.00	0.00	1.20	170.48[b]
	Non-Farmer	60	35.00	60.00	5.00	0.00	1.70	263.33
Ground Squirrel	Farmer	100	10.00	77.00	12.00	1.00	2.04	146.96[b]
	Non-Farmer	60	3.33	61.67	35.00	0.00	2.31	275.95
Green Parrot	Farmer	100	9.00	72.00	18.00	1.00	2.07	123.96[b]
	Non-Farmer	60	11.67	43.33	45.00	0.00	2.33	209.24
Bush Fowl	Farmer	100	84.00	15.00	1.00	0.00	1.17	191.28[b]
	Non-Farmer	60	68.33	31.67	0.00	0.00	1.32	253.37
Warthog	Farmer	100	5.00	25.00	63.00	7.00	2.72	86.72
	Non-Farmer	60	0.00	3.33	51.67	45.00	3.45	253.73
Green Monkey	Farmer	100	3.00	14.00	55.00	28.00	3.08	60.76
	Non-Farmer	60	0.00	3.33	33.33	63.33	3.60	282.18
Bushbuck	Farmer	100	0.00	13.00	50.00	37.00	3.24	61.52
	Non-Farmer	60	0.00	0.00	31.67	68.38	3.68	318.13
Grey Kestrel	Farmer	100	13.00	62.00	20.00	5.00	2.17	77.52
	Non-Farmer	60	3.33	43.33	50.00	3.33	2.53	233.31
Black Cobra	Farmer	100	0.00	6.00	59.00	35.00	3.29	89.68
	Non-Farmer	60	0.00	16.67	70.00	13.33	2.96	297.03
Dwarf Mongoose	Farmer	100	0.00	2.00	34.00	64.00	3.62	110.24[b]
	Non-Farmer	60	0.00	3.33	53.43	43.33	3.40	255.51
Grasscutter	Farmer	100	3.00	19.00	72.00	6.00	2.81	123.60[b]
	Non-Farmer	60	0.00	5.00	58.33	36.67	3.32	258.14

a) Based on mean calculated for each response scale, ranked "1 (Most severe) to 4 (Least severe)".
b) Significant ($p > 0.05$).

TABLE 2: **Response by farmers and non-farmers regarding preference for control methods appropriate to 12 species of wildlife around Bui National Park.**

Depredation Source	Respondent	Number	Lethal	Non-Lethal	Whichever works best	χ^2
Baboon	Farmer	100	83.00	11.00	6.00	111.59[b]
	Non-Farmer	60	75.00	20.00	5.00	242.50
Patas Monkey	Farmer	100	87.00	4.00	9.00	130.21[b]
	Non-Farmer	60	58.33	26.67	15.00	224.90
Ground Squirrel	Famer	100	78.00	5.00	17.00	92.13
	Non-Farmer	60	48.33	16.67	35.00	131.93
Green Parrot	Farmer	100	71.00	7.00	22.00	67.39
	Non-Farmer	60	53.33	5.00	41.67	170.27
Bush Fowl	Farmer	100	92.00	2.00	6.00	155.38[b]
	Non-Farmer	60	80.00	5.00	15.00	272.50
Bushbuck	Farmer	100	51.00	11.00	38.00	25.11
	Non-Farmer	60	38.33	13.33	48.33	139.13
Grey Kestrel	Farmer	100	65.00	7.0	28.00	51.89
	Non-Farmer	60	55.00	18.33	26.67	143.61
Black Cobra	Farmer	100	89.00	2.00	9.00	140.42[b]
	Non-Farmer	60	78.33	8.33	13.33	259.13
Dwarf Mongoose	Farmer	100	63.00	17.00	20.00	39.88
	Non-Farmer	60	46.67	23.33	30.00	121.12
Grasscuter	Farmer	100	94.00	1.00	5.00	161.12
	Non-Farmer	60	88.33	3.33	8.33	334.13
Green Monkey	Farmer	100	71.00	8.00	21.00	66.55
	Non-Farmer	60	46.67	21.67	31.67	122.53
Warthog	Farmer	100	14.00	82.00	4.00	108.28[b]
	Non-Farmer	60	2.00	90.00	8.00	348.40

[b] **Significant ($p < 0.05$)**

TABLE 3: Responses (%) by farmers and non-farmers around Bui National Park about wildlife depredation issues, 1995.

Respondents	Number	Yes	No	Not Sure	X^2
Did you participate in hunting at Bui National Park during 1993/94 hunting season?					
Farmer	100	58.0	42.0	0.0	53.99
Non-Farmer	60	45.0	55.0	0.0	192.50
If you hunted in 1994, did you choose to hunt a particular type of animal to reduce damage to your or anyone else's property?					
Farmer	100	57.0	43.0	0.0	53.09
Non-Farmer	60	45.0	55.0	0.0	192.50
Does hunting seem to help reduce damage caused by wild animals?					
Farmer	100	86.0	14.0	0.0	127.99[b]
Non-Farmer	60	71.67	28.33	0.0	236.96
Should maurauding species (Baboon) be hunted to control crop damage problem?					
Farmer	100	89.0	11.0	0.0	141.50[b]
Non-Farmer	60	70.0	30.0	0.0	230.00
Would paying farmers/non-farmers for damage caused by maurauding species (Baboon) be an acceptable alternative to hunting maurauding species?					
Farmer	100	83.0	17.0	0.0	115.56[b]
Non-Farmer	60	71.67	28.33	0.0	236.96

[b] Significant (p < o.05)

TABLE 4: Responses (%) by farmers and non-farmers around Bui National Park in 1995 to the question: "For what percentage of wildlife caused losses should farmers be paid?"

Respondent	Number	None	6-25%	26-50%	51-75%	76-100%	X^2
Farmer	100	5.00	0.00	41.00	31.00	23.00	59.8
Non-Farmer	60	28.33	0.00	18.33	43.33	10.00	199.67[b]

[b)] Significant (p > 0.05)

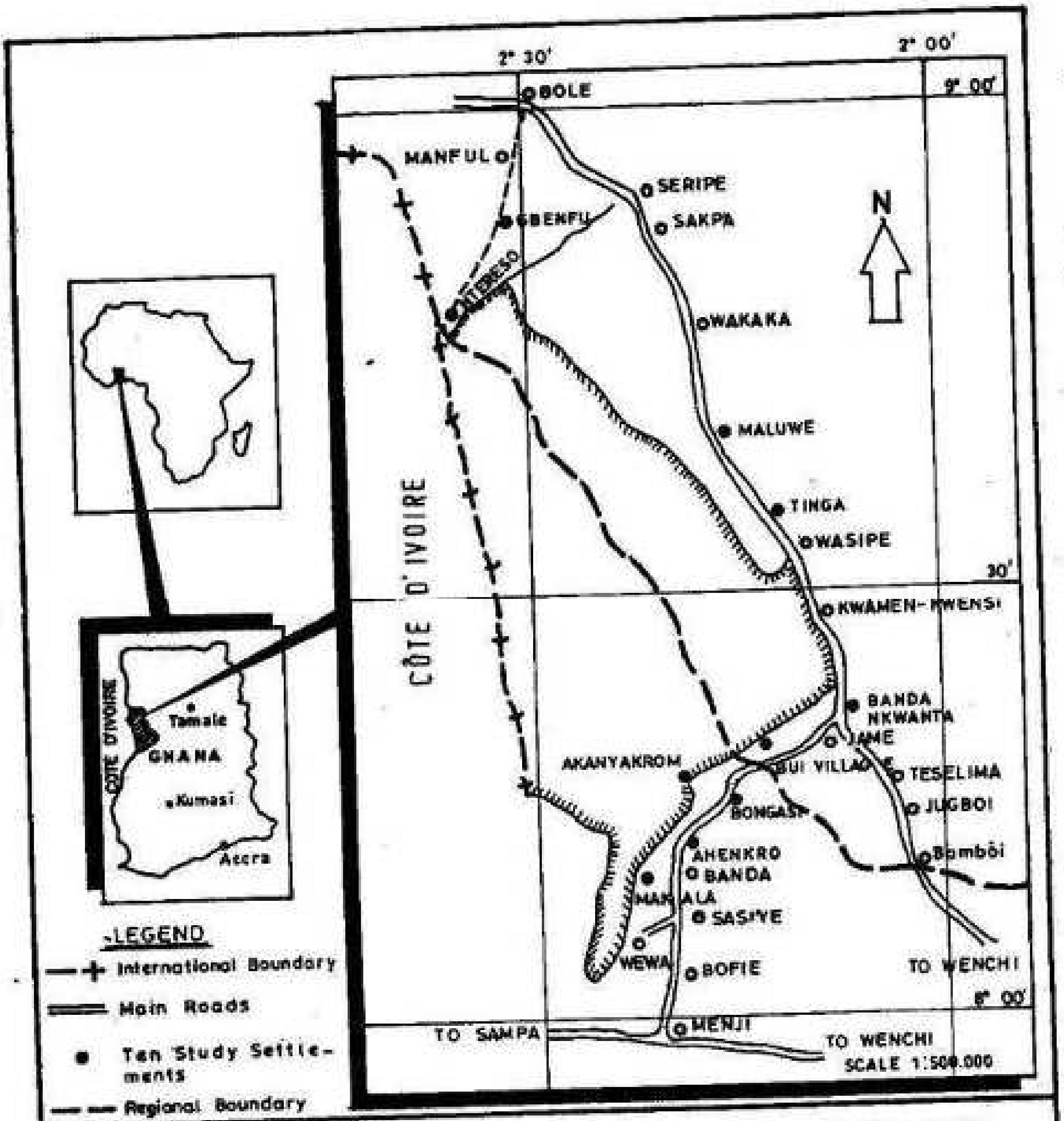

FIG. 1 – BUI NATIONAL PARK SHOWING POSITION OF TEN STUDY SETTLEMENTS