An investigation into the mineral status, especially phosphorus, of cattle not offered licks, feeding exclusively in the communal grazing areas of Mogosane Village, Molopo District, North West Province

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DECLARATION

I declare that the dissertation for the degree of B. Sc. Agriculture at the North-West University hereby submitted, has not previously been submitted by me for a degree at this or any other university, that it is my own work in design and execution and that all material contained herein has been duly acknowledged.

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ABSTRACT

Twenty-five animals that were randomly selected on the basis of sex and age from among the animals feeding exclusively on communal grazing in Mogosane village and were used to investigate the mineral (P, Ca and Mg) status, especially P, based on blood and faecal P and to estimate the quantity of P they consumed from the pasture they were grazing. The project was conducted in the same area each month for one year, and no supplement was given.

Months were blocks and seasonal changes were factors and the animals were experimental units within a block. Faecal, blood and grass samples were used as indicators of P, Ca and Mg minerals within experimental units, and Analysis of Variance was done to determine whether the P status of native pastures had a significant effect on the total P, Ca and Mg utilization and movement in and out of the blood and throughout the faeces during different periods the year. Body mass, condition scores and rainfall were also recorded during this trial.

When the mineral status was investigated in this trial, it was found that mineral content in blood and faeces was directly related to the minerals in the pasture since these indicators were curvilinear increasing from winter months to spring months peaking in summer months with highly ($P < 0.05$) significant values when grazing was best and declining as the grazing became worse during autumn and winter months. The values of the body condition of the animals increased and declined with the values of body mass. Blood P concentration was very inconsistent and varied

greatly and did not follow the same increasing and decreasing pattern followed by faeces and the grass. This emphasizes the fact that the P content of blood is not always good indicator of the P status in the animal.

The mean faecal P concentration during winter was lower with the value of 1.23 ± 0.13 mg/g, during spring was low with the value of 1.8 ± 0.06 mg/g, during summer was higher with the value of 3.22 ± 0.12 mg/g and during autumn was high with the value of 1.98 ± 1.04 mg/g.

The mean concentration of P in the grass during winter was lower with the value of 0.92 ± 0.04 mg/g, during spring was low with the value of 1.16 ± 0.08 mg/g, during summer was higher with the value of 1.68 ± 0.06 mg/g and during autumn was high with the value of 1.22 ± 0.09 mg/g.

The seasonal rainfall correlated with the faecal and grass P values vary much with the value of 0 mm in the winter season, with the value of 26.33 mm in the spring, the value of 90.4 mm during summer and the value of 44.83 mm during autumn.

Condition scores and body masses had the values of 2.08 units/201.4 Kg during winter season, had the values of 3.07 units/272.29 Kg in spring season, had the values of 3.88 units/371 Kg during summer season and the values of 2.75 units/286.65 during autumn season, respectively.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

Phosphorus (P) is an important mineral in the human and animal body. It is necessary for proper skeletal growth, tooth development, kidney functioning and transference of nerve impulses in the body. Phosphorus is also essential for utilization of carbohydrates, fats and proteins for growth, maintenance and repair of cells and energy production (Health Product Association of South Africa, 1998). Also P is a component of nucleic acids involved in cellular metabolism, enzyme systems and buffer systems. Regulation of P balance involves absorption from the small intestine, mobilization from bone, and secretion in saliva (Knowlton and Herbein 2002). They further stated that P (phosphate) absorption in the small intestine increases on an absolute basis with increasing P intake despite a reduction in apparent digestibility of P in response to increasing dietary P content.

Cohen (1975) stated that P is an essential constituent of soft tissue, and occurs as lecithins in various cells, cephalins and spingomyelins particularly in the brain, phospholipid in the blood and in many other cells as phosphoprotein, nucleoprotein, phosphocreatine, and hexosephosphate and in other forms all of which play a role in the composition and structure of cells. Phosphorus is transported through the body in the plasma as inorganic salt and rumen micro-organisms also require P for normal rumen function.

Beighle (2000) also explained that in large areas of the Northern Cape and North West Province 10 % or more of the animals in a number of herds of range cattle suffer from a lameness that appears clinically to be due to osteomalacia, even with the provision of various commonly accepted lick formulations. Even commercial farmers supplement their animals but still they may experience phosphorus deficiency in their animals.

Most communal farmers cannot afford to buy licks to supplement their animals. The animals feed only on natural pastures and many of the world's soils (Cohen 1975 and Read et al. 1986A) and almost all of Australian soils (Gartner et al. 1982) are low in P resulting in pastures that may not supply the requirements for P of grazing animals throughout the year. The above authors were supported by Read et al. (1986A) who clearly said that South African pasture could not supply adequate phosphorus for the P-deficient animals.

Based on their comments, it means that there is low P in the diet of the animals depending only on natural grazing, so animals depending only on natural grazing have a serious P deficiency, and according to Read et al. (1986A), possibly the most serious effect of the deficiency is the depression of feed intake, especially during late lactation and early pregnancy, so this is a serious matter when considering beef production as one of the country's main industries.

CHAPTER 2

OBJECTIVES

Studies related to mineral status in communally grazed cattle are rare and publications related to mineral status in the bovine have been limited to commercial farming animals. There is therefore a need to determine the mineral status among communally grazed cattle in order to intelligently and scientifically advise communal farmers. Beef production is one of the country's main industries and farmers need assistance on how to maintain the health of their animals and how they should supplement their animals in order to have good production.

When animals do not get supplements, e.g. bone meal, they obviously produce less and the most important part is that before providing the animals with any supplementary nutrients it is necessary to identify those nutrients which may possibly limit animal production (Read et al. 1986A), and to determine the mineral status of natural pastures because South African natural pastures, especially the grassland areas, are considered low in phosphorus (Read et al. 1986A). With the increasing costs of supplements it is critical that we recommend supplementation based on the actual need of the animal and not on the perceived need of the animal. (Erickson et al. 2002)

Livestock producers are becoming increasingly aware of the challenges associated with nutrient management. Perhaps the largest challenge will be managing phosphorus inputs and outputs in livestock feeding operations (Erickson et al. 2002). Based on the above statements, the objective of the research was to investigate the mineral status, especially phosphorus, in ruminants feeding exclusively in communal grazing and to estimate the quantity of phosphorus they consume from the pasture they are grazing, based on faecal P (Beighle et al. 1994) and P content of pasture so as to make recommendations for P supplementation for communally grazed livestock.

Although collection of bone samples as a part of the research project was a priority, the farmers would not allow us to take bone biopsies from the cows. We therefore had to rely completely on blood, faecal and pasture samples to evaluate the P status of the animals. The need for data from animals grazed communally was so great that we were willing to agree not to take bone samples in order to be able to collect the blood and faecal samples.

CHAPTER 3

LITERATURE REVIEW

3.1 MINERALS REQUIREMENTS

Growth rate, percentage of newborn and milk production influence mineral needs. Added requirements of gestation and lactation increase mineral needs and thereby consumption (McDowell 2003).

He further stated that mineral needs of ruminant animals depend greatly on their physiological makeup, age, health, nutritional status and function, such as producing meat, milk or developing a fetus. Dairy cows producing greater volumes of milk have higher mineral requirements than dry cows or cows producing low quantities, and Duncan (1958) explained that the requirements of animals for growth or the maintenance of health can be assessed for all practical purposes in an empirical way by trial and error and that animals need enough of a given mineral to prevent deficiency from limiting any process in which the mineral is concerned, but excess may also be limiting.

Recommendations for P supplementation are based largely on speculation and speculation over the P requirements of grazing cattle exists, because of the difficulty of determining the P intake of grazing ruminants, as well as the dependence of P requirements on the levels of protein and digestible energy of the pasture available for grazing animals (de Waal et al. 1996). According to Hemingway (1967), P requirements during growth will naturally be dependent upon the growth rate achieved. According to him the NRC requirements often do not take into account that in disease conditions, certain minerals are needed at higher-than-recommended levels needed for response.

Karn (2001) explained that suggested P requirements for cattle in various stages of the production cycle have varied widely in the United States and around the world and further said that accurate P requirements must be established for all classes of cattle grazing under various conditions before producers can determine whether diets are adequate in P to meet animal needs or whether P supplements must be provided to optimize performance.

He further explained that other factors that may have affected P supplementation responses are, P requirement differences among breeds of cattle, problems in accurately determining dietary P and DMI in grazing cattle and the confounding effect of reduced feed intake on apparent animal response.

Calcium requirements change depending on animal age and production status. Non-lactating and pregnant cows require Ca at a level of 0.18 percent of total dry matter intake, while the requirement for lactating cows is 0.27 percent of total dry matter intake. Growing and finishing cattle require 0.31 percent Ca for optimal growth (Hale and Olson 2001).

According to Hale and Olson (2001), cattle need about 0.04 to 0.1 percent Mg in the dry matter of their ration and in areas where grass tetany is prevalent, higher levels of Mg (up to 0.25 percent of dry matter intake) have been found beneficial to prevent grass tetany. According to Tiffany et al. (2000), consumption of mineral supplement from 57 to 69 g/d and was apparently adequate for all treatment animals.

Given the environmental concerns associated with P, supplementation should not exceed animal requirements to have a 'safety' margin in diet formation (Erickson et al. 1999). An important point to emphasize is that like other nutrients, the requirement of the cow for P is for quantities, not concentrations, and for convenience in balancing rations, P requirements are commonly expressed as a percentage of DM and the actual dietary concentration required to yield the required quantity of P, however, varies with dry matter intake (Knowlton and Kohn 1999).

According to Knowlton and Kohn (1999), better understanding of the P requirements of dairy cows, and reducing the P content of diets to true requirements will reduce P excretion, a critical step in addressing this nutrient imbalance, and further stated that requirements for P are calculated using a factorial approach: the P requirement for a cow is the sum of the calculated requirements for maintenance based on body weight, the requirement for pregnancy, and the requirement for milk yield based on the P content of milk.

They further stated that true requirements are divided by the efficiency of absorption of dietary P to yield total P requirements and the maintenance requirement for P is estimated based on minimum endogenous losses of P in the faeces and urine.

When animals are not allowed access to minerals for long periods of time, they may become so voracious that they injure each other in attempting to reach salt and under these conditions they will consume 2-20 times the normal daily quantities of minerals until their appetite is satisfied. By overindulging, they may suffer salt poisoning (McDowell 2003).

3.2 IMPORTANCE OF MINERALS

Beef cattle require a number of dietary mineral elements for normal bodily maintenance, growth and reproduction. Phosphorus, calcium and magnesium are amongst the major minerals that are required in relatively large amounts for body maintenance, growth and reproduction (Hale and Olson 2001). Hemingway (1967) said that it was usual to consider calcium and phosphorus together in their effect on nutrition and to relate their respective roles with those of vitamin D, and further said that it tended to obscure the paramount role of phosphorus in a wide range of biological systems. According to him the economic importance of phosphorus to the grazing ruminant laid in such practical considerations as growth rate, reproductive performance, skeletal and dental health, milk yield and wool growth.

Phosphorus is a widely studied element that is integral to many vital body functions. In ruminant nutrition, however, the degree of naturally occurring P deficiency in grazing cattle, the lack of uniformity in response to P supplementation, and even suggested P requirements have generated a great deal of confusion in United States and around the world (Karn 2001).

Phosphorus is often fed to dairy cattle in excess of published requirements because high P diets are commonly believed to improve reproductive performance and this perception likely originates from the observation that severe P deficiency impairs reproductive performance in cattle (Knowlton and Kohn 1999).

During research by Espinoza et al. (1991), the low phosphorus (LP) group had a lower (P <0.05) pregnancy rate in year 1 when the concentrations of dietary P were 4 % (LP), 8 % medium phosphorus (MP) and 12 % high phosphorus (HP) and pregnancy rates were similar (P >0.05) in years 2 and 3 when dietary P levels were 6 % (LP), 8 % (MP) and 12 % (HP).

Cohen (1975) stated that many of the world's soils are low in phosphorus, and he stated that cattle grazing pasture low in P have depraved appetites, retarded growth, low reproductive efficiency, reduced milk yield, frequently walk with a stiffened gait and readily sustain fractures of the bones.

According to him there are many workers who reported osteomalacia, bone fractures, swollen joints and stiffened gait in cattle which graze pasture of low P content, which indicates that P is essential for the rigidity of bone.

He further stated that P is an essential constituent of soft tissue, and occurs as lecithin in various cells, cephalins and sphingomyelins particularly in the brain, phospholipid in the blood and in many other cells as phosphoprotein, nucleoprotein, phosphocreatine, hexosephosphate and in other forms all of which play a role in the composition and structure of cells, and said that P is transported through the body in the plasma as inorganic salts and said that rumen micro-organism also requires P.

Beighle (2000) also explained that in large areas of the Northern Cape and North West Province 10 % or more of the animals in a number of herds of range cattle suffer from a lameness that appears clinically to be due to osteomalacia, even with the provision of various commonly accepted lick formulations. But this problem can be of less importance as Cohen (1975) found out that the feeding of a phosphate supplement considerably reduced the incidence of hypophosphataemia. Wu and Satter (2000) suggested that phosphorus at 0.38 to 0.40 % of diet dry matter should be adequate for cows producing 11,400 kg /308 d.

Magnesium and phosphorus are minerals that have been shown to improve an animal's ability to cope with infections (McDowell 2003). According to Hale and Olson (2001), the most common problem associated with Mg deficiency, known as grass tetany, is observed most frequently in early spring and it results from the consumption of lush forage, which has low levels of Mg. This mineral is involved in the maintenance of electrical potentials across nerve and muscle membranes and for nerve impulse transmission (Hale and Olson 2001).

Calcium is used in the formation and maintenance of bones and teeth and because of its importance in bone structure, deficiency of Ca in young animals leads to skeletal deformities. It also functions in transmission of nerve impulses and contraction of muscle tissue (Hale and Olson 2001)

As evidenced by the hypercalciuria for the low cation Mg diets in the Waterman et al. (1991) study, a better understanding of metabolic disorders such as milk fever and grass tetany may be achieved with more research on the role of Mg in dietary cation-anion balance because according to Hurley et al. (1990), magnesium supplements increase the Mg status of livestock and consequently aid in preventing the grass tetany syndrome.

3.3 MINERAL ABSORPTION

According to Wu and Satter (2000) efficiency of absorption of P varies with P intake. Absorbed P not used for growth, deposited in bone, or secreted in milk is secreted in the saliva and then secreted in the faeces. In lactating cows, increased P demands increase P absorption from the gut and at the same time their need for Ca increases P mobilization from the bone (Knowlton and Kohn 1999).

Hemingway (1967) stated that phosphorus insufficiency in the ruminant is reflected in retarded growth, poor reproductive performance, reduced milk yield and wool growth, and impaired skeletal and dental health.

There is no significant net absorption of P before the small intestine and P absorption from the small intestine occurs in the proximal part, the region that has low pH values (Pfeffer et al. 1970). Apparent Ca absorption decreased linearly ($P < 0.01$) with increased Mg intake, whether expressed as grams per day or percentage of calcium intake, and apparent absorption of P (g/d) decreased linearly ($P < 0.01$) with increased dietary Mg (Chester- Jones et al. 1990).

They further stated that apparent P absorption decreased with increased dietary Mg up to the 2.5 % level when expressed as percentage of intake, followed by a slight increase in steers fed 4.7 % Mg, which was described by an overall linear response ($P < 0.01$)

3.4 MINERAL DEFICIENCIES

According to McDowell et al. (1983) mineral deficiencies or imbalances in soils and forages have long been held responsible for low production and reproduction problems among grazing tropical cattle. The range between deficiency and excess obviously depends on the way in which the mineral is used by the animal (Duncan 1958) and according to Stowe and Bonyongo (2003) P is considered deficient when levels are lower than 0.20 % and in excess when they are above 1.00 %.

Call et al. (1986) said that the first sign of a P deficiency was a decrease in total feed consumption and they further stated that with decreased feed intake, the next clinical sign was a loss of body weight and according to Braithwaite (1985) phosphorus deficiency in the diet results in a decreased blood P concentration.

Histological examination of the bones by Young et al. (1966) suggested that either late rickets or osteoporosis could be produced in 4 to 6 month old lambs by feeding them on a low P diet, supplying approximately 0,5 to 0,6% P daily together with adequate vitamin D.

The results also showed that sheep on a P deficient diet had a considerable reduction of mineralized tissue, or lesions typical of osteoporosis without excessive osteoid or lesions of late rickets and narrow osteoid borders surrounding the trabeculae. According to McKenna (1929) diseases like stiffsickness, rickets, pica and paralysis in dairy cattle are recognized as being due, either to deficient intake of phosphorus or calcium, or to a disturbance of the metabolism of these minerals which may be associated with deficient intake either of the minerals or some other substance essential to their proper assimilation and use by the animal.

Magnesium deficiency can exhibit either clinical or subclinical symptoms and both can lead to decreased productivity and economic losses to the livestock industry (Hurley et al. 1990). According to McDowell et al. (1983) signs of hypomagnesemic tetany are encountered in both grazing ruminants and calves reared too long on milk without access to other feeds and they further explained that grass tetany generally occurs during early spring, or a particularly wet autumn, among older cattle grazing grass or small grain forages in cool weather.

It should be emphasized that subacute deficiencies can exist although clinical deficiency signs do not appear. Such borderline deficiencies are both the most costly and the most difficult to manage and often go unnoticed and unrectified, yet they may result in poor and expensive gains, impaired reproduction or depressed production (McDowell 2003). According to Tyler (2002), deficiencies may be diagnosed by observing symptoms in affected animals and by considering the country they are grazing.

3.5 BLOOD MINERALS

The concentration of inorganic P in blood serum appeared slightly lower for cows fed the low P diet than for those fed the high P diet, and serum concentrations of inorganic P during the dry period increased compared with the last measurement during the lactation period but were similar between treatments, reflecting that cows that were fed the same diets.

According to Gartner et al (1966) there were significant increases with age in serum magnesium, globulin and total proteins, whereas blood inorganic phosphorus and plasma potassium decreased with age and serum calcium showed little relationship to time.

Blood inorganic P concentrations observed in heifers during the P depletion phase were lower for cattle fed a similar dietary P level (Williams et al. 1991). According to them controversy over the use of whole blood P concentration as a P status indicator in ruminants also exists and whole blood P was more variable than serum or plasma inorganic P, as standard errors of whole blood P were approximately threefold that of serum or plasma P assays.

Preston and Pfander's (1964) observations indicated that live mass gains were increased by a higher intake of P than is required for the maintenance of normal levels of inorganic P in the blood. The absence of P supplementation resulted in a marked and significant reduction in the concentration of P in the blood (Fishwick et al. 1977).

The pattern of feed consumption appeared to relate to changes of inorganic P of blood plasma (Forar et al. 1982). Blood Ca concentration during late pregnancy and the first 3 weeks of lactation tends to elevate in the absence of supplementary P and normal blood P concentration is maintained throughout both the pregnancy and lactation period when additional P is given (Fishwick et al. 1977).

According to Beighle et al. (1997) blood P was seen to fluctuate more than bone P or faecal P when concentration of P in blood, bone and faeces was compared in animals offered an anionic diet. Beighle et al. (1994) stated that P content of blood is not always a good indication of the P status of the animal and was supported by Karn (2001) who said that blood P may have more value as an indicator of dietary P levels, than as a P status indicator, because it is evident that age, the physiological stage of production and the length of time on a P- deficient diet all affect an animal's P status, and thus have a modulating effect on blood P levels. Jackson et al. (1992) stated that blood pH increased linearly with increasing dietary cation-anion balance.

Excess dietary Cl is hypothesized to increase dietary Ca absorption and prevent the excessive drop in blood Ca concentration at calving when included in the diet of the dry cow (Jackson et al. 2001). In contrast to ruminal concentrations, plasma Ca, Mg and Cl concentrations decreased immediately postfeeding and then increased throughout most of the postfeeding interval (Tucker et al. 1993). They further stated that plasma concentrations of these minerals appeared to be related inversely to their concentrations in ruminal fluid and according to Engels (1981), the magnesium concentration of blood is fairly constant within the range of 2 to 5 mg per 100 ml serum. According to West et al. (1991) serum Ca declined quadratically with increasing dietary electrolyte balance and Ca tended to be highest in cows receiving high Cl in the diet.

3.6 DIETARY PHOSPHORUS

In research by Wu and Satter (2000) dietary P content was computed from the P content of ingredients and was 0.38 and 0.48 % of diet DM during confinement feeding for the low and high P diets, and also dietary P concentration ranged from 0.39 to 0.40 % of diet DM for low P groups and from 0.39 to 0.61 % for high P groups.

They also presented results pertaining to reproductive performance of the cows in their experiment, realizing that insufficient numbers precluded drawing conclusions about any kind of relationship between dietary P and reproductive performance.

Erickson et al. (2000) concluded that decreasing dietary P to animal requirements would decrease P excretion. According to Wright (2003) a dietary P deficiency can affect milk production, feed consumption and animal performance.

According to Knowlton and Kohn (1999) the assumed digestibility of dietary P has a tremendous impact on the dietary P requirements of lactating cows. If five units allowing decreased P feeding increase digestibility of dietary P, P excretion could be reduced by about 15 % in lactating cows.

Thomas et al. (1982) suggested that low calcium (Ca) diets, regardless of dietary P intake, seemed to prevent parturient paresis by prepartal activation of both bone and the intestinal tract. It also seemed to activate the Ca homeostasis mechanisms before parturition by stimulating both bone and the gut. They found no indication of increased bone resorption caused by prepartal low dietary P. The amount of prepartal dietary P may influence vitamin D metabolism and the incidence of parturient paresis in dairy cows.

Rapid changes in dietary P levels may only be reflected by blood (Cohen 1973A) and dietary P and dietary Ca have no significant effects on inorganic P concentrations in milk (Forar et al. 1982).

According to Knowlton et al (2001), most studies indicate that dietary P affects Ca metabolism only in P deficient animals. In research by Melendez et al (2002), there was a cubic effect of P concentration by day, and older cows had higher concentrations.

3.7 PHOSPHORUS INTAKE

Knowlton and Kohn (1999) stated that if improved P availability allowed reduced P intake, the P content of livestock manure could be reduced and further explained that P intakes in the field were then typically in excess of current requirements by 25 to 40 %, giving farmers a tremendous opportunity to benefit both economically and environmentally by feeding at the current published requirements.

According to Braithwaite's (1985) results, P intake is directly related to apparent P absorption, and maximum P absorption is also higher for the young animals (apparent P absorption = P intake – total P in faeces).

An increase in P intake will result in an increase in P balance, and an adequate level of P intake supports greater weight gains than a lower level of dietary P (Preston and Pfander 1964).

Inadequacy of P intake during the lactation period results in a significant reduction in voluntary straw consumption and digestibility (Fishwick et al. 1977). Young et al. (1966) suggested that Ca absorption was reduced when giving a diet low in P and was increased when the intake of P was raised.

3.8 CALCIUM - PHOSPHOSRUS HOMEOSTASIS

Phosphorus metabolism is closely linked to Ca metabolism in Ca deficient animals and P homeostasis is largely brought about by a control of urinary P excretion since excretion of urinary P varies considerably (Braithwaite 1975). Thomas et al. (1982) stated that low Ca diets seemed to stimulate bone resorption of Ca and P prepartum, thus activating the Ca homeostatic mechanism before parturition.

Beighle et al. (1997) showed that the P homeostasis mechanisms responded differently to an anionic diet thus resulting in an increase in both bone and blood P and they indicated that an acidiogenic diet had additional effects on P homeostasis, independent of those seen in combination with Ca.

3.9 RUMEN PHOSPHORUS

An inadequate intake of P results in a decrease in the transfer of endogenous P into the rumen, therefore saliva, as it may contain inorganic P in a concentration that is 4 to 5 times that of blood, is responsible for maintaining rumen P concentration when the dietary P is inadequate (Preston and Pfander, 1964). They further showed that the total endogenous P and the percentage of P present in the rumen fluid, tended to increase with P intake.

Karn (2001) reported that ruminal P levels would not be maintained when blood inorganic P falls below 20 mg/l and animals exhibit clinical P-deficient symptoms.

3.10 PLASMA PHOSPHORUS

Blood plasma inorganic P concentrations followed a similar pattern as observed for serum inorganic P concentrations, except that values tended to be slightly lower than for serum (Williams et al. 1991)

First lactation cows have higher plasma inorganic P than multiparous cows. Decreases in milk yields and decreases in inorganic P in milk result in an increase in inorganic P in plasma (Forar et al. 1982). Thomas et al. (1982) stated that cows fed prepartal low P diets had significantly lower mean plasma P concentration during the entire prepartal period than those fed diets high in P, and cows fed with high P diets but with either low or high Ca contents had similar plasma P concentration during the prepartal period.

They further stated that cows fed a low Ca diet with low P content tended to have greater mean plasma P concentration than did cows fed the high Ca diet with low P content. According to Read et al. (1986B) the conclusions drawn from the results of plasma analyses agree with the general thesis that low plasma P levels reflect low P intakes but that plasma levels are unsatisfactory for distinguishing between higher levels.

During the trial by Ross et al. (1994), plasma Ca followed a linear pattern ($P < 0.10$), whereas Mg followed a cubic pattern of ($P < 0.05$).

3.11 BONE PHOSPHORUS

Findings of Judkins et al. (1985) proved that the lower bone P of lactating control cows compared with lactating supplemented cows may be a result of lower dietary P combined with depletion of bone P during late pregnancy and early lactation. Control cows had slightly higher bone P after lactation stress was removed and made more rapid increases in bone P according to their results and unsupplemented cows could recover as readily as their supplemented counterparts from a draw down of the body pool of P.

Bone P is unlikely to be influenced by exercise or excitement of cattle when samples are collected (Cohen 1973A) and the P content of bone ash is not altered by dietary intake of P (Preston and Pfander 1964). Beighle et al. (1997) showed that bone P responded more positively to dietary anions than Ca with an increase in bone P and decrease in bone Ca.

Prolonged low levels of dietary P which cause P deficiency may be better detected from the measurement of bone P since bone P content significantly reflects a variation in P content of pasture and it can provide a better estimate of the P status of grazing cattle than blood or hair P (Cohen 1973A).

Not only are blood and hair P inadequate indicators of the P status of cattle, but Forar et al. (1982) also indicated that milk inorganic P was also not a satisfactory indicator for predicting P intake of cattle.

3.12 URINARY PHOSPHORUS

Urinary P excretion is small when compared with faecal P excretion (Barrow and Lambourne 1962), and it increases as the dietary levels of both Ca and P increase (Braithwaite 1975). He showed that initial increases in urinary excretion rate appears to be inversely related to the rate of Ca retention and this excretion of urinary P is high for animals with Ca deficient diets, and then decreases markedly as the Ca intake is increased.

He also stated that the decrease in urinary P excretion is accompanied by a decrease in P absorption and an increase in faecal endogenous excretion of P. Urinary Ca concentration is inversely proportional to plasma Ca, blood H^+ and urine H^+ (Tucker et al. 1992).

3.13 FAECAL PHOSPHORUS

According to Karn (2001) the amount of faecal P depends on diet P, and overall diet quality as well as the animal's physiological state and according to him endogenous faecal P levels appear to be unrelated to class of animals.

Faecal P is a combination of indigestible P and inevitable endogenous loss. Faecal P as a proportion of body weight was very different, but faecal P as a fraction of dry matter intake was essentially identical (1.2g/kg DMI) (Knowlton and Kohn 1999).

According to Braithwaite (1984), normally P is absorbed by passive transport in direct relation to intake and P absorbed in excess of requirements is secreted as endogenous P in the faeces hence the concentration in faeces is an indication of the degree to which the feed has been concentrated. Supplemented cows had higher faecal P levels ($P<0.05$) than control cows, which probably reflected the additional P consumed by supplemented cows from the free choice mineral mix.

According to Barrow and Lambourne (1962), faeces might contain both organic and inorganic P. They confirmed that faecal excretion of organic P per unit feed eaten is not significantly affected by the P content of feed eaten, or by the level of feed intake.

An increased endogenous faecal loss of P with increased P intake is unavoidable and this endogenous loss of P in faeces is directly related to P intake and P absorption but inversely related to P demand (Braithwaite 1985).

According to Williams et al. (1991) faecal P levels were compared to dietary P, however, no differences ($P> 0.10$) were observed over their sampling periods. Faecal P includes undigested feed P and endogenous P, including microbial cell walls, sloughed cells from the digestive tract and P secreted in saliva that is not reabsorbed (Knowlton et al. 2001).

In the study by Beighle et al. (1990), total faecal P was measured and in general reflected the P content of the diet, and according to them this is in agreement with the findings of Belonje (1978), in which he concluded that concentration of faecal P have shown to be an indicator of dietary P values.

Bromfield and Jones (1970) cited by Holechek et al. (1985) found that faecal P concentration was highly associated with dietary P concentration because nearly all P was excreted through the faeces, and according to Holechek et al. (1985) it appears that dietary P concentration can be reliably predicted from P concentration in the faeces of cattle. According to Faure (1984) faecal and blood P concentration are therefore not reliable indicators of P status.

3.14 CALCIUM: PHOSPHORUS RATIO

Because of their mutual role in bone metabolism, Ca supplementation and P supplementation are usually considered simultaneously (Hale and Olson (2001). According to them Ca-to-P ratios of 2:1 to 1.2:1 are recommended for beef cattle diets. They stated that variation from the recommended ratios, especially providing more phosphorus than calcium in the diet, can lead to urinary calculi, or water-belly in steer calves and according to McDowell et al. (1983), a calcium-phosphorus ratio of 1:1 to 2:1 is usually recommended, with a close ratio most critical if phosphorus intake is margin or inadequate.

Normally Ca and P are retained at a fairly constant ratio of 1:1-5 (Braithwaite 1985) and a ratio of 6:1 is allowed for adequate growth in ruminants when the P intake is adequate (Young et al. 1966).

Performance is improved when limestone is added to P rations which results in a ratio of Ca to P ratio of 6:1 (Kincaid et al. 1981). An indication of a substantial effect of an anionic diet on the ability of animals to maintain a constant Ca:P ratio in the bone, with wide variations in the ratio as a result of the loss of Ca from the bone, has been reported by Beighle et al. (1997).

According to Cohen (1973B) the ratios of calcium to phosphorus measured during his experiment varied considerably, and it was notable that the ratio that departed most from 2:1 was recorded in unsupplemented steers at the time of lowest pasture phosphorus content, and Call et al. (1986) indicated that any confounding effect due to the wide Ca: P ratio seems to have been small or insignificant.

CHAPTER 4

4.1 MATERIALS AND METHODS

Twenty-five animals were randomly selected from among the animals grazing communally in Mogosane village. Animals were selected on the basis of sex and age and in order to have a homogenous group of animals. No supplement was given.

They were allowed to graze in the veld. Accurate records of body mass and condition score were recorded at each sampling date and actual rainfall of the whole year was also recorded.

Faecal, blood and grass samples were collected once a month for twelve months, from March until February the following year. All samples were taken on the same day of the month to prevent variation between samples and mineral contents.

4.1.1 COLLECTION OF SAMPLES

4.1.1.1 Faecal Samples

Faecal samples were collected from the rectum and placed in aluminium plates and left in the sunlight to dry completely for 3 to 5 days and then stored in clean plastic jars for later analysis. The tag numbers of animals and dates were clearly recorded on each plate and plastic jar.

4.1.1.2 Blood Samples

Blood samples were aseptically collected from the jugular vein after restraining to minimize variation in blood level of P mineral. Anticoagulant free red-stoppered tubes were used when collecting blood and were then stored for 24 hours at a temperature of 4° C to allow it to clot. Serum was harvested by centrifugation at 1000 rpm for 10 minutes and was frozen immediately and stored in clean plastic tubes at a temperature of –20° C for later analysis.

4.1.1.3 Grass Samples

Grass samples were collected directly from the field. A 50 m rope that was divided into five knots was used to measure randomly selected areas, and grass was collected from 50 cm around each knot. A scissor was used to cut grass. The samples were then air dried, ground through a 2 mm screen and digested in the same way as the faeces.

4.1.2 DIGESTION OF SAMPLES

4.1.2.1 FAECAL AND GRASS SAMPLES

All necessary laboratory equipment used in the digestion and analysis of samples were soaked in 36 % HCl overnight. They were then rinsed with distilled water 3 times and dried in a hot air oven for 16 hrs at 60° C. After drying, crucibles were allowed to cool in a desiccator for 6 hours when they were then weighed to determine the empty weight.

After drying in the sun faecal and grass samples were ground through a 2 mm screen after which 1 g duplicate samples were weighed in the acid cleaned, dried crucibles, and their weights were recorded. The difference between the weights of the crucible with the fresh sample and the weight of the empty crucible gave the fresh weight of the faeces and grass. Weighing was done on an analytical scale and was carried out to 4 decimal places. Crucibles containing the faeces and grass were then dried overnight in the drying oven at 106° C for 16 hrs. After removal from the oven crucibles with faeces and grass were cooled in desiccators for 6 hours and reweighed. The difference between the weights of the crucible with the dried sample and the weight of the empty crucible was recorded as the dry weight of the sample. They were then ashed overnight in a muffle furnace at 800° C for 16 hrs. Samples were removed from the furnace and allowed to cool in desiccators for 6 hours. Crucibles were then weighed to determine the ash weight of the samples.

One ml of concentrated nitric acid (HNO_3) was added to the ashed samples in the crucibles and was evaporated to dryness on a hot plate, at a low temperature to avoid spattering. Crucibles were then reashed in the muffle furnace for 2 hrs at 600° C. They were then removed and cooled, and 10 ml of 5 N Hydrochloric acid (5 N = 415 ml concentrated HCl + 500 ml distilled water) was added to each crucible and was evaporated on very low heat until approximately 3 ml was left in the crucible. The solution was then transferred to 100 ml volumetric flasks and filled up to the mark with distilled water using a glass funnel. The solution in the volumetric flasks was mixed thoroughly by inverting the flasks and was then left overnight to allow the sediment to settle to the bottom. The next day, the supernatant was taken without disturbing the sediment and transferred to and stored in McCartney bottles for later analysis.

4.1.2.2 PRECIPITATION OF THE PROTEIN IN THE BLOOD SERUM SAMPLES

Serum was transferred into a clean test tube using a pipette. To precipitate the protein in the serum, 0.7 ml of serum in duplicate was added to 6.65 ml of stock trichloracetic acid in clean test tubes which were covered, mixed individually on an electric stirrer and left to stand at room temperature for 5 minutes. Samples were then centrifuged at 2600 rpm for 10 minutes. Exactly 5 ml of supernatant fluid from each sample was taken off with the pipette and was transferred to clean tubes without disturbing the centrifuged material at the bottom.

The sample solution was then mixed with 1.5 ml of ammonium molybdate, 1.5 ml of hydroquinone and 1.5 ml of sodium sulphite. They were then thoroughly mixed and allowed to stand at room temperature for 40 minutes, and then poured into cuvettes and analysed and the absorption was read at 646 nm in the Aquamate spectrophotometer.

4.1.3 PREPARATION OF REAGENTS AND STANDARDS

4.1.3.1 REAGENTS AND STANDARDS FOR DETERMINATION OF FAECAL AND GRASS PHOSPHORUS

(i) Reagents

Solution A was prepared by dissolving 2.53 g of ammonium metavanadate in 200 ml of hot (90° C) distilled water and was then cooled and transferred to a four litre volumetric flask, and 1500 ml of distilled water and 320 ml of concentrated nitric acid was added to the solution and was then mixed.

Solution B was prepared by dissolving 46.6 g of ammonium molybdate in one litre of hot (90^0 C) distilled water. It was cooled and then 2 ml of Levor IV was added to the solution and the solution was then mixed.

The working molybdanavate reagent was prepared by adding solution B to the 1 litre volumetric flask containing solution A and was diluted up to the mark with distilled water.

(ii) Standard phosphorus solution

A standard curve was drawn with the dilutions representing the following:

From the 1000 ppm P stock solution, 5 ml was added to 95 ml of distilled water to make 50 ppm P, 10 ml was added to 90 ml of distilled water to make 100 ppm P and 20 ml was added to 80 ml of distilled water to make 200 ppm.

4.1.3.2 REAGENTS AND STANDARDS FOR DETERMINATION OF FAECAL AND GRASS CALCIUM.

(i). Reagents.

In order to prepare a 1000 ppm stock Ca solution, calcium carbonate ($CaCo_3$) was dried at 100^0 C for 2 hours and then 2.497 g was dissolved in the minimum quantity of dilute (1N) HCl and was made up to 1000 ml in a volumetric flask with distilled water.

A working calcium solution of 500 ppm Ca was prepared by diluting 50 ml of 1000 ppm stock calcium solution in 100 ml with distilled water.

A stock potassium solution, 1000 ppm K was prepared by first drying potassium chloride (KCl) at 100^0 C for 2 hours then 1.907 g was dissolved and made up to a litre with distilled water.

A working potassium solution of 100 ppm K was prepared by diluting 20 ml of 1000 ppm stock potassium solution to 200 ml distilled water.

To prepare 1000 ppm stock sodium solution, sodium chloride (NaCl) was first dried at 100^0 C for 2 hours and, 2.541 g was then dissolved in distilled water and made to a litre.

A working sodium solution of 50 ppm Na was prepared by diluting 10 ml of 1000 ppm stock sodium solution in 200 ml distilled water.

To prepare 0.15 % Lanthanum chloride, 1.5 g of lanthanum chloride was dissolved in distilled water and diluted to a litre.

One normal sulphuric acid (H_2SO_4) was prepared by carefully diluting 28 ml of concentrated sulphuric acid to a litre with distilled water.

(ii). Calcium standard solution

A pipette was used to transfer 5, 10, 15, 20 and 30 ml of the 500 ppm Ca solution into 500 ml volumetric flasks to give a standard solution containing 5, 10, 15, 20 and 30 ppm Ca respectively. To each flask 25 ml of the 100 ppm K solution, 25 ml of the 50 ppm Na solution, 200 ml of the 0.15% lanthanum chloride solution and 70 ml of 1 N sulphuric acid solution were added and distilled water was used to fill the volumetric flasks up to volume. The solution was then mixed thoroughly.

4.1.3.3 REAGENTS AND STANDARDS FOR FAECAL AND GRASS MAGNESIUM

(i). Reagents

For 1000 ppm stock magnesium solution, a commercial 1000 ppm stock Mg standard was used.

A working magnesium solution, 50 ppm Mg was prepared by diluting 10 ml of 1000 ppm stock magnesium solution to 200 ml distilled water in a 200 ml volumetric flask.

(ii). Magnesium standard solutions

A pipette was used to dilute separately 50, 40, 30, 20, 10 and 5ml of the 50 ppm Mg solution to a litre volumetric flask, and 140 ml of 1 N sulphuric acid was added to each flask before filling up to the mark with distilled water. That gave a standard solution containing 2.5, 2.0, 1.5, 1.0 and 0.5 ppm Mg respectively.

4.1.3.4 REAGENTS AND STANDARDS FOR BLOOD PHOSPHORUS

(i) Reagents

To prepare solution A, 25 g of ammonium molybdate was dissolved in 300 ml distilled water.

To prepare solution B, 75 ml of concentrated sulphuric acid was slowly added to 125 ml distilled water.

A working ammonium molybdate solution was prepared by adding solution B to solution A in a 1000 ml volumetric flask and then was thoroughly mixed and was filled to the volume with distilled water.

To prepare the sodium sulphite solution, 10 g of anhydrous sodium sulphite was dissolved in 100 ml of distilled water. That solution had to be prepared as a fresh solution daily.

A Hydroquinone solution was prepared by dissolving 1 g of Quinol in 100 ml distilled water and the solution had to be prepared on daily basis.

To prepare a 1000 ppm stock P solution, 4.3937 g of potassium phosphate (KH_2PO_4) was dissolved with distilled water in a litre volumetric flask.

(ii) Standards

A standard curve was drawn with the dilutions representing the following:

From the 1000 ppm P stock solution, 0.25 ml was added to 9.75 ml of distilled water to make 25 ppm P, 0.5 ml was added to 9.5 ml of distilled water to make 50 ppm P and 1.0 ml was added to 9.0 ml of distilled water to make 100 ppm.

4.1.4 SAMPLE ANALYSIS

4.1.4.1 Faecal and grass samples analysis

A Bran and Luebbe Auto-Analyzer 2: (Technicon Industry System, Tarytown NY 10591) was used to determine the phosphorus content in faecal and grass samples using the method of Kaplan and Szabo (1979).

The calcium content of faecal and grass samples was determined with the Atomic Absorption Spectrophotometer (Pye Unican Model, Cambridge England SP90 AA Spectrophotometer) in which the Ca standards, blank and unknown sample solutions were sprayed into the AA Spectrophotometer flame using the wavelength of 4227 A and a slit width of 0.07 mm in the spectrophotometer.

The magnesium content was determined with the Atomic Absorption Spectrophotometer (Pye Unican model, Cambridge England SP90 AA Spectrophotometer) in which the Mg standards, blank and unknown sample solutions were sprayed into the AA Spectrophotometer flame using a Mg lamp with an absorption wavelength of 2852 A and a slit width of 0.1 mm in the spectrophotometer.

4.1.4.2 Blood sample analysis

Blood phosphorus was determined by using an Aquamate UV-Visible Spectrophotometer (Thermo Spectronic, Mercers Row, Cambridge CB5 8HY UK) in which blank, phosphorus standards and unknown blood sample solutions were subjected to the spectrophotometer with a wavelength of 646 nm

CHAPTER 5

5.1 EXPERIMENTAL DESIGN

The design was based on the investigation of the mineral status (P, Ca and Mg) especially P, in ruminants feeding exclusively on communal grazing based on blood and faecal P, Ca and Mg and to estimate the quantity of P, Ca and Mg they consumed from the pasture they were grazing.

The survey was conducted in the same area each month for the complete research project i.e. for one year, to avoid unnecessary fluctuations between the areas that might not liaise with the problem of the research. Months were blocks and seasonal changes were factors and the animals were experimental units within a block. Faecal, blood and grass samples were used as indicators of P, Ca and Mg minerals within experimental units.

An analysis of variance (ANOVA) was done to determine whether the P status of native pasture had a significant effect on the total P, Ca and Mg utilization and movement in and out of the blood and throughout the faeces during different periods of the year. Least significant differences were calculated by student t-test for the comparison of the differences in the means.

5.2 STATISTICAL ANALYSIS

Statistical analysis was done on a Minitab Data Analysis Software, Release 7.2 and Standard Version 1989. Analysis of Variance (ANOVA) was done to determine whether the phosphorus status of native pasture had a significant effect on the total P, Ca and Mg utilization and movement in and out of the blood and throughout the faeces during different periods of the year. To compare the differences in the means the least significant differences (LSD) was calculated by student t-test with the following formulas:

A. Read QK, V

Q = The standard values in a P 0.05, 0.01 table for factors
K = Numbers of means to be compared
V = Error degree of freedom (EDF)

B. LSR = Q SEM / n

Where SEM = error means square and
n = number of observations in each treatment

C. LSD =√ EMS / r

Where LSD = least significant differences
EMS = Error means square and
r = dividend of total mean per sample

CHAPTER 6

RESULTS AND DISCUSSION

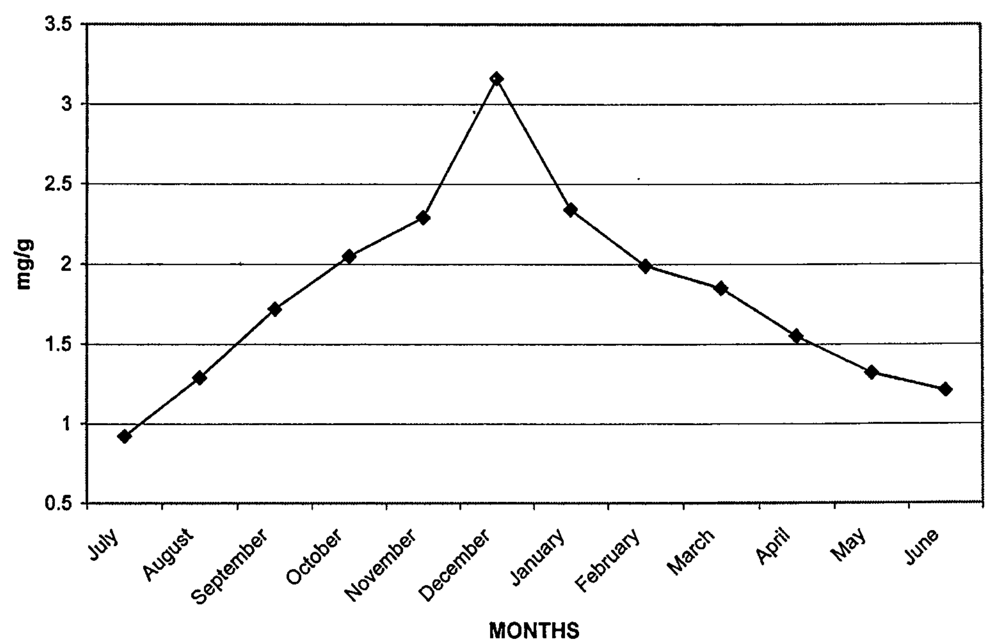
6.1. Faecal samples

6.1.1 Means faecal phosphorus concentration (mg/g)

Table 1. Mean faecal P concentration by months (mg/g, fresh weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	Jun
Faecal P (mg/g, fw)	0.92	1.29	1.72	2.05	2.29	3.16	2.34	1.99	1.85	1.55	1.32	1.2

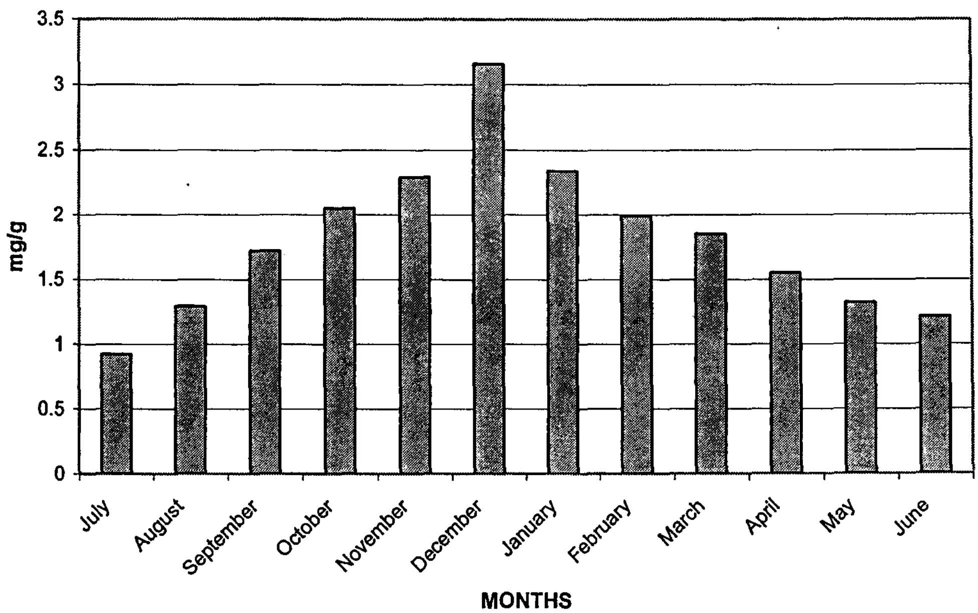
Figure1. Mean faecal P concentration by months (mg/g, fresh weight)



The faecal P concentration measured on a fresh weight basis by months is given in Table 1 and illustrated in Figures 1 and 2. The mean concentration increased from July to December and declined from

December to June. December samples had the highest value of faecal P concentration (3.16 mg/g) and July samples had the lowest value of 0.92 mg/g.

Figure 2. Mean faecal concentration by months (mg/g, fresh weight)

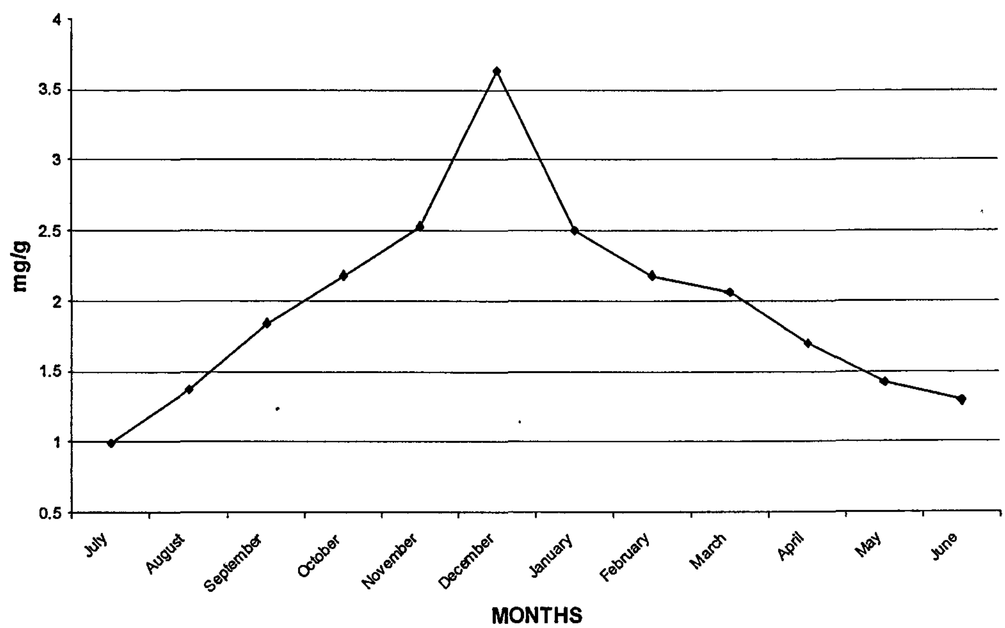


The difference between the highest value and the lowest value of faecal P concentration was 2.24 mg/g of faecal P concentration. The increment difference from November to December had the value of 0.87 mg/g and had the decline difference of 0.82 mg/g between December and January.

Table 2. Mean faecal P concentration by months (Mg/g, dry weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal P (mg/g, dw)	0.99	1.37	1.84	2.18	2.53	3.63	2.5	2.18	2.06	1.7	1.42	1.29

Figure 3. Mean faecal P concentration by months (mg/g, dry weight)



The faecal P concentration measured on a dry weight basis by months is given in Table 2 and illustrated in Figures 3 and 4. The concentration increased from July to December and declined from January to June. December samples had the highest value of faecal P concentration (3.63 mg/g) and July samples had the lowest value of 0.99 mg/g.

The difference between the highest value and the lowest value of faecal P concentration was 2.64 mg/g of faecal P concentrations.

Figure 4. Mean faecal P concentration by months (mg/g, dry weight)

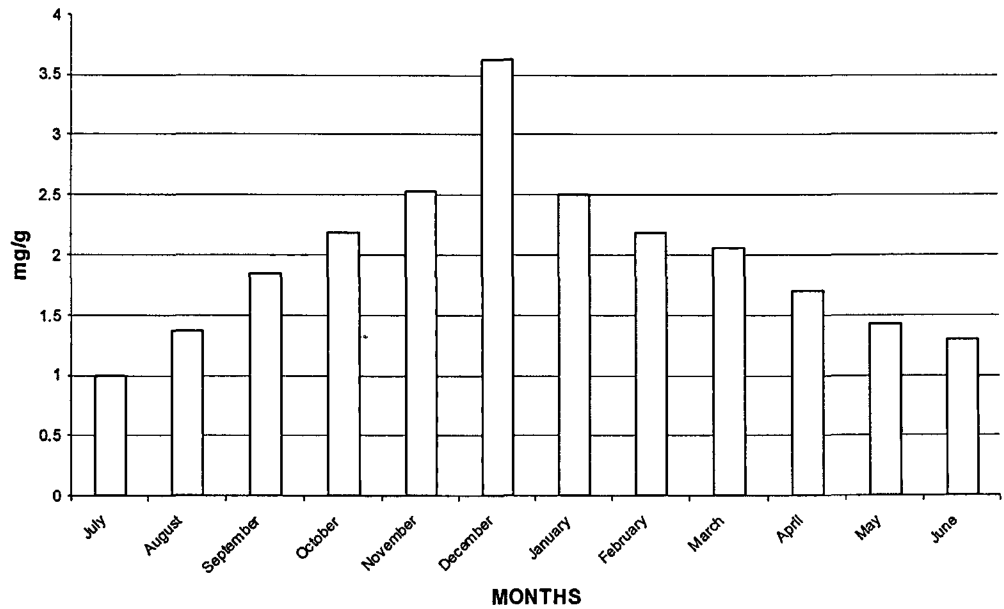
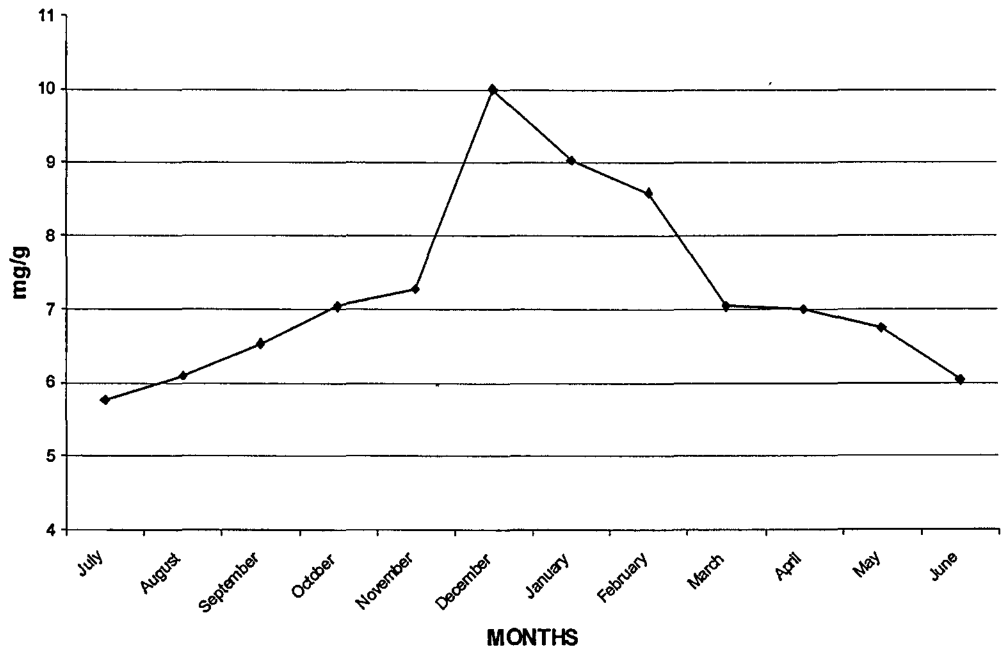


Table 3. Mean faecal P concentration by months (mg/g, ash weight)

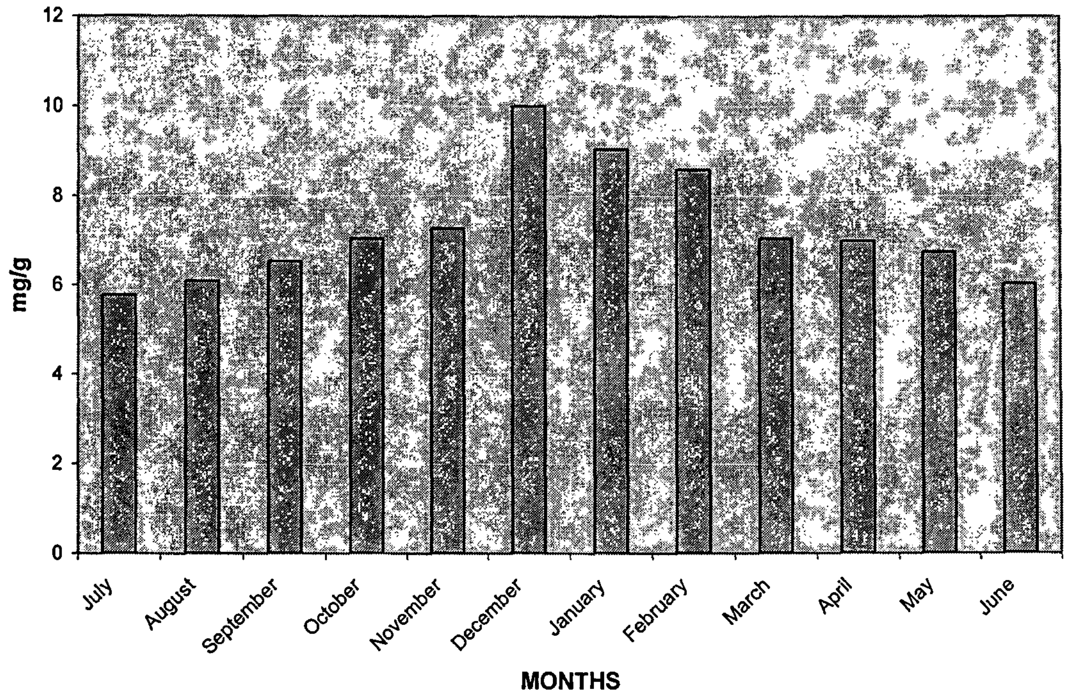
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal P (mg/g, aw)	5.77	6.09	6.53	7.04	7.27	10	9.04	8.59	7.04	6.99	6.74	6.03

Figure 5. Mean faecal P concentration by months (mg/g, ash weight)



The faecal P concentration measured on an ash weight basis by months increased from July until December and declined from December to July. Samples collected in December had the highest value of faecal P concentration (10 mg/g) and July had the lowest value of 5.77 mg/g. The difference between the highest value and the lowest value of faecal P concentration was 4.23 mg/g of faecal P concentration. (Table 3 and Figures 5 and 6)

Figure 6. Mean faecal P concentration (mg/g, ash weight) by months

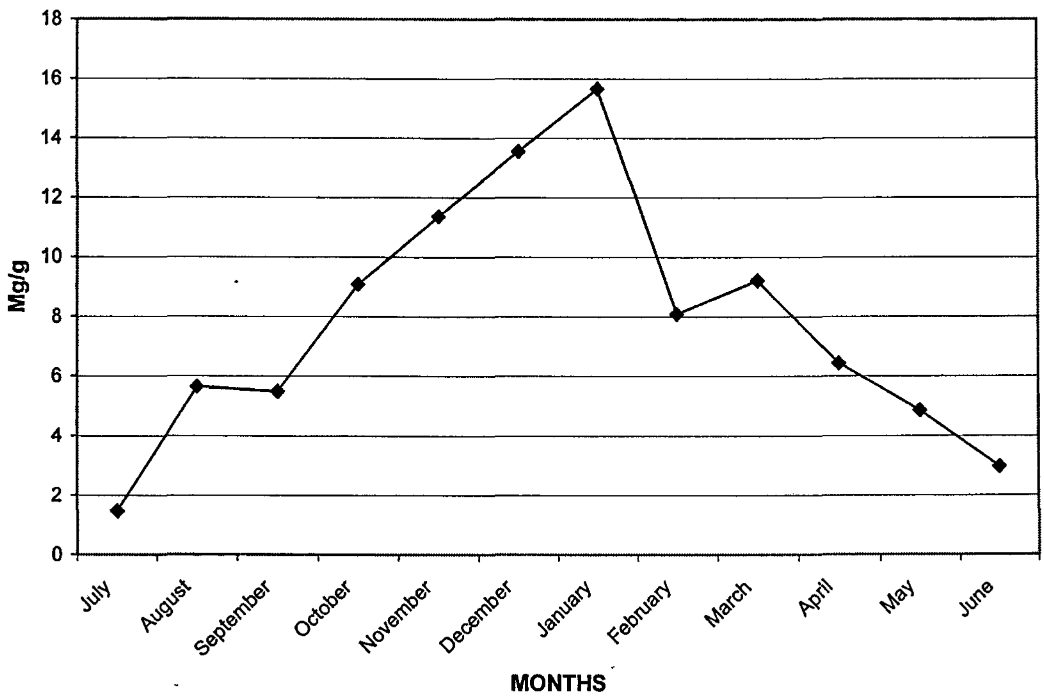


6.1.2 Mean faecal calcium concentration

Table 4. Mean faecal Ca concentration by months (Mg/g, fresh weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Ca (mg/g, fw)	1.47	5.65	5.48	9.08	11.36	13.54	15.66	8.08	9.2	6.43	4.85	2.97

Figure 7. Mean faecal Ca concentration by months (mg/g, fresh weight)



When the faecal Ca concentration was measured it showed a different picture than that one measured in faecal P. The mean concentration increased from July until January but in September animals had a lower concentration of faecal Ca than the animals had in August and the concentration decreased from January to July but in March animals had a higher concentration than in February (Table 4). Calcium in faeces from animals collected in January had the highest value of faecal Ca concentration (15.66 mg/g) and July samples had the lowest value of 1.47

mg/g. The difference between the highest value and the lowest value of faecal Ca concentration was 14.19 Mg/g of faecal Ca concentration (Figures 7 and 8)

Figure 8. Mean faecal Ca concentration by months (mg/g, fresh weight)

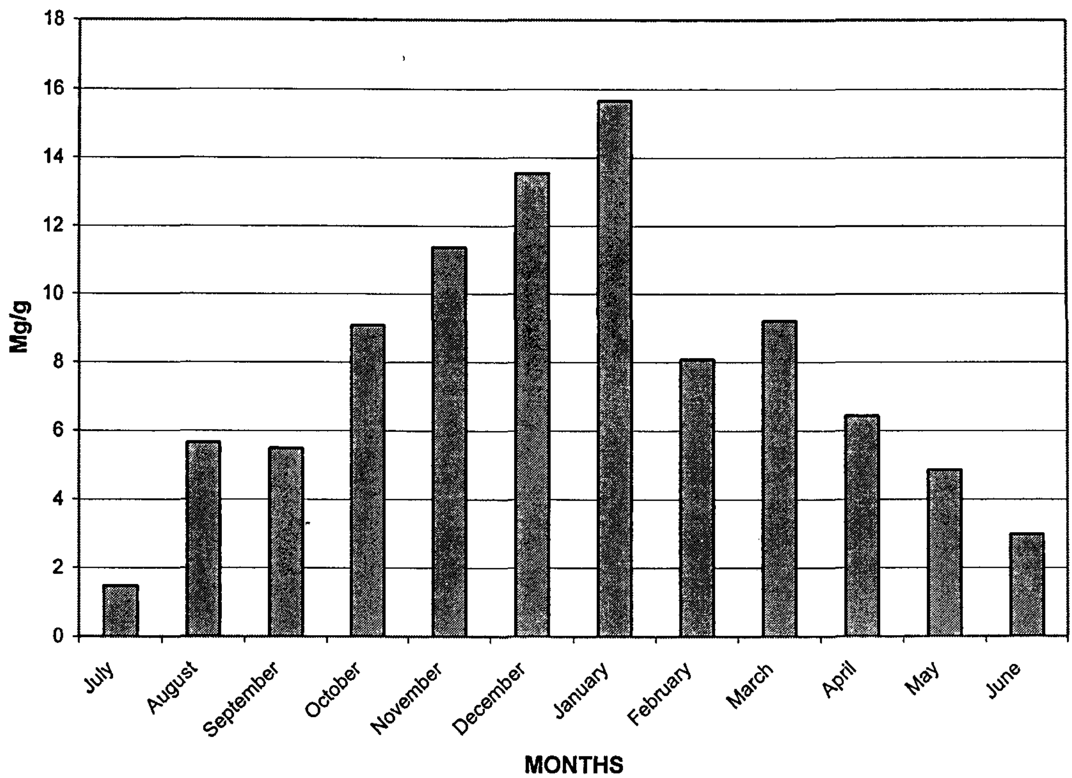
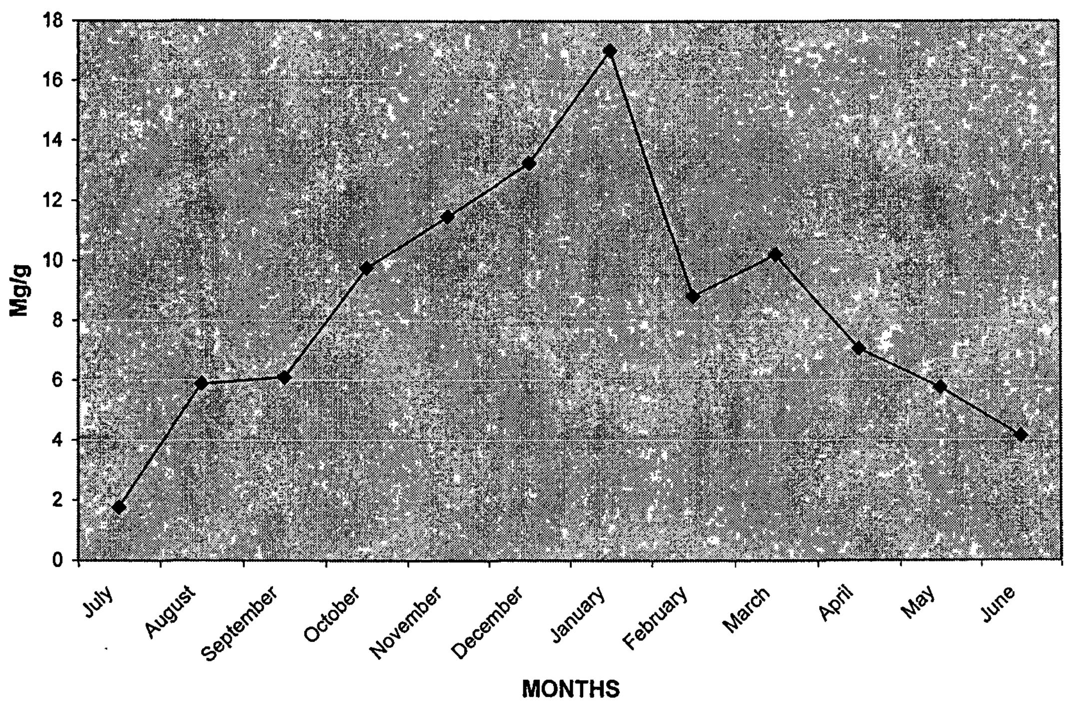


Table 5. Mean faecal Ca concentration by months (mg/g, dry weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Ca (mg/g, dw)	1.76	5.89	6.1	9.76	11.47	13.25	17.01	8.82	10.21	7.06	5.76	4.13

Figure 9. Mean faecal Ca concentration by months (mg/g, dry weight)



The faecal Ca concentration measured on a dry weight basis is given in Table 5 and illustrated in Figures 9 and 10. The mean concentration increased from July until January and decreased from February to June but samples collected in March (10.21 mg/g) had more Ca than those collected in February (8.82 mg/g) (Table 5). January samples had the highest value of faecal Ca concentration (17.01 mg/g) and July samples had the lowest value of 1.76 mg/g. The difference between the highest value and the lowest value of faecal Ca concentration was 15.25 mg/g of faecal Ca concentration.

Figure 10. Mean faecal Ca concentration by months (mg/g, dry weight)

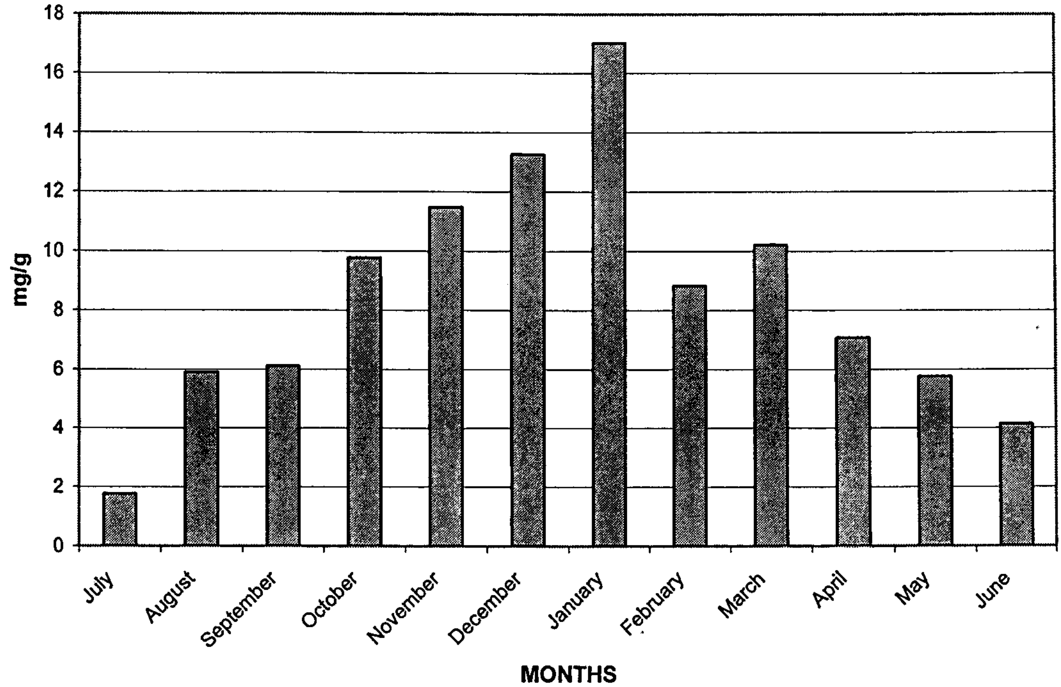
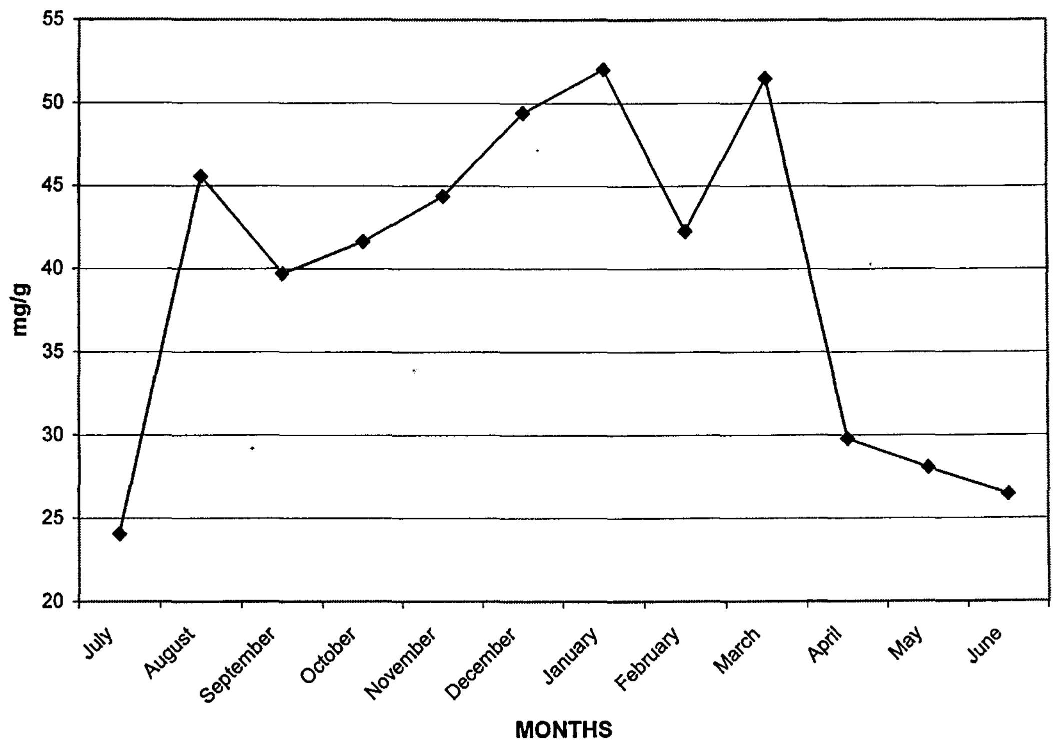


Table 6. Mean faecal Ca concentration by months (mg/g, ash weight)

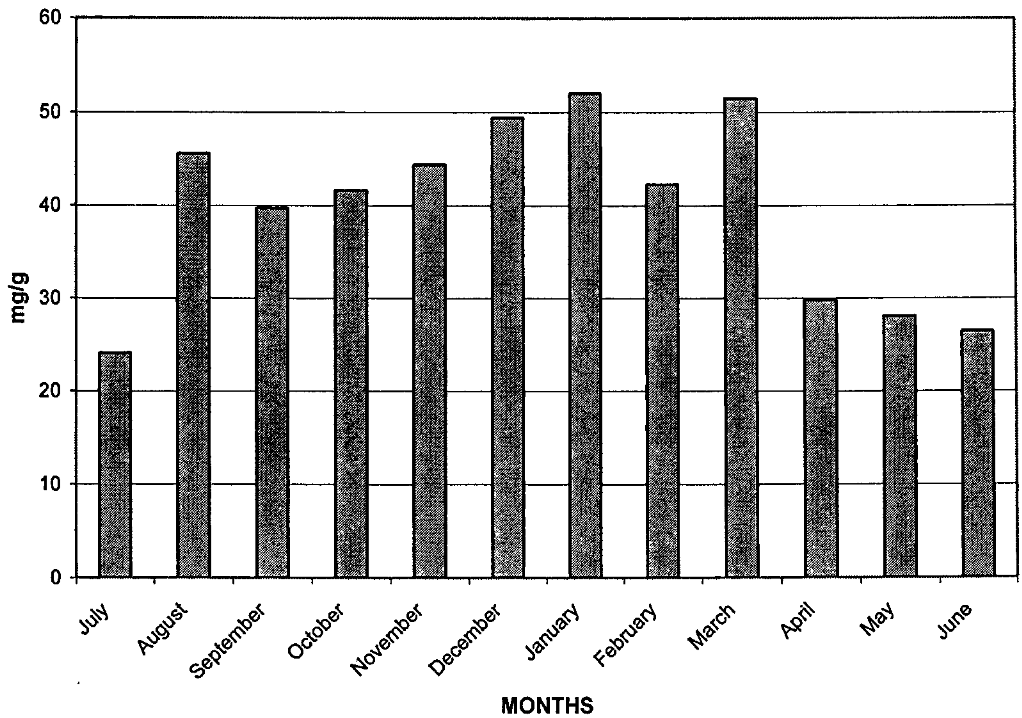
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Ca (mg/g, aw)	24.06	45.55	39.69	41.62	44.36	49.39	52.01	42.26	51.48	29.77	28.05	26.44

Figure11. Mean faecal Ca concentration by months (mg/g, ash weight)



The faecal Ca concentration measured on an ash weight basis by months is given in Table 6 and illustrated in Figures 11 and 12. The mean concentration increased from July until January but August samples had the high value between the increasing months and the concentration decreased from February to July but March samples had the high value of 51.48 mg/g of faecal Ca concentration between the decreasing months (Table 6). January had the highest value of faecal Ca concentration (52.01 mg/g) and July had the lowest value of 24.06 mg/g. The difference between the highest value and the lowest value of faecal Ca concentration was 27.95 mg/g of faecal Ca concentration.

Figure 12. Mean faecal Ca concentration by months (mg/g, ash weight)

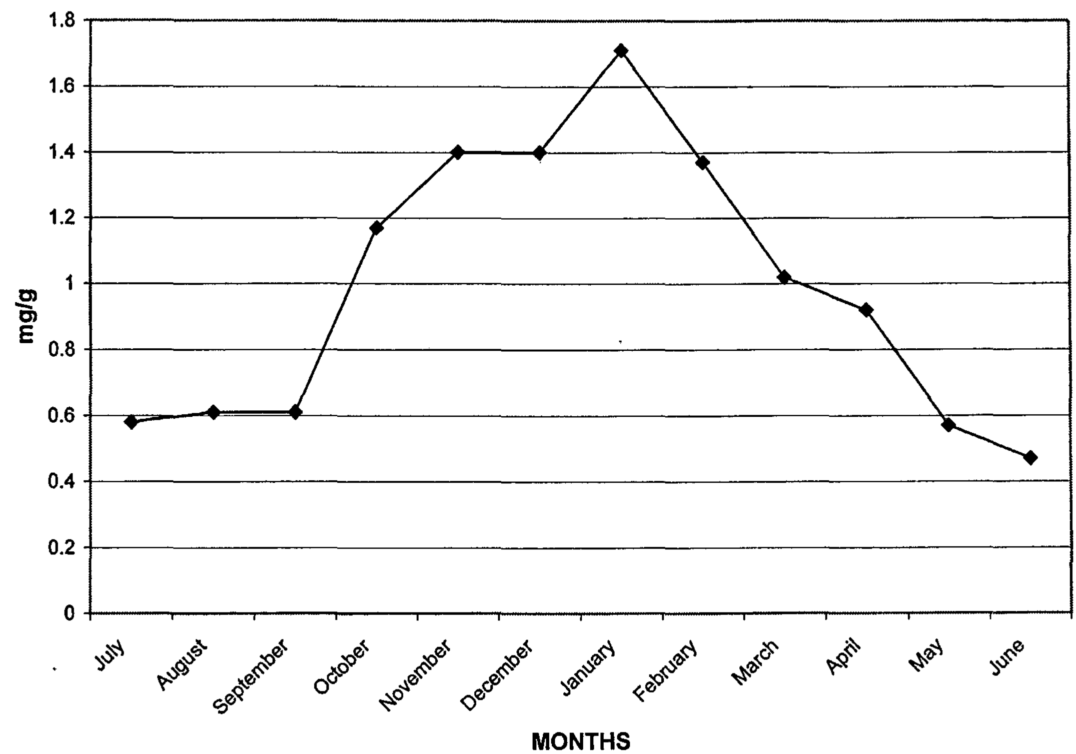


6.1.3 Mean faecal magnesium concentration (mg/g)

Table 7. Mean faecal mg concentration by months (mg/g, fresh weight).

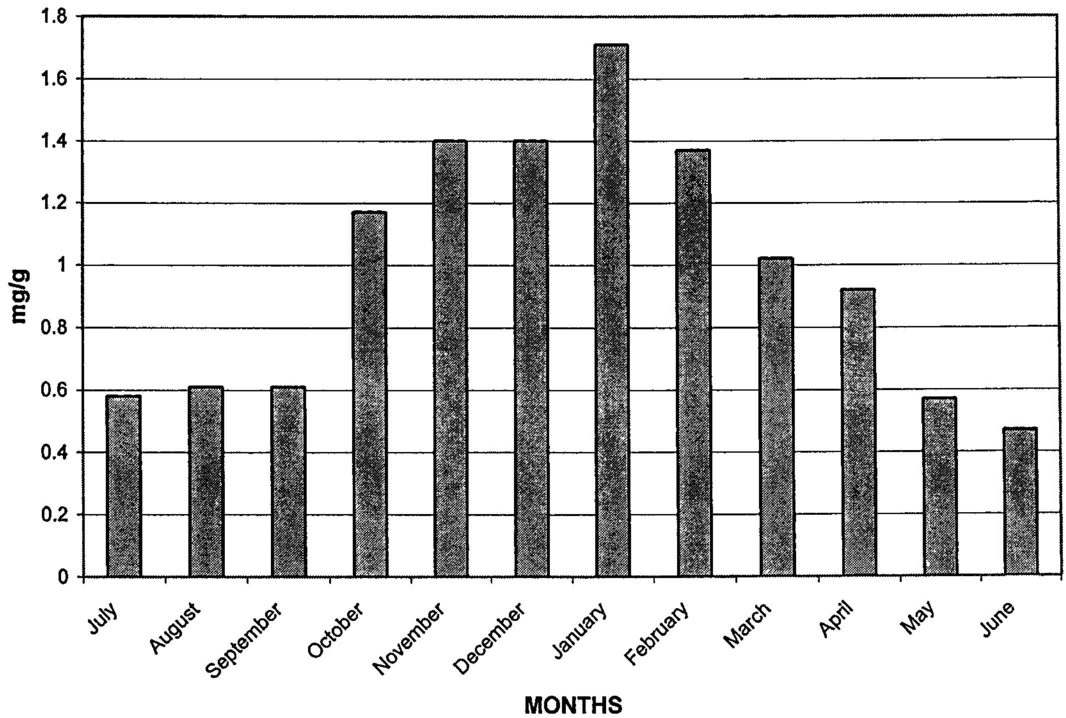
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Mg (mg/g, fw)	0.58	0.61	0.61	1.17	1.4	1.4	1.71	1.37	1.02	0.92	0.57	0.47

Figure 13. Mean faecal Mg concentration by months (mg/g, fresh weight)



Faecal Mg concentration measured on a fresh weight basis responded to the changing seasons and changing dietary values as a result of wet and dry seasons much differently than that seen in faecal P and faecal Ca. During the dry months of May, June, July, August and September the mean concentration was low when compared to the rainy months. August and September samples had the same value (0.61 mg/g) and also November and December samples had the same value (1.4 mg/g). The mean concentration decreased from February to June (Table 7, Figures 13 and 14).

Figure 14. Mean faecal Mg concentration by months (mg/g, fresh weight)

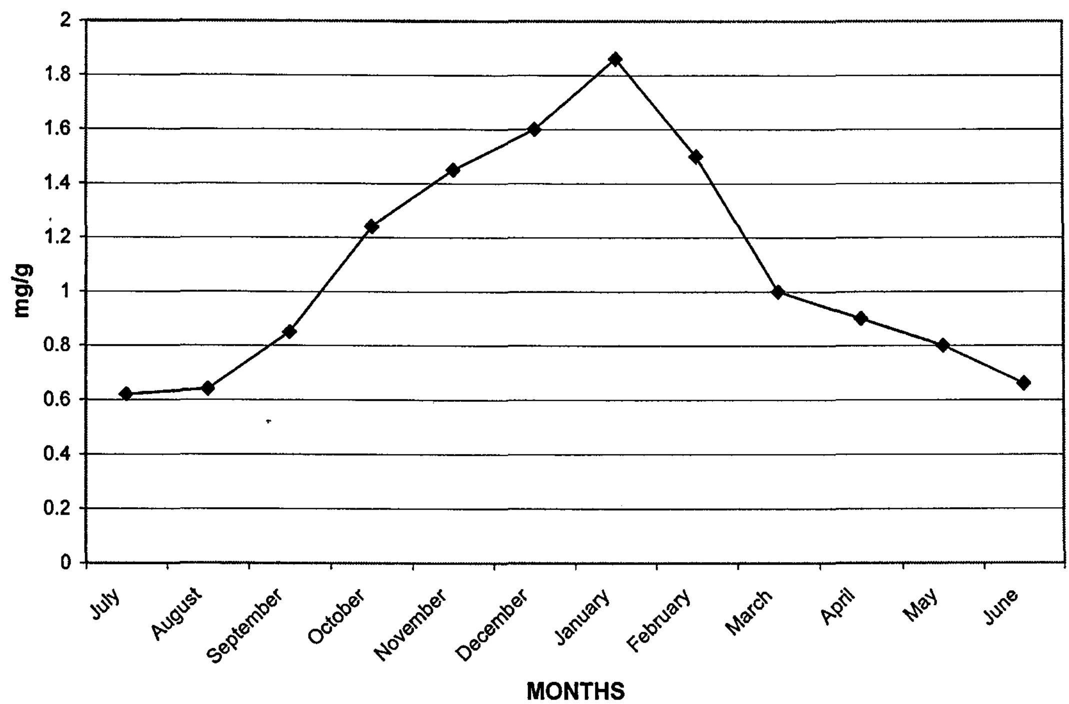


January samples had the highest value of faecal Mg concentration (1.71 mg/g) and June samples had the lowest value of 0.47 mg/g of faecal Mg concentration. The difference between the highest value and the lowest value of faecal Mg concentration was 1.24 mg/g of faecal Mg concentration (Figures 13 and 14).

Table 8. Mean faecal Mg concentration by months (mg/g, dry weight).

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Mg (mg/g, dw)	0.62	0.64	0.85	1.24	1.45	1.6	1.86	1.5	1	0.9	0.8	0.66

Figure 15. Mean faecal Mg concentration by months (mg/g, dry weight)



The faecal Mg concentration measured on a dry weight basis by months is given in Table 8 and Figures 15 and 16. The mean concentration increased from July until January and the animals sampled in July had the lowest concentration (0.62 mg/g) of faecal Mg. The concentration decreased from January to July (Table 8, Figures 15 and 16).

January samples had the highest value of faecal Mg concentration (1.86 mg/g) and July samples had the lowest value of 0.62 mg/g of faecal Mg concentration. The difference between the highest value and the lowest value of faecal Mg concentration was 1.24 mg/g of faecal Mg concentration.

Figure 16. Mean faecal Mg concentration by months (mg/g, dry weight)

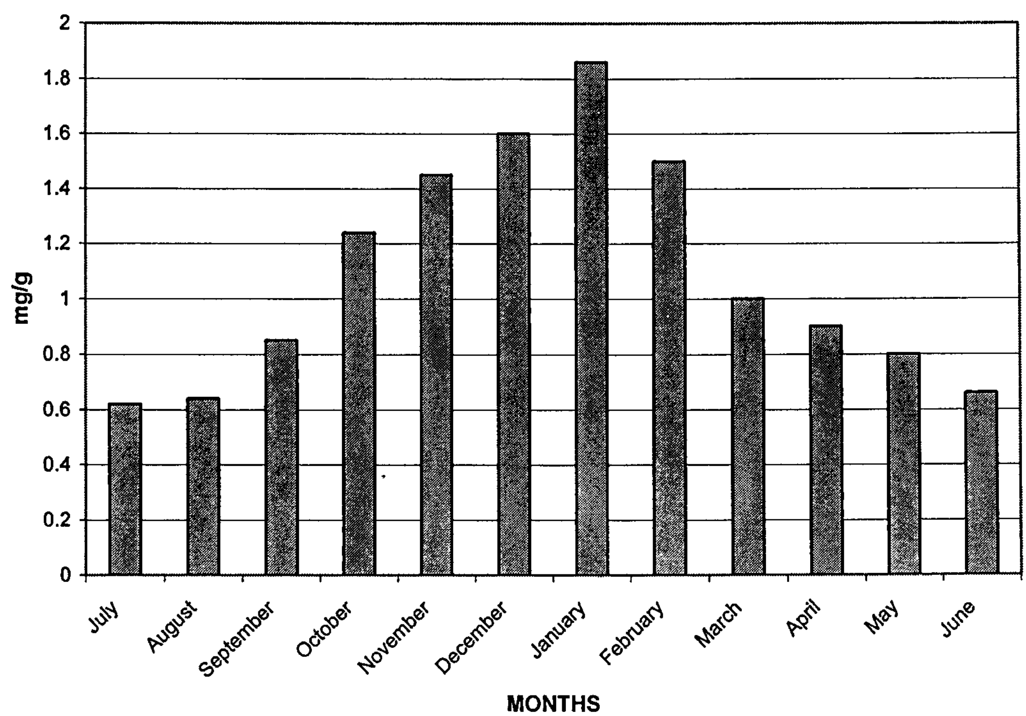
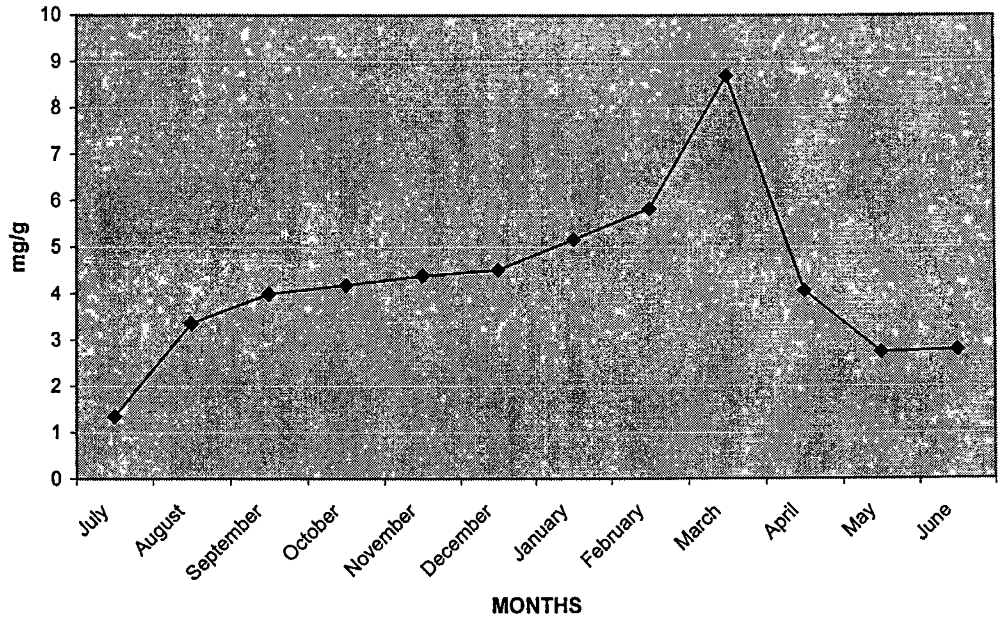


Table 9. Mean faecal Mg concentration by months (mg/g, ash weight).

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Mg (mg/g, aw)	1.34	3.35	3.98	4.17	4.37	4.5	5.15	5.82	8.69	4.05	2.73	2.78

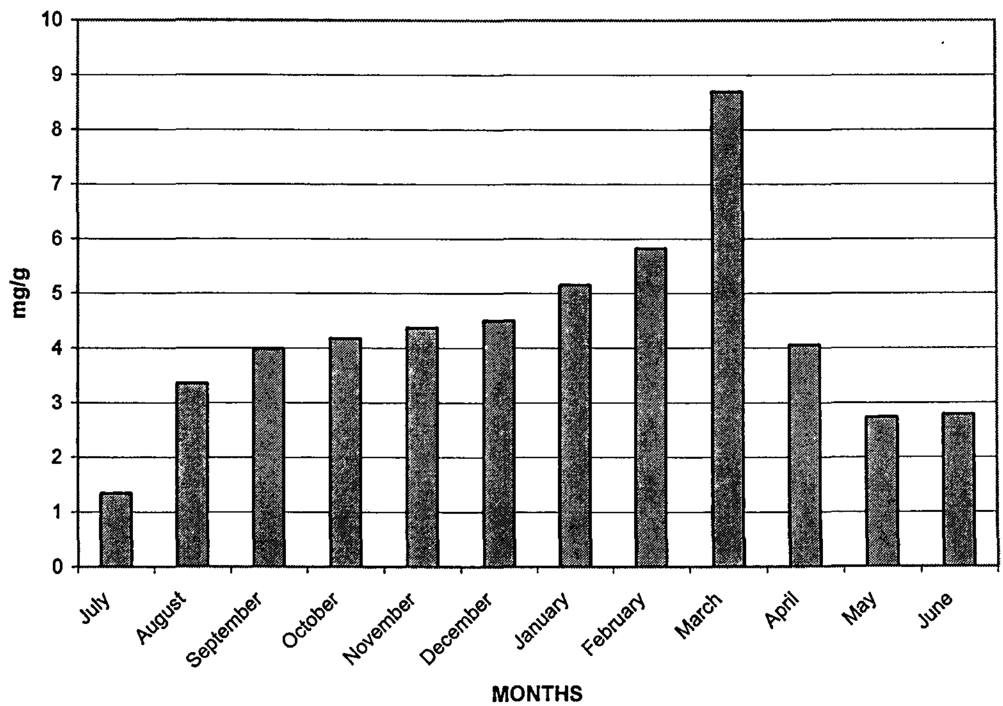
Figure 17. Mean faecal Mg concentration by months (mg/g, ash weight)



The faecal Mg concentration measured on an ash weight basis by months increased from July until March and decreased from March until June. March had the highest value of faecal Mg concentration (8.69 mg/g) and July had the lowest value of 1.34 mg/g of faecal Mg concentration.

The difference between the highest value and the lowest value of faecal Mg concentration had the value of 7.35 mg/g of faecal Mg concentration (Table 9 and Figures 17 and 18)

Figure 18. Mean faecal Mg concentration by months (mg/g, ash weight)

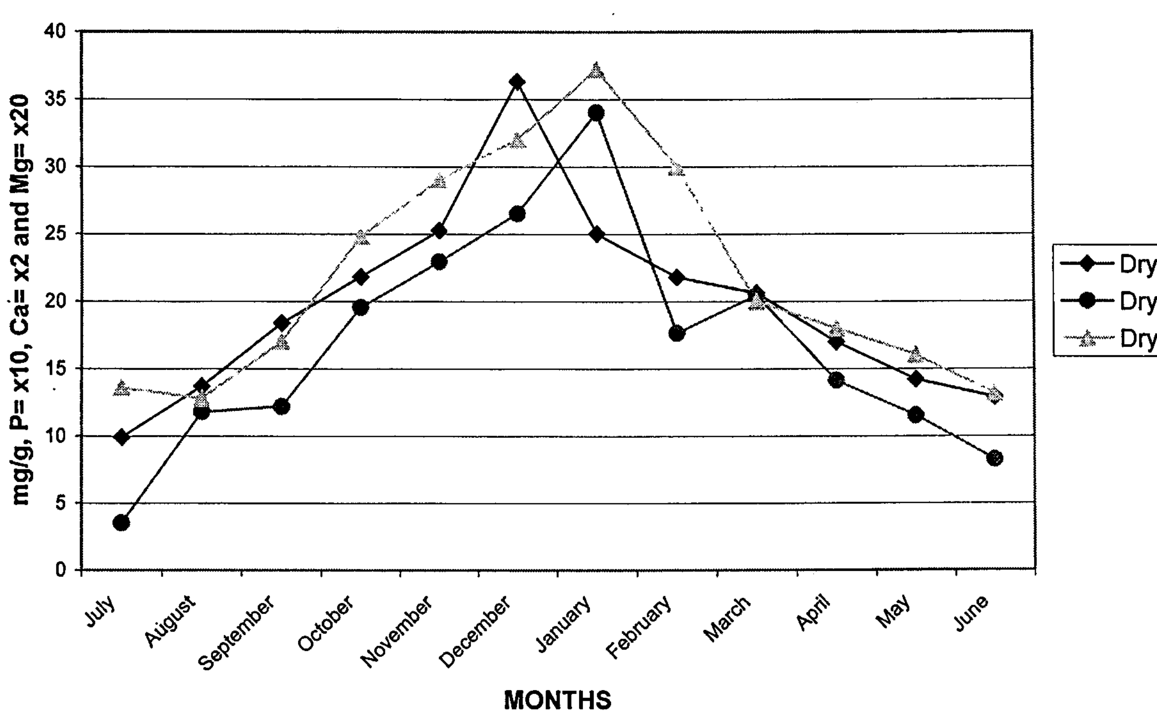


6.1.4 Mean faecal phosphorus, calcium and magnesium (mg/g, dry weight)

Table 10. Mean faecal P, Ca and Mg concentrations (mg/g, dry weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal P (mg/g, dw)	0.99	1.37	1.84	2.18	2.53	3.63	2.5	2.18	2.06	1.7	1.42	1.29
Faecal Ca (mg/g, dw)	1.76	5.89	6.1	9.76	11.47	13.25	17.01	8.82	10.21	7.06	5.76	4.13
Faecal Mg (g/g, dw)	0.62	0.64	0.85	1.24	1.45	1.6	1.86	1.5	1	0.9	0.8	0.66

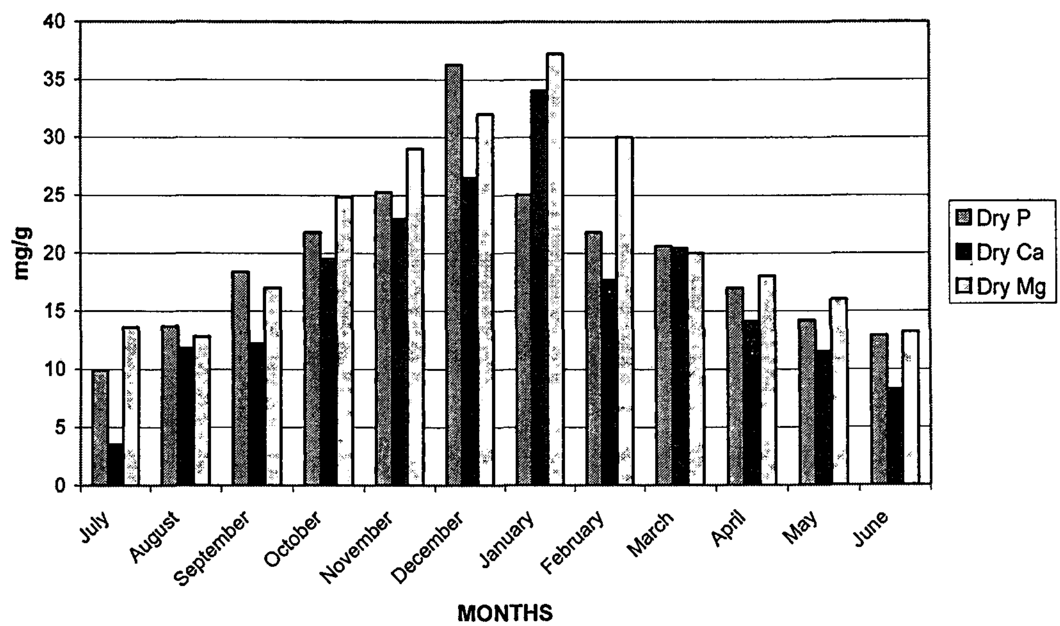
Figure 19. Mean faecal P, Ca and Mg concentrations by months (mg/g, dry weight)



The mean faecal P, Ca and Mg concentrations by months on a dry weight basis are given in Table 10 and illustrated in Figures 19 and 20. When the faecal P concentration peaked up in December, faecal Ca and faecal Mg peaked up in January. There was an increment from July to December in faecal P and faecal Ca concentrations and faecal Ca concentration continued to increase until January, and then, except for an increase in March, decreased until June. Faecal P concentration decreased from January until June, and faecal Mg increased from August until January and declined from January until July.

When the faecal P concentration was decreasing from December to January, the faecal Ca and faecal Mg concentrations were increasing. December samples had the highest values of faecal P concentration and July samples had the lowest values.

Figure 19B. Mean faecal P, Ca and Mg concentrations by months (mg/g, dry weight)



For faecal Mg concentration, the highest value was observed in January and the lowest value in July. The difference between the highest values and the lowest values of faecal P, faecal Ca and faecal Mg concentrations were 2.6 mg/g, 1.2 mg/g and 0.12 mg/g respectively.

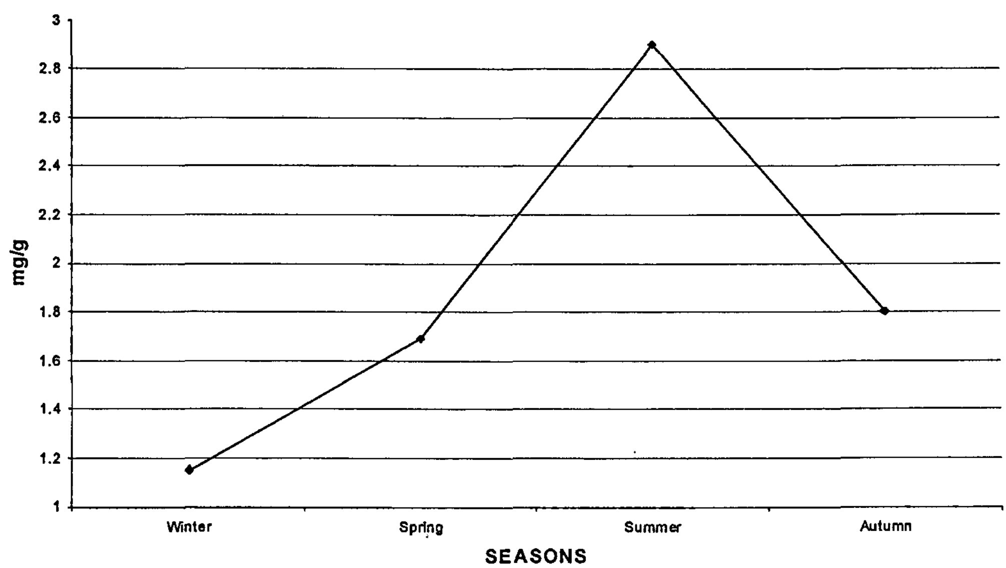
6.1.5 Mean faecal phosphorus concentration by seasons (mg/g)

Table 11. Mean faecal phosphorus concentration by seasons (mg/g, fresh weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal P (mg/g, fw)	1.15[a]	1.69[a]	2.9[b]	1.8[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 20. Mean faecal P concentration by seasons (mg/g, fresh weight)



The mean faecal P concentration on a fresh weight basis was signifantly (P< 0.05) higher in the summer season when compared with winter, spring and autumn (Table 11). The concentration increased from winter to summer and declined during autumn. Winter samples had the lowest value of faecal P concentration (1.15 mg/g) and summer samples had the highest value 2.9 mg/g (Figures 20 and 21)

Figure 21. Mean faecal P concentration by seasons (mg/g, fresh weight)

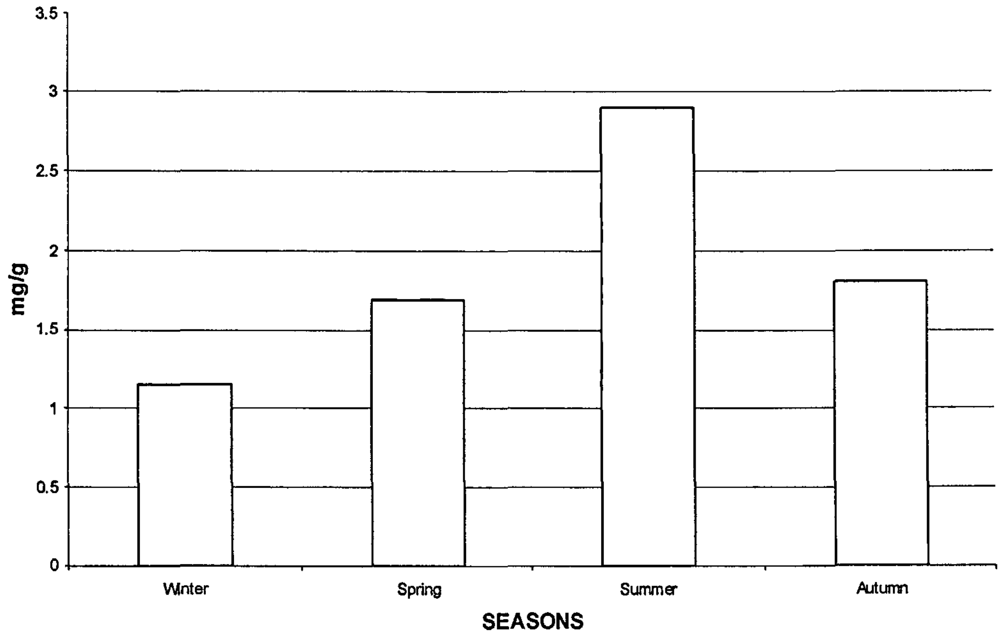
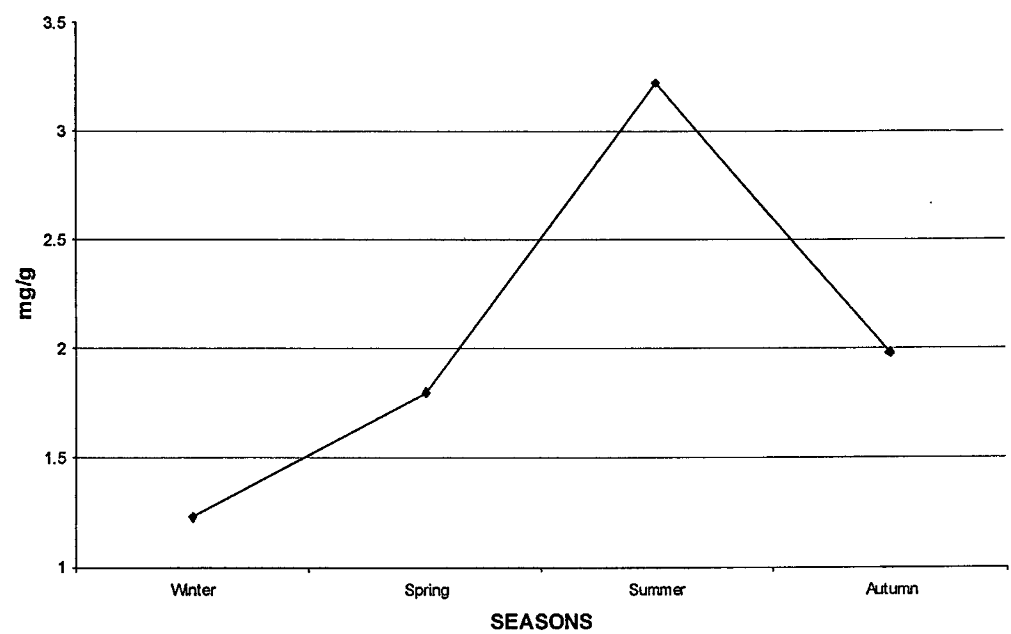


Table 12. Mean faecal phosphorus concentration by seasons (mg/g, dry weight).

SEASONS	Winter	Spring	Summer	Autumn
Faecal P (mg/g, dw)	1.23[a]	1.8[a]	3.22[b]	1.98[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 22. Mean faecal P concentration (mg/g, dry weight)



The mean faecal P concentration by seasons on a dry weight basis is given in Table 12 and illustrated in Figures 22 and 23. The concentration increased from winter to summer and declined during autumn. The concentration was significantly (P<0.05) higher during summer when compared with winter, spring and autumn. The difference between the highest and the lowest value of faecal P concentration had the value of 1.99 mg/g.

Figure 23. Mean faecal P concentration (mg/g, dry weight)

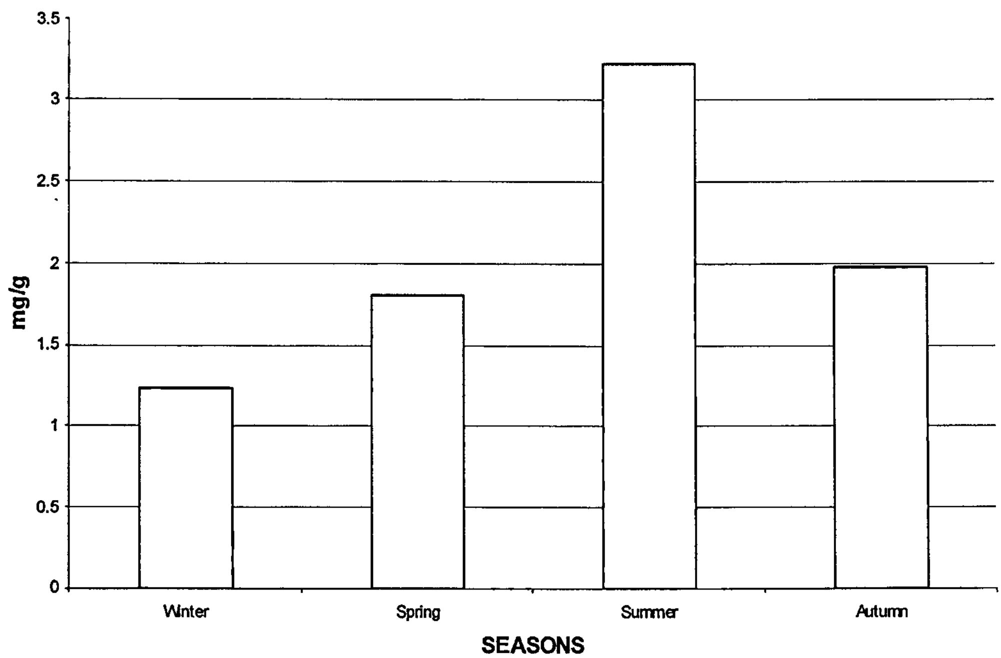
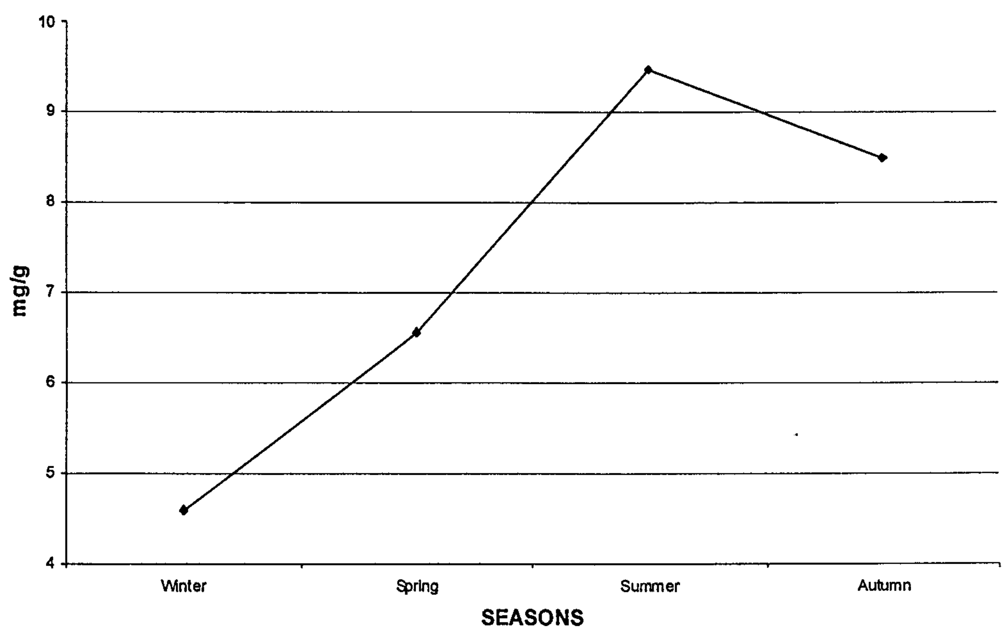


Table 13. Mean faecal phosphorus concentration by seasons (mg/g, ash weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal P (mg/g, aw)	4.59[a]	6.55[a]	9.47[b]	8.48[a]

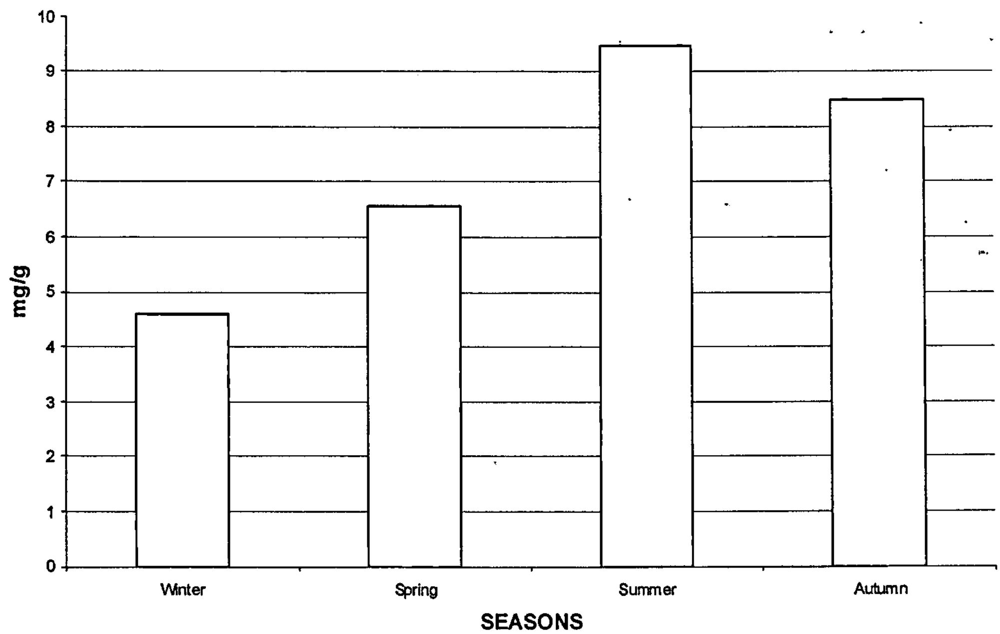
[a,b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 24. Mean faecal P concentration by seasons (mg/g, ash weight)



The mean faecal P concentration on an ash weight basis increased from winter to summer and declined in autumn and was significantly ($P < 0.05$) higher in summer when compared with the other three seasons (Table 13). The difference between the seasons with the highest and lowest had an extreme high value of 4.88 mg/g. The faecal P concentrations measured on fresh, dry and an ash weight basis had the lowest point during winter (Figures 20, 22 and 24 respectively).

Figure 25. Mean faecal P concentration by seasons (mg/g, ash weight)



In this experiment faecal P concentrations measured on a fresh, dry and ash weights basis were lower in the dry season and higher in wet season. These findings are similar to the ones that Holroyd et al. (1983) have reported in which faecal phosphorus concentrations followed a seasonal pattern, being higher in the wet season than in the dry season.

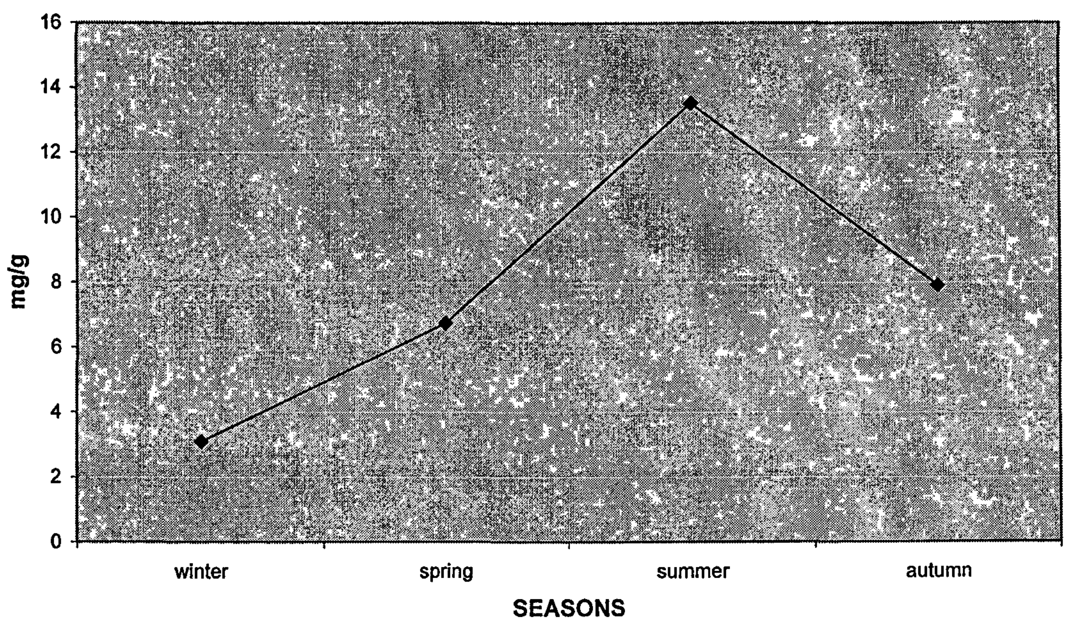
6.1.6 Mean faecal calcium concentration by seasons (mg/g)

Table 14. Faecal calcium concentration by seasons (mg/g, fresh weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal Ca (mg/g, fw)	3.1[a]	6.74[a]	13.25[b]	7.9[a]

[a, b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 26. Mean faecal Ca concentration (mg/g) by seasons on a fresh weight basis



The mean faecal Ca concentration by seasons on a fresh weight basis given in Table 14 and illustrated in Figures 26 and 27 increased from winter to summer and declined in autumn. The concentration was significantly ($P<0.05$) higher during summer when compared with winter, spring and autumn, and winter samples had the lowest value of faecal Ca concentration. The difference between the highest and the lowest value was 10.15 mg/g.

Figure 27. Mean faecal Ca concentration (mg/g) by seasons on fresh weight basis

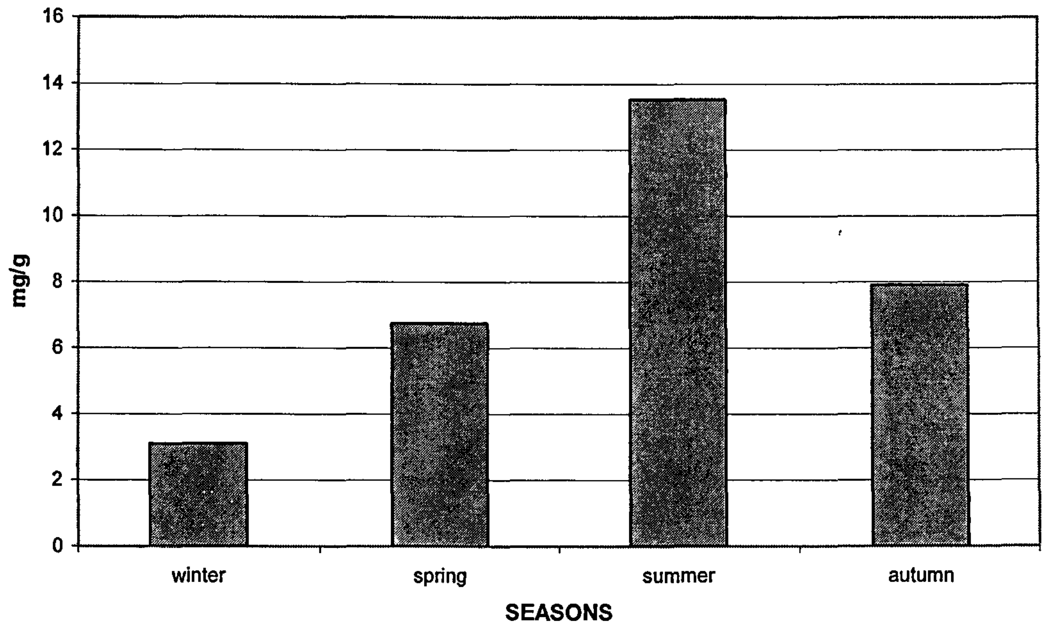
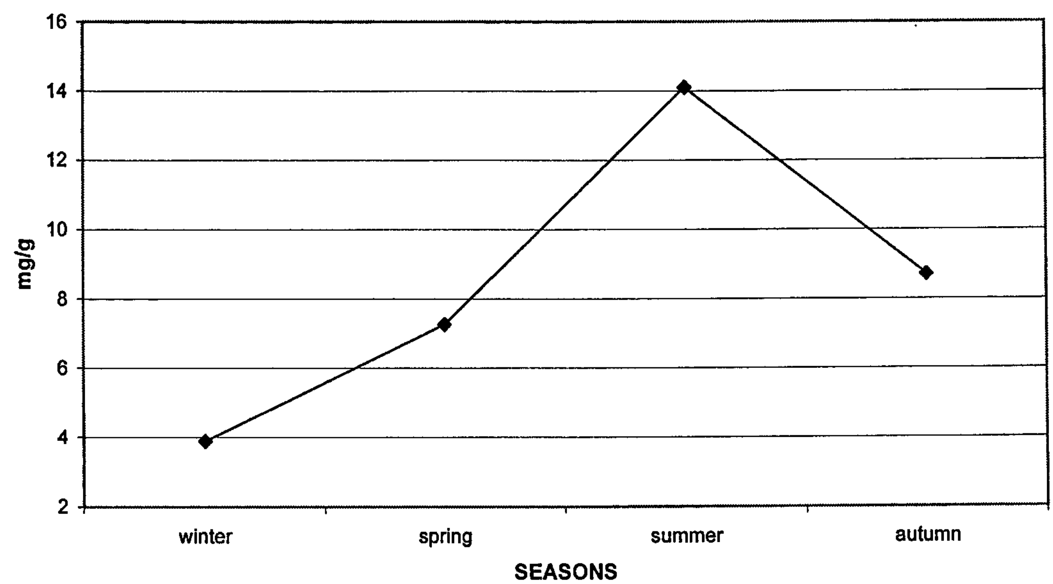


Table 15. Mean faecal calcium concentration by seasons (mg/g, dry weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal Ca (mg/g, dw)	3.88[a]	7.25[a]	14.1[b]	8.7[a]

[a, b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 28. Mean faecal Ca concentration (mg/g) by seasons on a dry weight basis



The mean faecal Ca concentration by seasons on a dry weight basis given in Table 15 and illustrated in Figures 28 and 29, increased from winter to summer and declined in autumn. The concentration was significantly (P< 0.05) higher during summer when compared with winter, spring and autumn, and winter had the lowest value of faecal Ca concentration. The difference between the highest and the lowest value was 10.22 mg/g.

Figure 29. Mean faecal Ca concentration (mg/g) by seasons on a dry weight basis

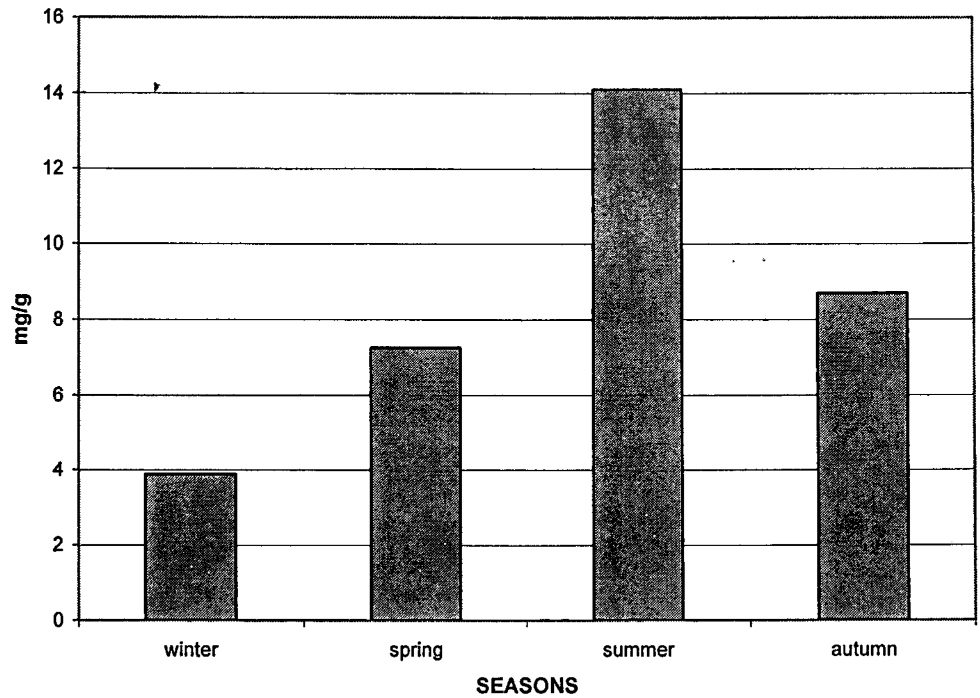
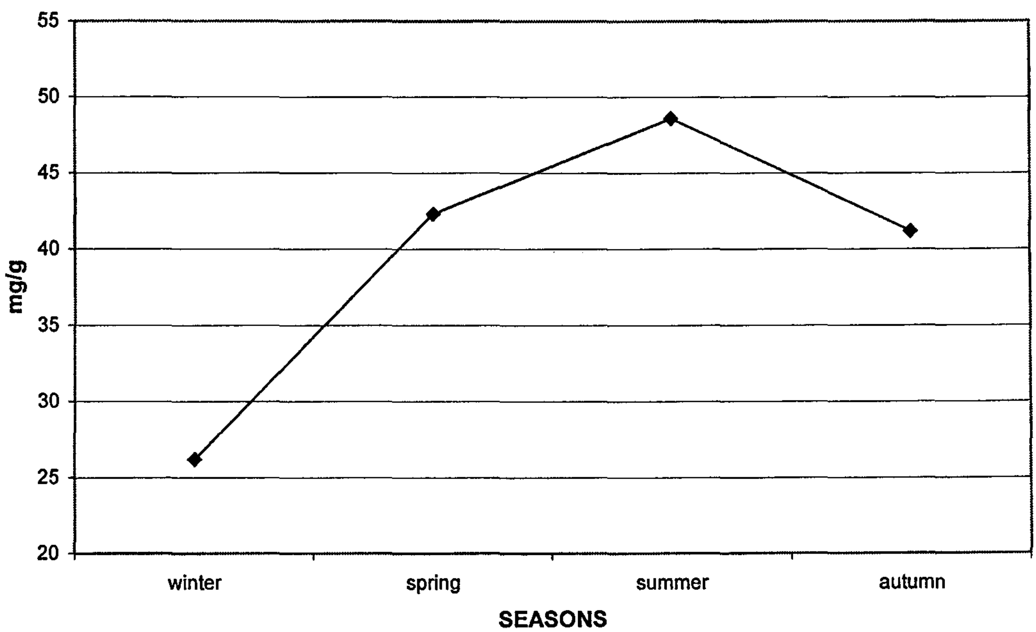


Table 16. Mean faecal calcium concentration by seasons (mg/g, ash weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal Ca (mg/g, aw)	26.18[a]	42.29[c]	48.59[b]	41.17[c]

[a, b, c] means with the same letter are not significantly (P< 0.05) different between the seasons

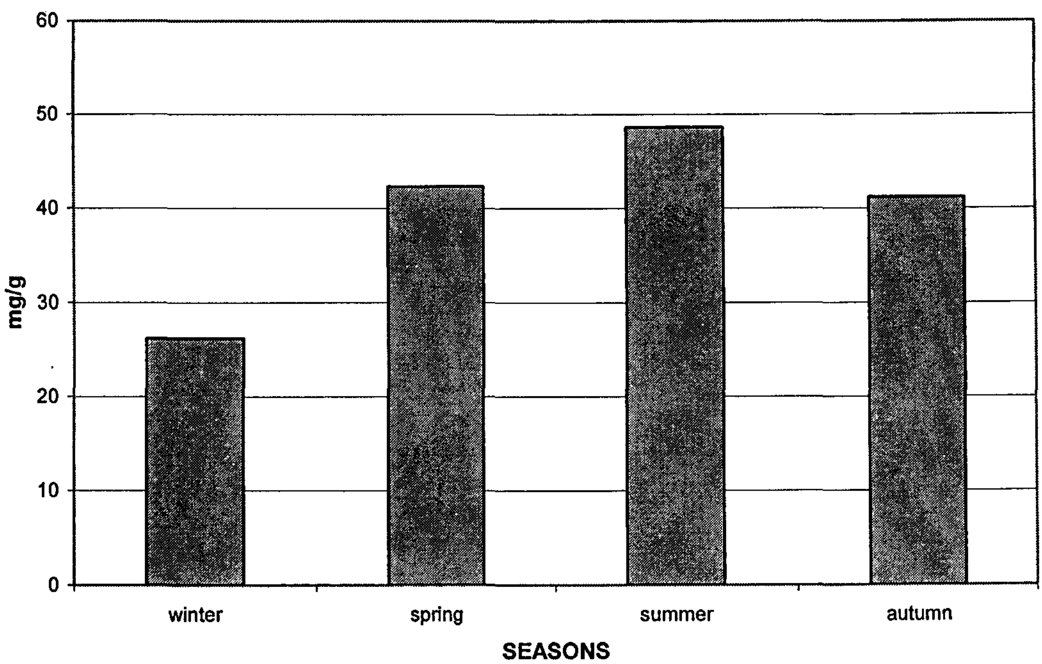
Figure 30. Mean faecal Ca concentration (mg/g) by seasons on an ash weight basis



The mean faecal Ca concentration by seasons on an ash weight basis given in Table 16 and illustrated in Figures 30 and 31, increased from winter to summer and declined in autumn. The concentration was significantly (P< 0.05) higher during summer when compared with winter, spring and autumn, and was also significantly higher during spring and autumn when compared with the winter season.

Winter samples had the lowest value of faecal Ca concentration, and the degree of difference between the months with the highest and the lowest value was 22.41 mg/g, and there was a slight difference of 1.12 mg/g between samples sampled during spring (42.29 mg/g) and samples sampled during autumn (41.17 mg/g).

Figure 31. Mean faecal Ca concentration (mg/g) by seasons on an ash weight basis



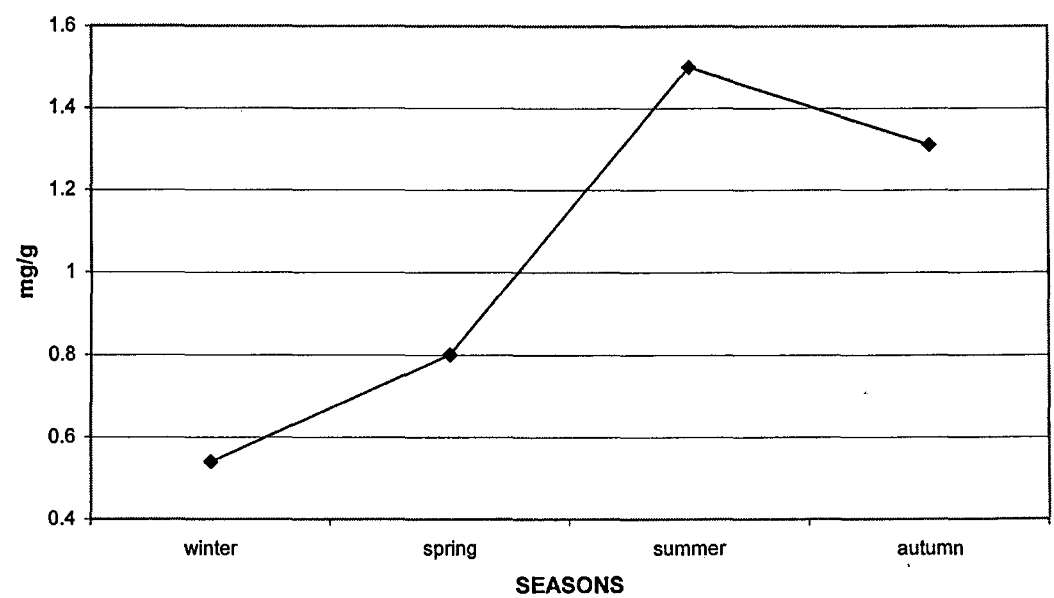
6.1.7 Mean faecal magnesium concentration by seasons (mg/g)

Table 17. Faecal magnesium concentration by seasons (mg/g, fresh weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal Mg (Mg/g, fw)	0.54[a]	0.8[a]	1.5[a]	1.31[a]

[a, b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 32. Mean faecal Mg concentration (mg/g) by seasons on a fresh weight basis



The mean faecal Mg concentration on a fresh weight basis is given in Table 17 and illustrated in Figures 32 and 33. The concentration increased from winter to summer and declined in autumn. Even though there were no significant differences among the seasons in faecal Mg concentration, summer samples had the high value of faecal Mg concentration (1.5 mg/g) and the difference between the highest and the lowest value was 0.96 mg/g.

Figure 33. Mean faecal Mg concentration (mg/g) by seasons on a fresh weight basis

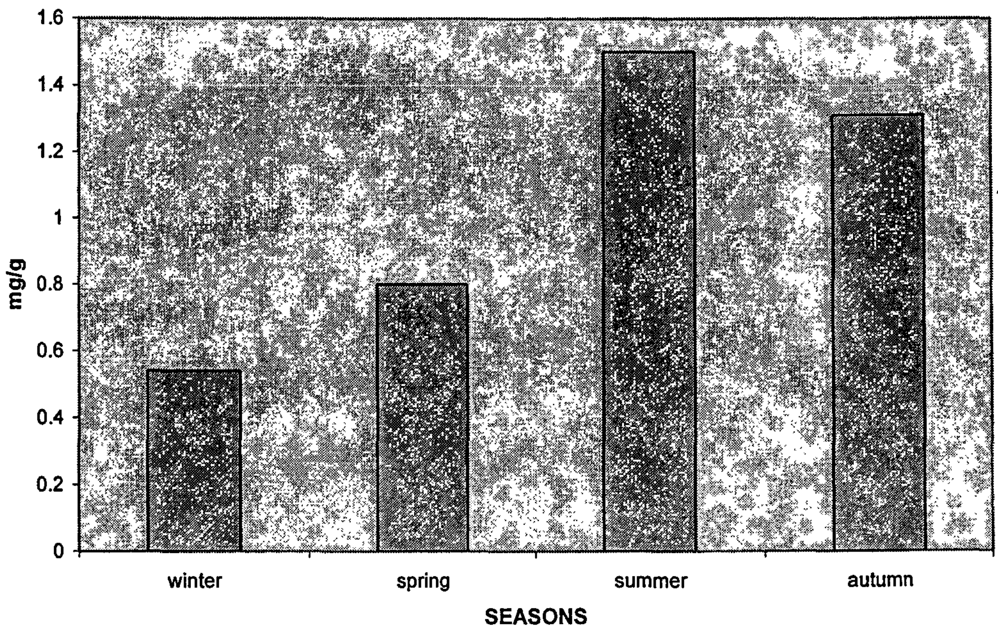
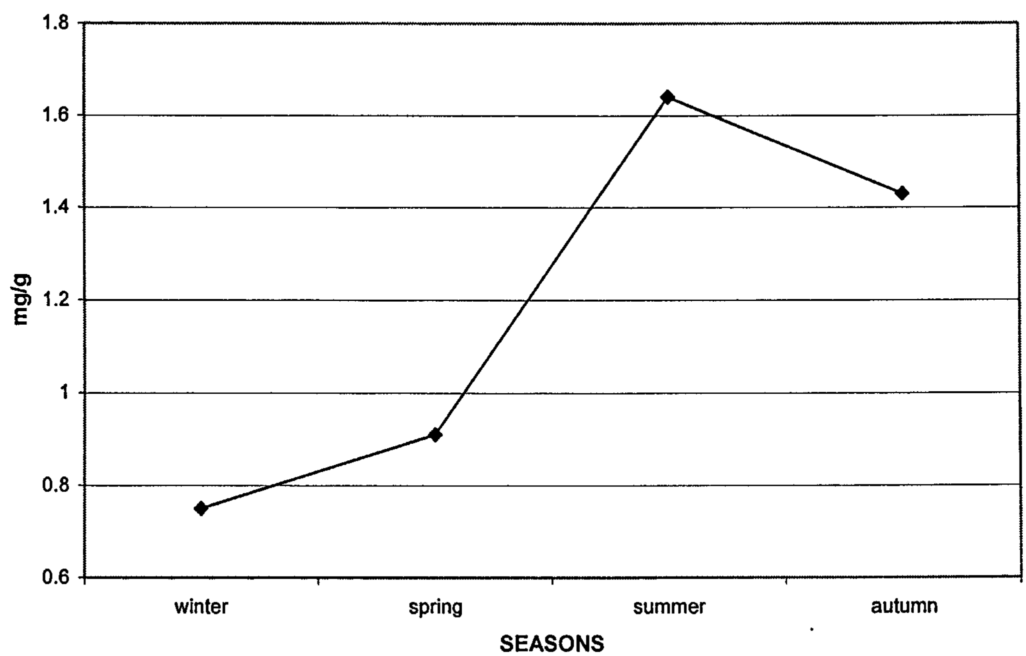


Table 18. Mean faecal magnesium concentration by seasons (mg/g, dry weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal Mg (mg/g, dw)	0.75[a]	0.91[a]	1.64[a]	1.43[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 34. Mean faecal Mg concentration (mg/g) by seasons on a dry weight basis



The mean faecal Mg concentration on a dry weight basis increased from winter to summer and declined in autumn, and even though there were no significant differences among the seasons in faecal Mg concentration, summer had the high value of faecal concentration (1.64 mg/g) and the difference between the highest and the lowest values was 0.89 mg/g (Table 18 and Figures 34 and 35)

Figure 35. Mean faecal Mg concentration (mg/g) by seasons on a dry weight basis

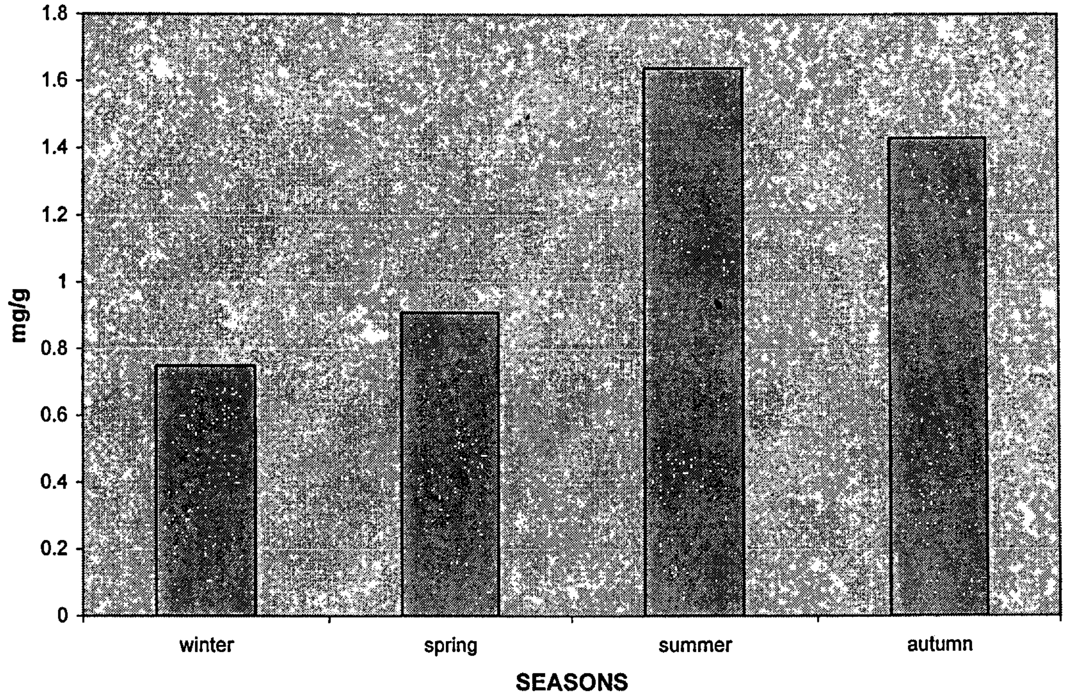
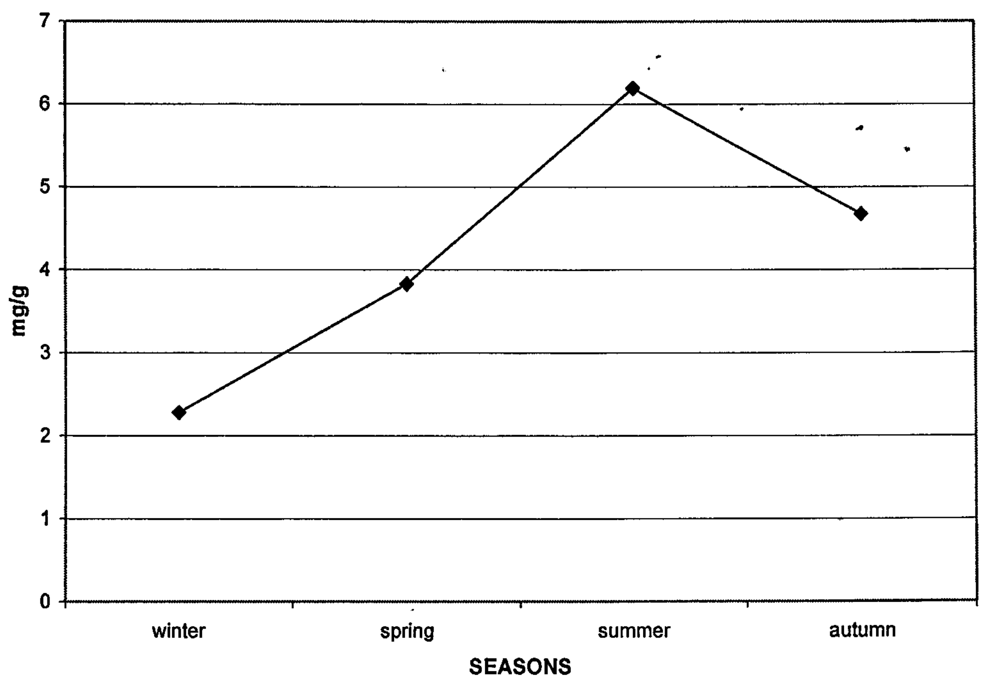


Table 19. Mean faecal magnesium concentration by seasons (mg/g, ash weight)

SEASONS	Winter	Spring	Summer	Autumn
Faecal Mg (mg/g, aw)	2.28[a]	3.83[a]	6.19[b]	4.67[a]

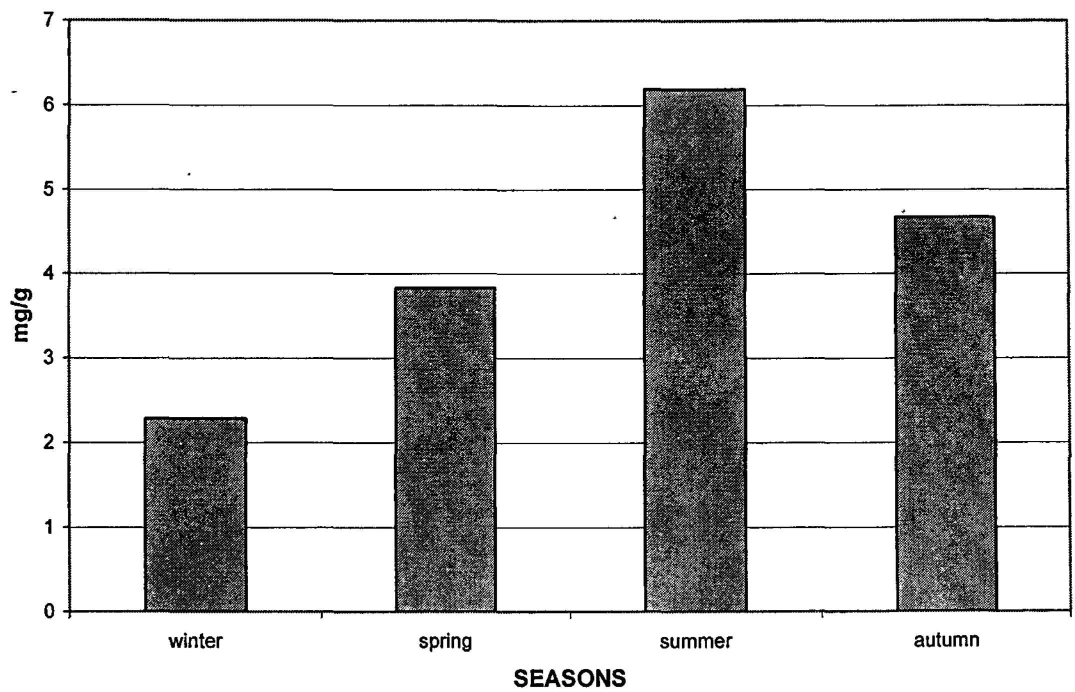
[a,b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 36. Mean faecal Mg concentration by seasons (mg/g, ash weight)



The mean faecal Mg concentration on an ash weight basis increased from winter to summer and declined in autumn. The concentration was significantly ($P < 0.05$) higher during summer when compared to winter, spring and autumn (Table 19). Winter samples had the lowest value of faecal Mg concentration, and the difference between the seasons with the highest and the lowest value of the faecal concentration was 3.91 mg/g (Figures 36 and 37).

Figure 37. Mean faecal Mg concentration by seasons (mg/g, ash)



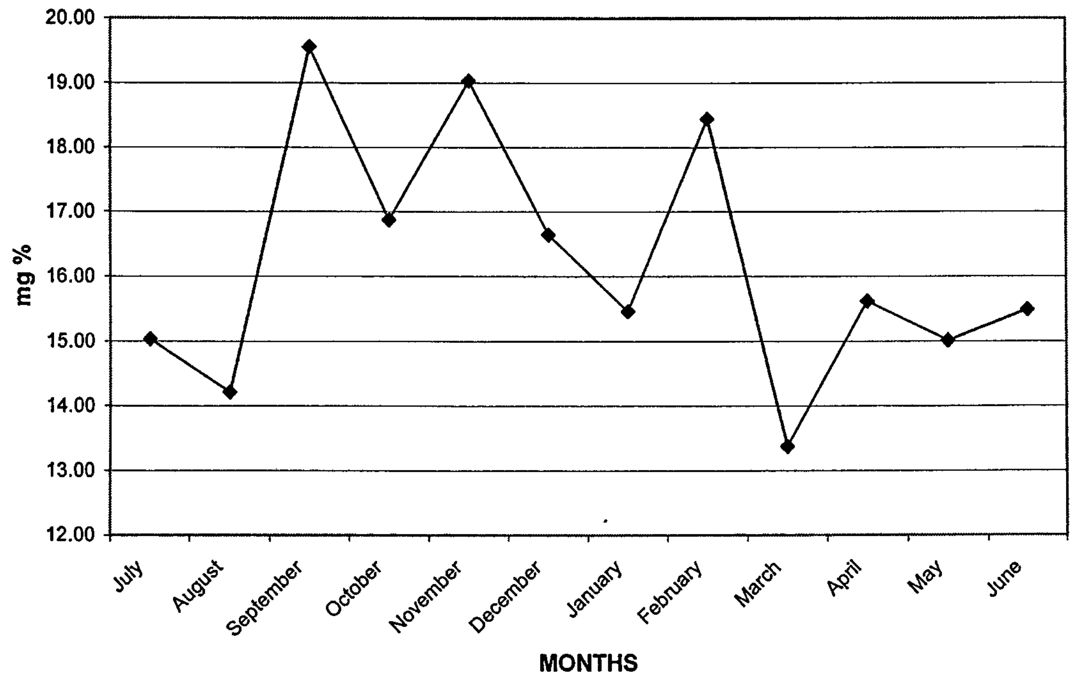
6.2 Blood samples

6.2.1 Mean blood phosphorus concentration by months (mg %)

Table 20. Mean blood phosphorus concentration (mg %) by months

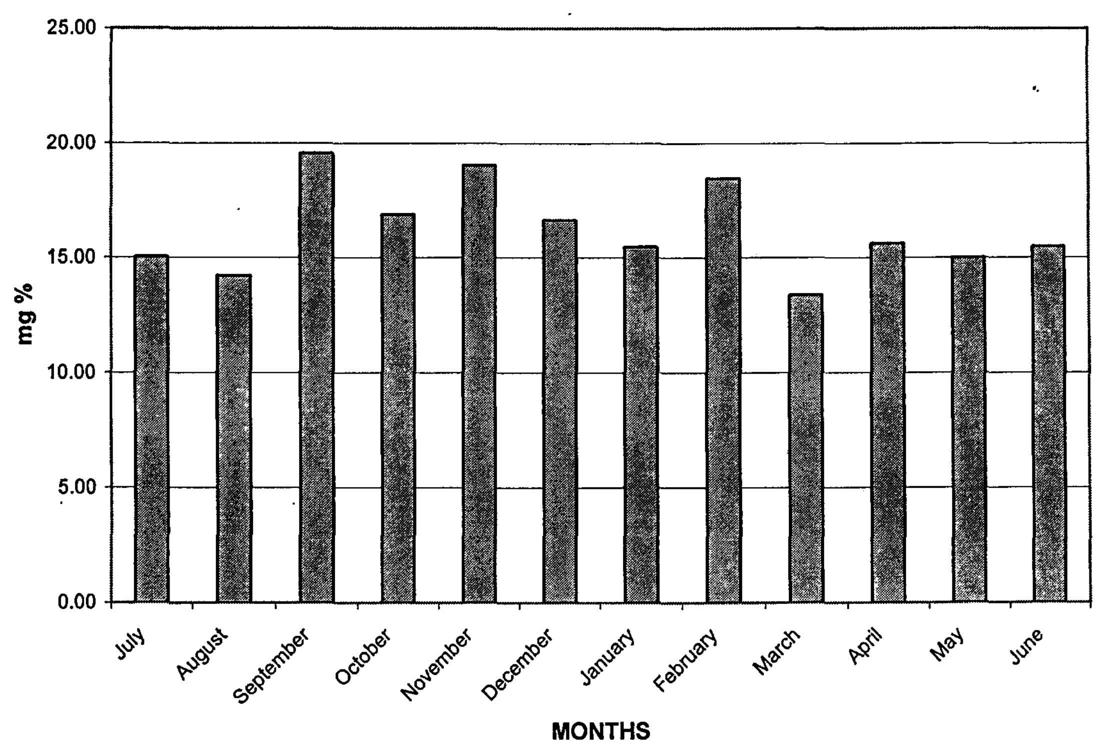
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Blood P (mg %)	15.03	14.21	19.55	16.87	19.03	16.64	15.46	18.44	13.37	15.62	15.01	15.4

Figure 38. Mean blood P concentration (mg %) by months



The mean blood P concentration (mg %) by months is given in Table 20 and illustrated in Figures 38 and 39. There were high values of blood P concentrations in September, November and February months with September samples having the highest value (19.95 mg %). March had the lowest value of blood P concentration (13.37 mg %) and the difference between the highest value and the lowest value had the blood P concentration of 6.28 mg %. It was unexpected to find such a high blood P concentration in September because it follows immediately after the dry season but it helps support the conclusions of previous research that the P content of blood is not always a good indication of the P status of the animal (Beighle et al. 1994) and that the plasma inorganic P levels varied greatly between sampling times (Cohen 1973A).

Figure 39. Mean blood P concentration (mg %) by months



The very low blood P concentration in the animals in March was unexpected so soon after the rainy season. These results support conclusions by Beighle et al. (1994) that blood is not a good indication of P status in the bovine as blood concentration of P varied greatly and did not follow the same increasing and decreasing pattern followed by faeces and the grass in this research.

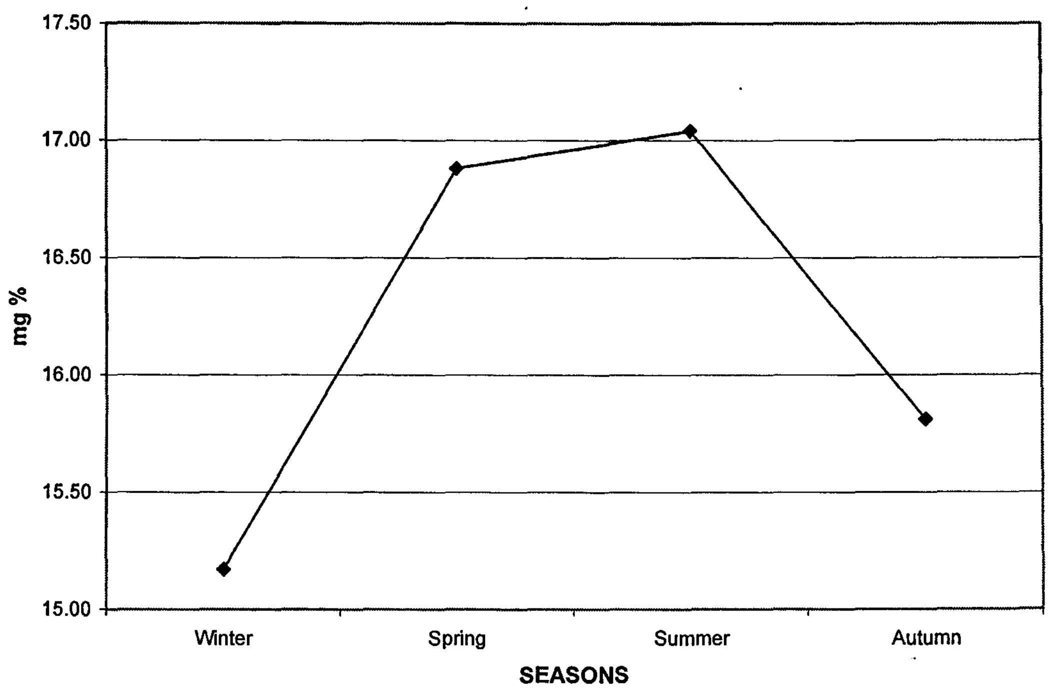
6.2.2 Mean blood phosphorus concentration by seasons (mg %)

Table 21. Mean blood phosphorus concentration (mg %) by seasons

SEASONS	Winter	Spring	Summer	Autumn
Blood P (mg %)	15.17[a]	16.88[a]	17.04[a]	15.86[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

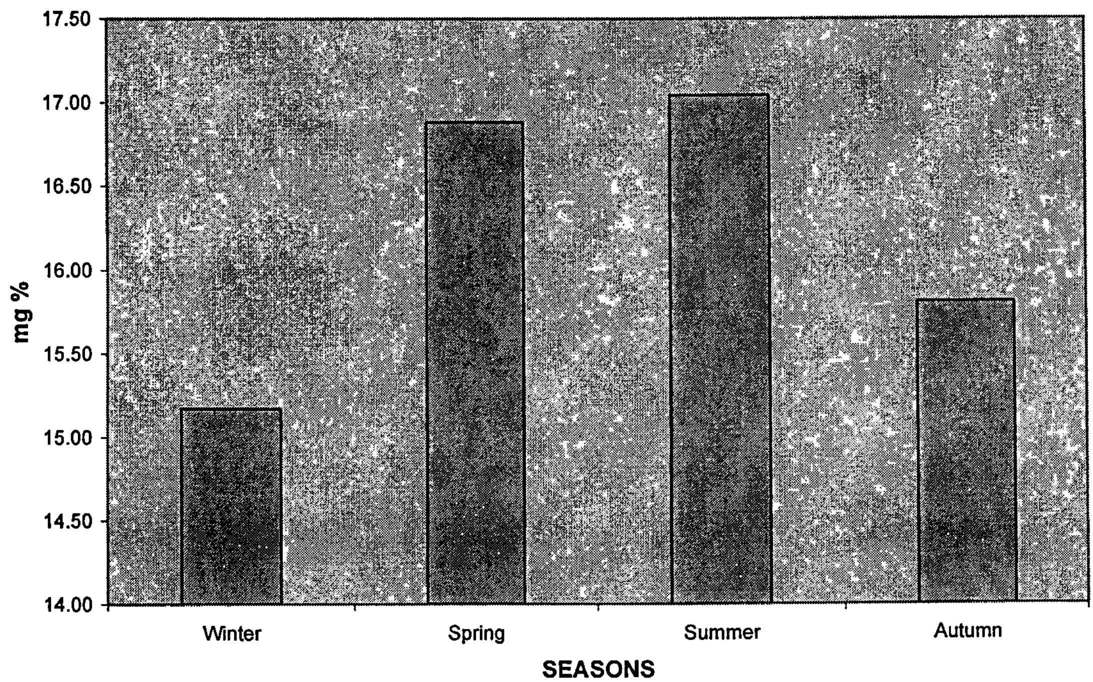
Figure 40. Mean blood P concentration (mg %) by seasons



When plotted against seasons the blood P concentration increased from winter to summer and declined during autumn. Winter and autumn had the lowest values of blood P concentration with the difference of 0.68 mg % between the two seasons. There were no significance differences among the seasons. Summer samples had the highest values of blood P concentration and winter samples had the lowest values and the results are in agreement with the one found by Gartner et al. (1966) in which the levels for blood inorganic P were higher in summer than in winter.

The difference between the highest value and the lowest value of blood P concentration was 1.87 mg % (Table 21 and Figures 40 and 41). This very small difference in blood P concentrations between seasons further supports the view that blood is not a good measure of P status in the bovine and is in agreement with Beighle et al. (1994) and Faure (1984).

Figure 41. Mean blood P concentration (mg/g) by seasons

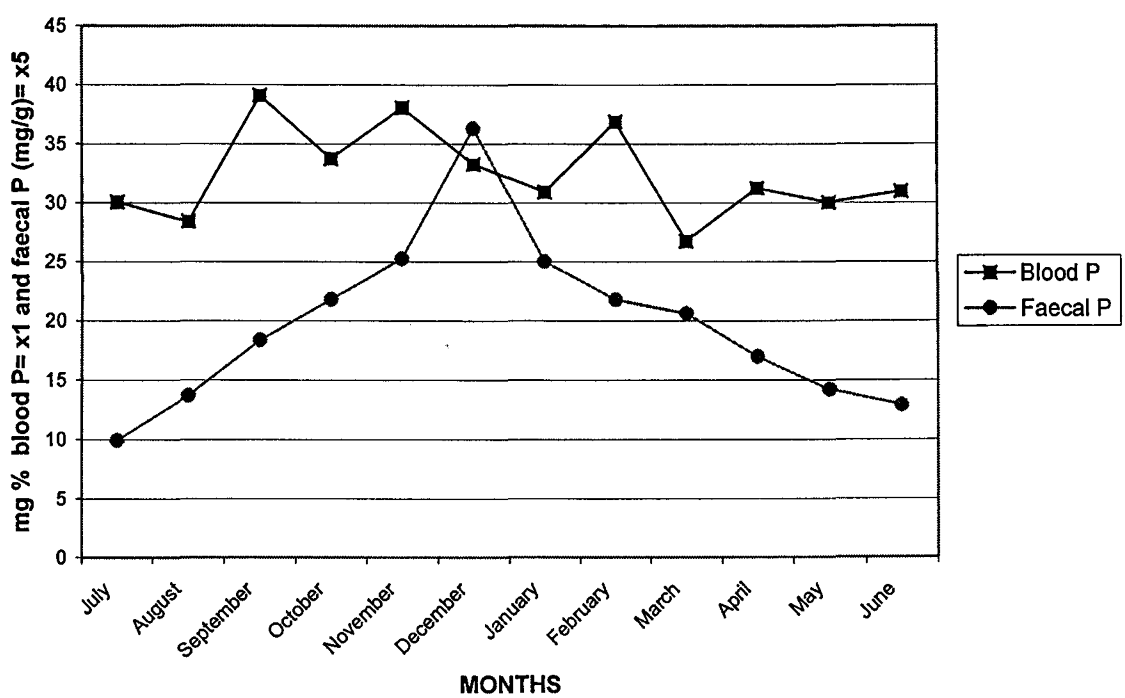


6.2.3 Mean blood phosphorus concentration (mg %) and faecal P concentration (mg/g, dry weight) by months.

Table 22. Mean blood phosphorus concentration (mg %) and mean faecal P concentration (mg/g, dry weight) by months

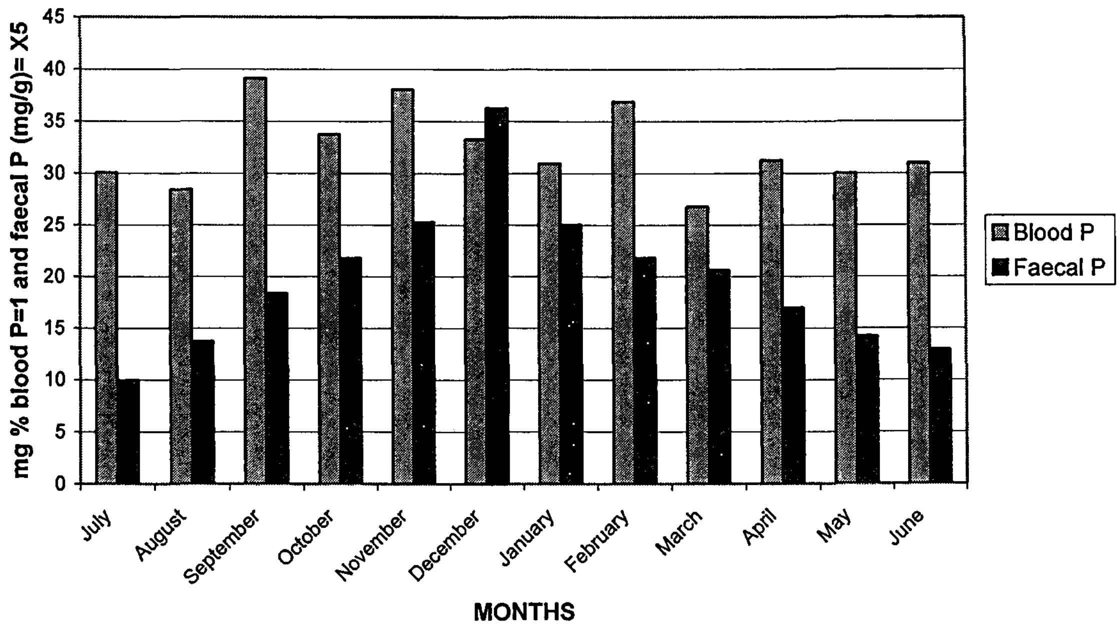
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Blood P (mg %)	15.03	14.21	19.55	16.87	19.03	16.64	15.46	18.44	13.37	15.62	15.01	15.48
Faecal P (mg/g, dw)	0.99	1.37	1.84	2.18	2.53	3.63	2.5	2.18	2.06	1.7	1.42	1.29

Figure 42. Mean blood P (mg %) and mean feacal P concentration (mg/g, dry weight) by months



The comparison between the means of blood P concentration and faecal P concentration (mg/g, dry weight) by months is given in Table 22 and illustrated in Figures 42 and 43. Faecal P was curvilinear increasing from winter months to spring months peaking in December when grazing was best and decreasing as the grazing became worse during fall and winter again but blood P concentrations were very irregular from month to month and showed no pattern (Table 22, Figures 42 and 43).

Figure 43. Mean blood concentration (mg %) and mean faecal P concentration (mg/g, dry weight) by months



Results reported here illustrate the ability of the cow to maintain normal concentrations of blood P even when the faecal P concentrations were very low (Figure 42).

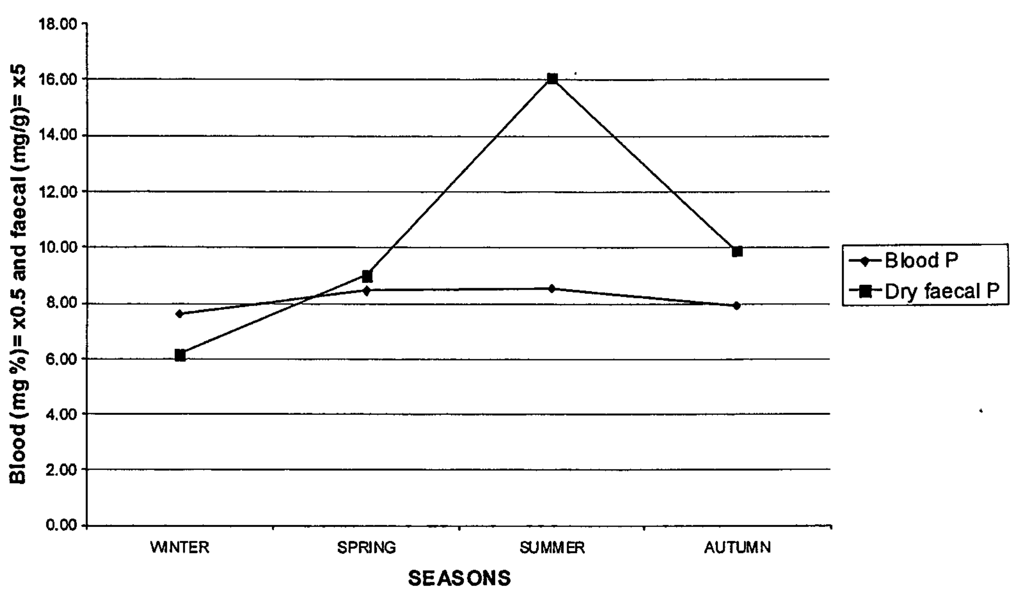
6.2.4 Mean blood phosphorus concentration (mg %) and mean faecal P concentration (mg/g, dry weight) by seasons

Table 23. Mean blood phosphorus concentration (mg %) and mean faecal P concentration (mg/g, dry weight) by seasons

SEASONS	Winter	Spring	Summer	Autumn
Blood P (mg %)	15.17[a]	16.88[a]	17.04[a]	15.81[a]
Faecal P (mg/g, dw)	1.23[a]	1.8[a]	3.22[b]	1.98[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

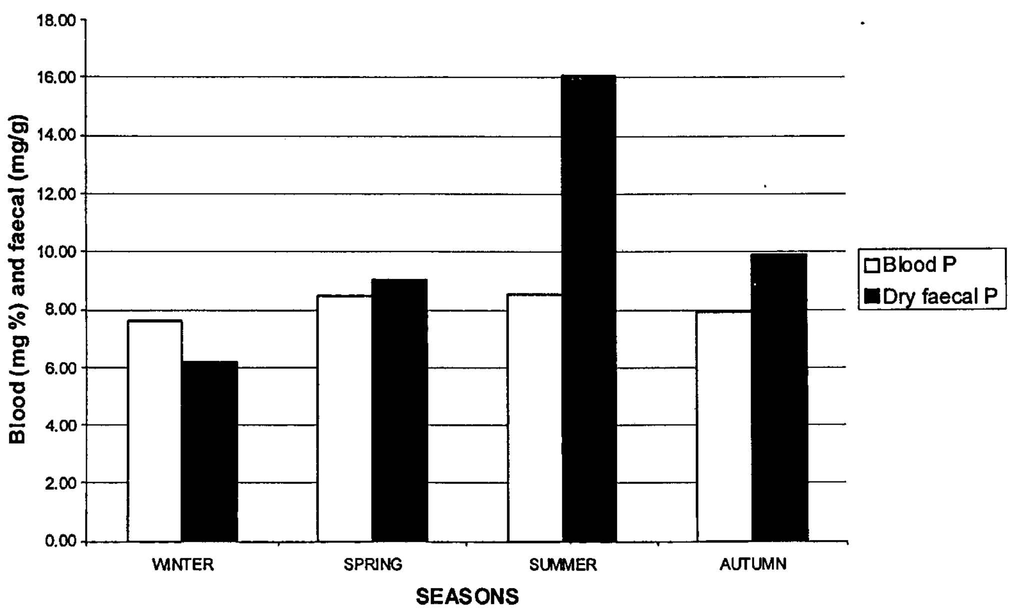
Figure 44. Mean blood P concentration (mg %) and mean faecal P concentration (mg/g, dry weight) by seasons



Both blood P concentration (mg %) and faecal P concentration (mg/g, dry weight) increased from winter to summer. The concentrations then decreased during autumn with the difference of 1.87 mg % of blood P and the difference of 1.99 mg/g faecal P. The large difference between P concentrations in faeces among seasons compared with the small difference between P concentrations of blood among seasons (Figure 44) illustrate the narrow range in which the animal maintains blood P values despite increases in faecal P due to greater availability of P in grazing (Figure 52 and 70).

Further research is needed to determine the extent of P depletion in bone during winter to maintain blood P values and to determine the extent to which the animal is able to replace bone P during the summer months when dietary and faecal P is high.

Figure 45. Mean blood concentration (mg %) and mean faecal P concentration (mg/g, dry weight) by seasons



The winter season had the lowest values of both faecal P and blood P concentrations, and the concentrations were significantly (P< 0.05) higher during summer. The degree of the difference between the highest value of blood P and lowest value was 1.87 mg % and between the highest value and the lowest value of faecal P concentration was 1.99 mg/g (Table 23 and Figures 44 and 45)

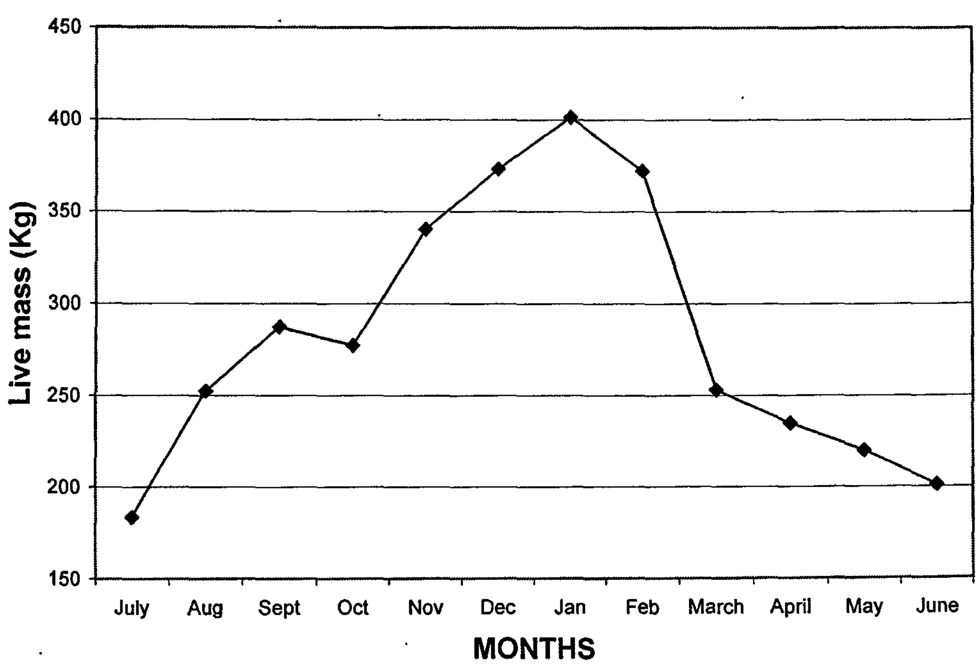
6.3 Live mass

6.3.1 Mean live body mass (Kg) by months

Table 24. Mean live body mass (Kg) by months

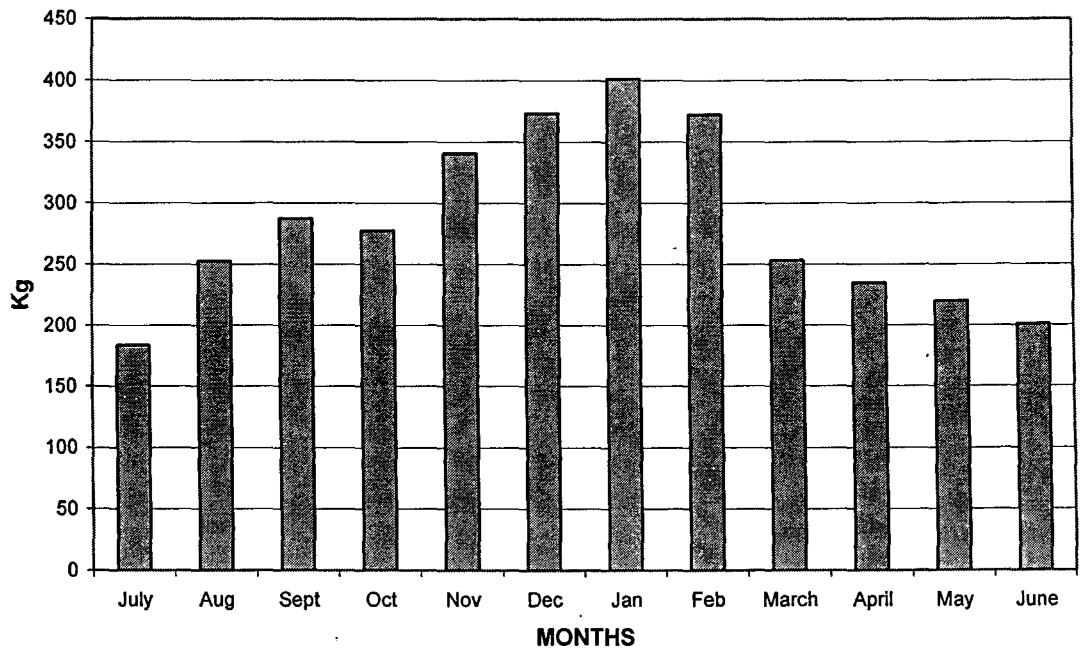
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Body weights (Kg)	183.5	252.33	287.21	277.33	340.33	373.2	401.33	372.07	253.13	234.75	219.75	20

Figure 46. Mean live body mass (Kg) by months



The mean body live masses of the animals sampled by months are shown in Table 24 and illustrated in Figures 46 and 47. The live masses increased from July until January except for October, when mean masses recorded in October month was lower than those in September (277.3 Kg vs 287.2 Kg). The masses decreased from January to June and the masses recorded in January were very high (401.33 Kg) and the one recorded in July was very low (183.5 Kg). There was a mean mass loss of 9.88 Kg between September and October.

Figure 47. Mean live body mass (Kg) by months



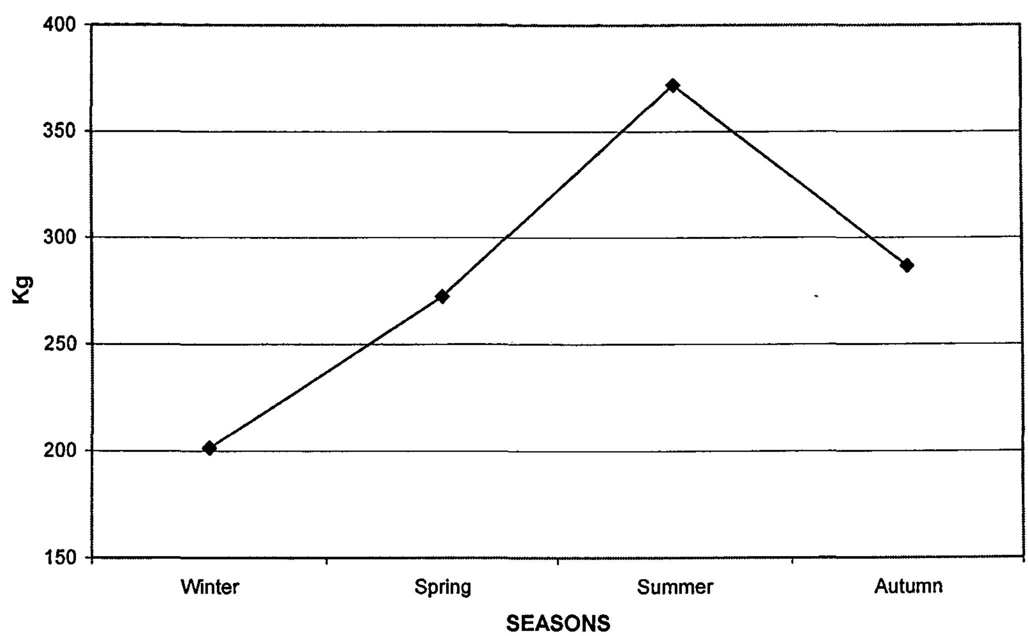
6.3.2 Mean live body mass (Kg) by seasons

Table 25. Mean live body mass (Kg) by seasons

SEASONS	Winter	Spring	Summer	Autumn
Body mass (Kg)	201.4^a	272.29^a	371.62^a	286.65^a

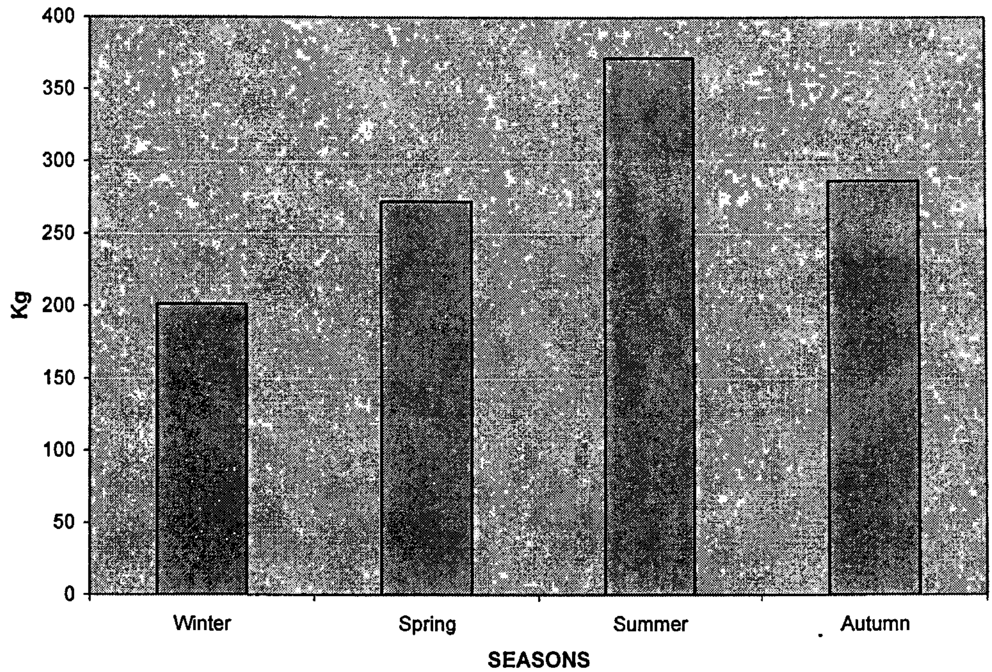
^{a,b} means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 48. Mean live body mass (Kg) by seasons



The body masses of the animals sampled by seasons increased from winter to summer, and declined in autumn. Even though there were no significant differences of the masses recorded at sampling among the seasons the masses recorded in summer were higher (371.62 Kg) than the ones recorded during the other three seasons. The masses recorded in winter were very low (201.4 Kg). There was again a live mass loss between summer and autumn (Table 25 and Figures 48 and 49).

Figure 49. Mean live body mass (Kg) by seasons



The results found here are in agreement with McDowell et al. (1983) who said that livestock gain weight rapidly during the wet season since energy and protein supplies are adequate and thus the mineral requirements are high, while during the dry season inadequate protein and energy result in animals losing weight, which lowers mineral requirements. Holroyd et al. (1983) also showed that weight gains had been recorded during the wet and early part of dry seasons and weight loss during the latter half of the dry season, and in their 1983 article, they reported that non-supplemented cows lost significantly more weight than the ones supplemented during the final dry season, while Preston and Pfander's (1964) observations indicated that live mass gains were increased by a higher intake of P than is required for the maintenance of normal levels of inorganic P in the blood.

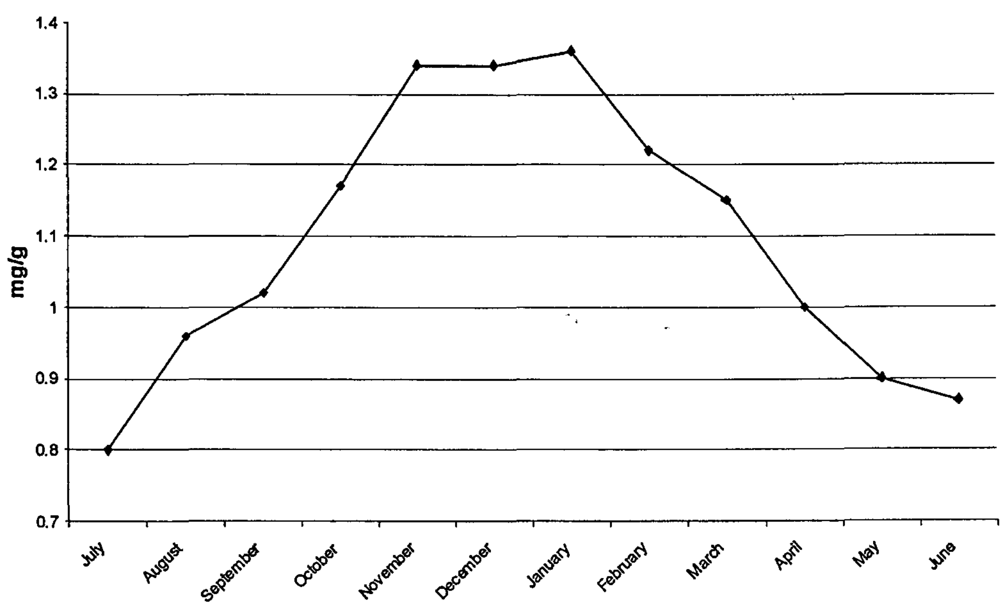
6.4 Grass samples

6.4.1 Mean grass phosphorus concentration by months

Table 26. Mean grass P concentration by months (mg/g, fresh weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Grass P (mg/g, fw)	0.8	0.96	1.02	1.17	1.34	1.34	1.36	1.22	1.15	1	0.90	0.

Figure 50. Mean grass P concentration by months (mg/g, fresh weight)



The grass P concentration (mg/g) by months measured on a fresh weight basis is shown in Table 26 and illustrated in Figures 50 and 51. The mean concentration increased from July until January, and declined from January until June. July month had the lowest grass P concentration (0.80 mg/g) and January had the highest value (1.36 mg/g).

Figure 51. Mean grass P concentration by months (mg/g, fresh weight)

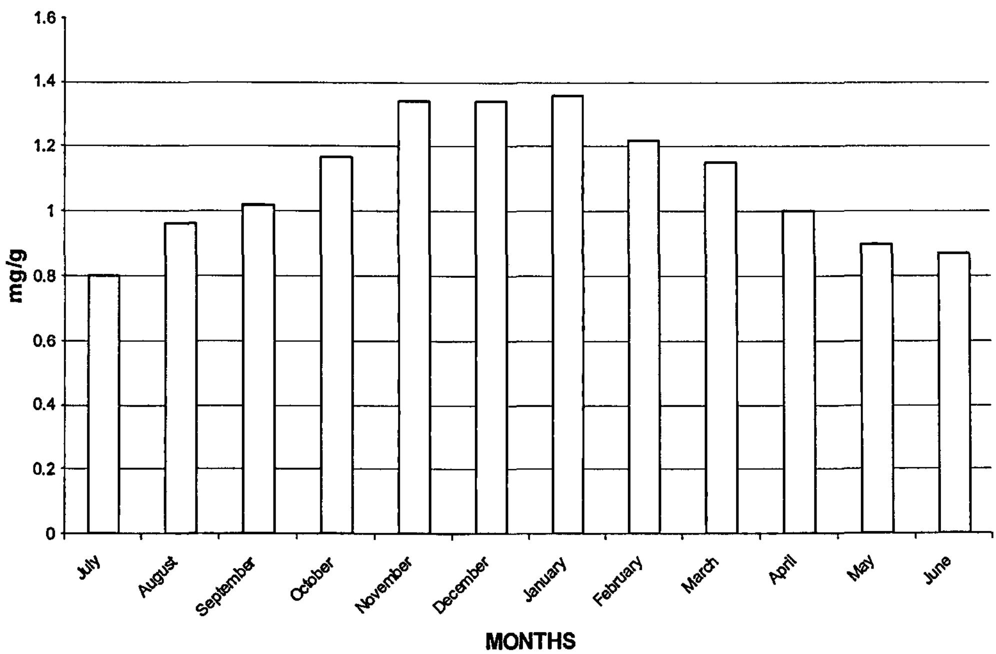
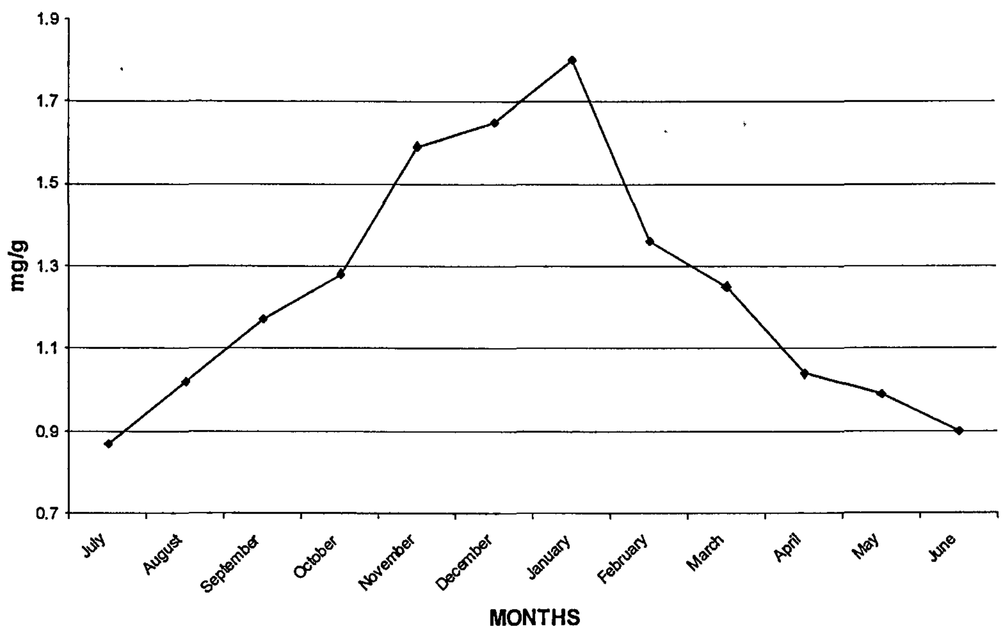


Table 27. Mean grass P concentration by months (mg/g, dry weight)

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	J
Grass P (mg/g, dw)	0.87	1.02	1.17	1.28	1.59	1.65	1.80	1.36	1.25	1.04	0.99	(

Figure 52. Mean grass P concentration by months (mg/g, dry weight)



The grass P concentration (mg/g) by months measured on a dry weight basis is shown in Table 27 and illustrated in Figures 52 and 53. The concentration increased from July until January, and declined from January until June. July month had the lowest grass P concentration (0.87 mg/g) and January had the highest value (1.80 mg/g).

Figure 53. Mean grass P concentration by months (mg/g, dry weight)

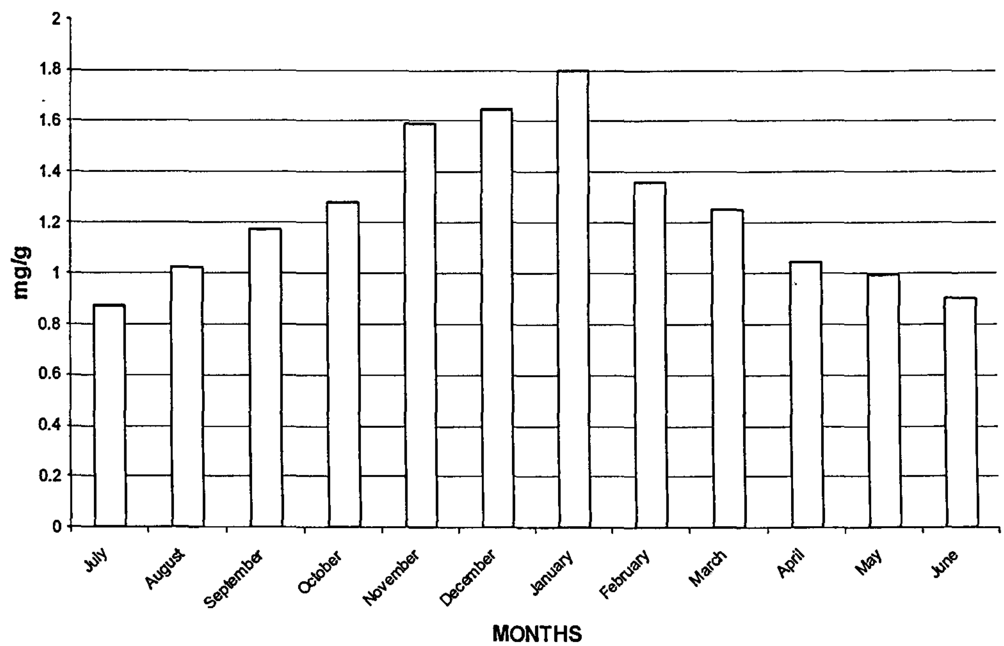
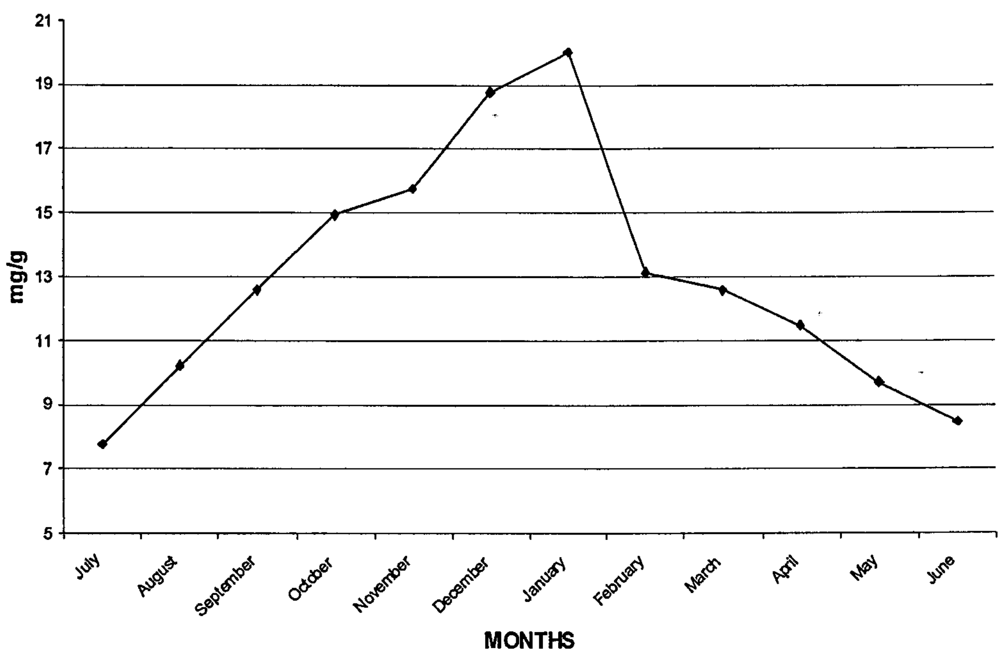


Table 28. Mean grass P concentration by months (mg/g, ash weight)

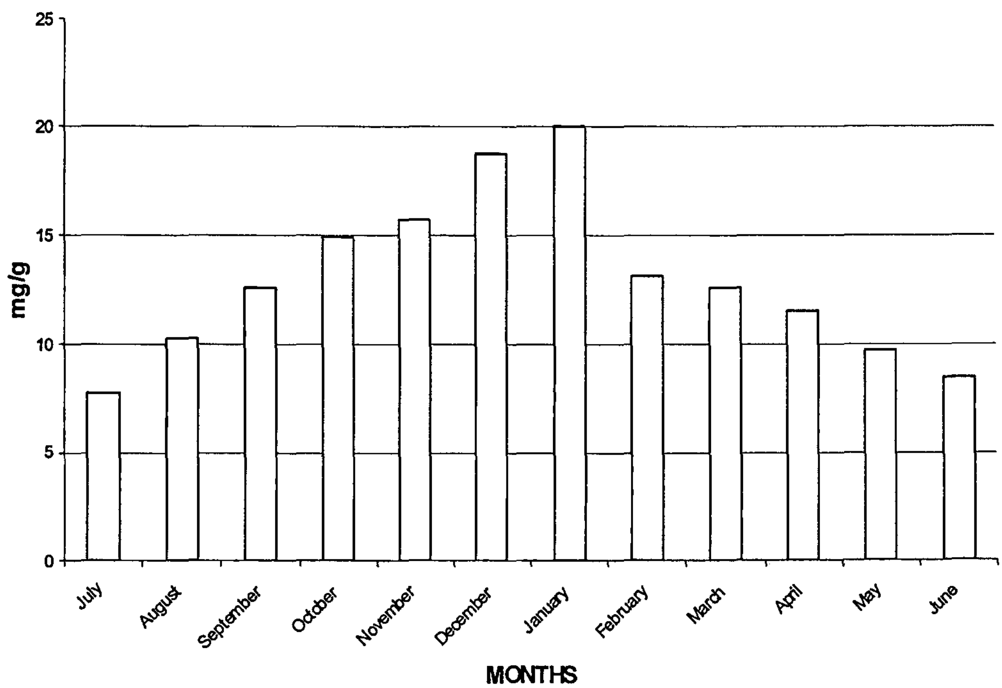
MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Grass P (mg/g, aw)	7.76	10.21	12.57	14.93	15.75	18.77	20.01	13.14	12.57	11.47	9.69	8.

Figure 54. Mean grass P concentration by months (mg/g, ash weight)



The grass P concentration (mg/g) by months measured on an ash weight basis increased from July until January, and declined from January until June. July month had the lowest grass P concentration (7.76 mg/g) and January had the highest value (20.01 mg/g) (Table 28 and Figures 54 and 55)

Figure 55. Mean grass P concentration by months (mg/g, ash weight)

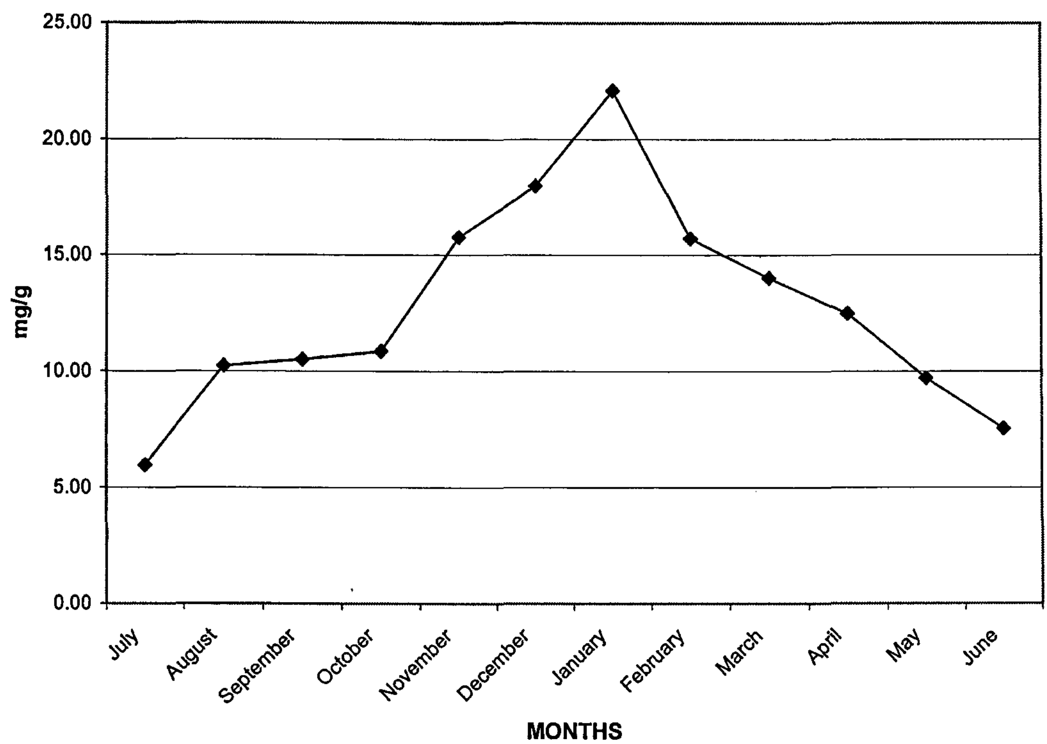


6.4.2 Mean grass Ca concentration by months

Table 29. Mean grass Ca concentration by months (mg/g, fresh weight)

MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Grass Ca (mg/g, fw)	5.96	10.22	10.50	10.85	15.76	17.98	22.09	15.71	14.01	12.47	9.70	7..

Figure 56. Grass Ca concentration by months (mg/g, fresh weight)



The grass Ca concentration (mg/g) by months measured on a fresh weight basis is shown in Table 29 and illustrated in Figures 56 and 57. The mean concentration increased from July until January, and declined from January until June. July month had the lowest grass Ca concentration (5.96 mg/g) and January had the highest value (22.09 mg/g).

Figure 57. Mean grass Ca concentration by months (mg/g, fresh weight)

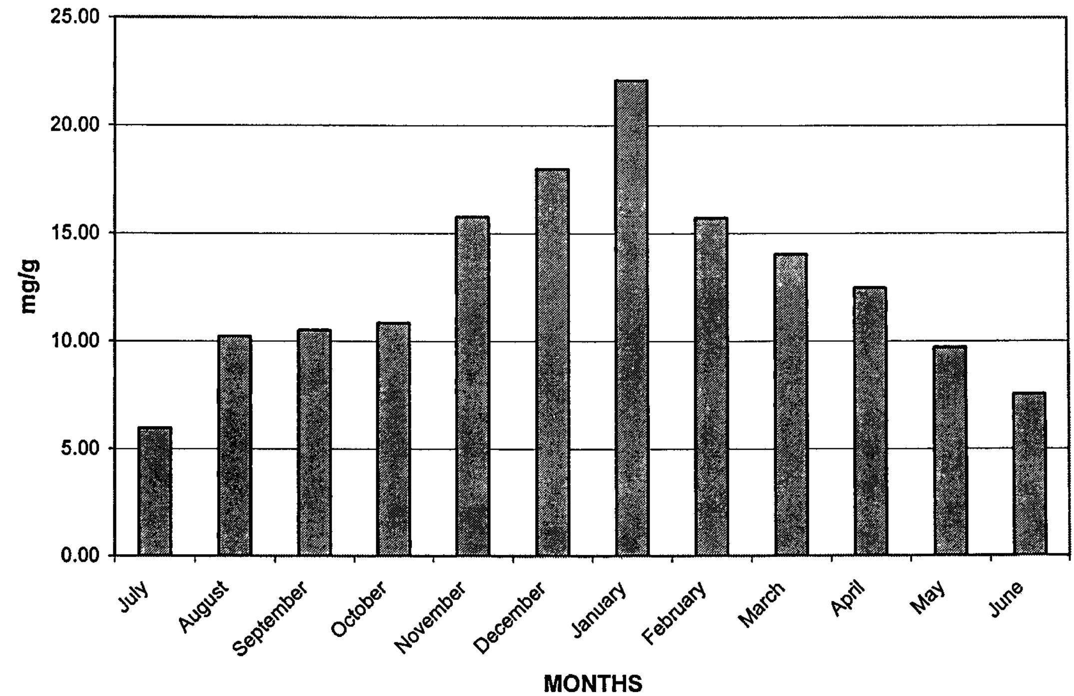
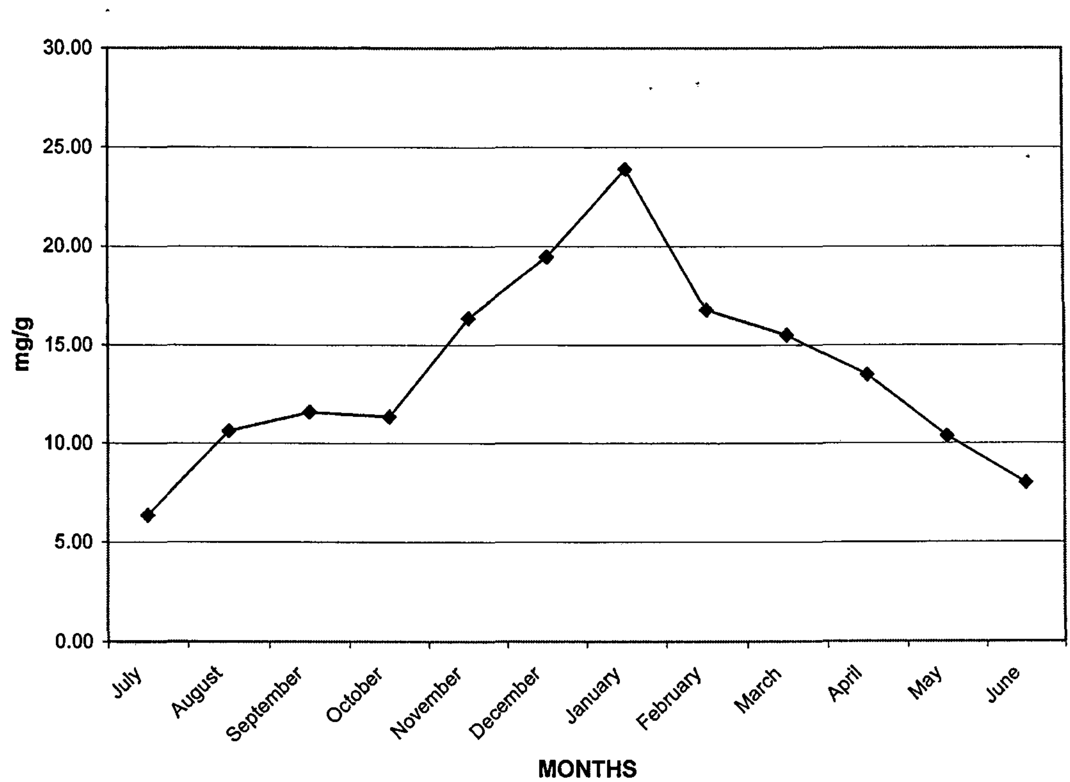


Table 30. Mean grass Ca concentration by months (mg/g, dry weight)

MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	J
Grass Ca (mg/g, fw)	6.36	10.61	11.58	11.34	16.33	19.45	23.89	16.76	15.49	13.48	10.36	8

Figure 58. Mean grass Ca concentration by months (mg/g, dry weight)



The grass Ca concentration (mg/g) by months measured on a dry weight basis is shown in Table 30 and illustrated in Figures 58 and 59. The mean concentration increased from July until January, and declined from January until June. July month had the lowest grass Ca concentration (6.36 mg/g) and January had the highest value (23.89 g/g)

Figure 59. Mean grass Ca concentration by months (mg/g, dry weight)

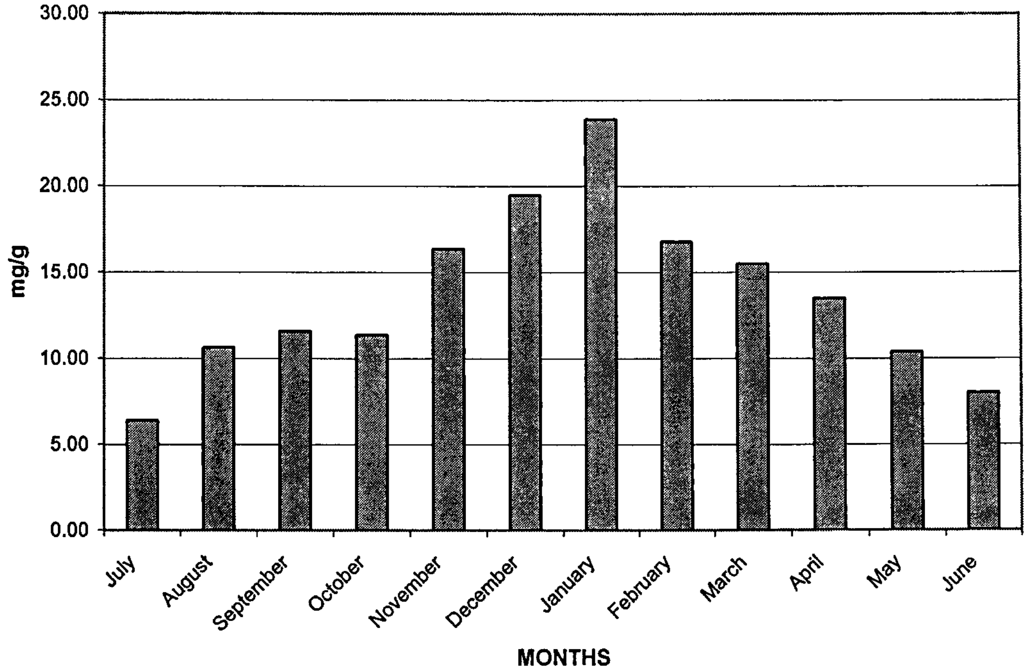
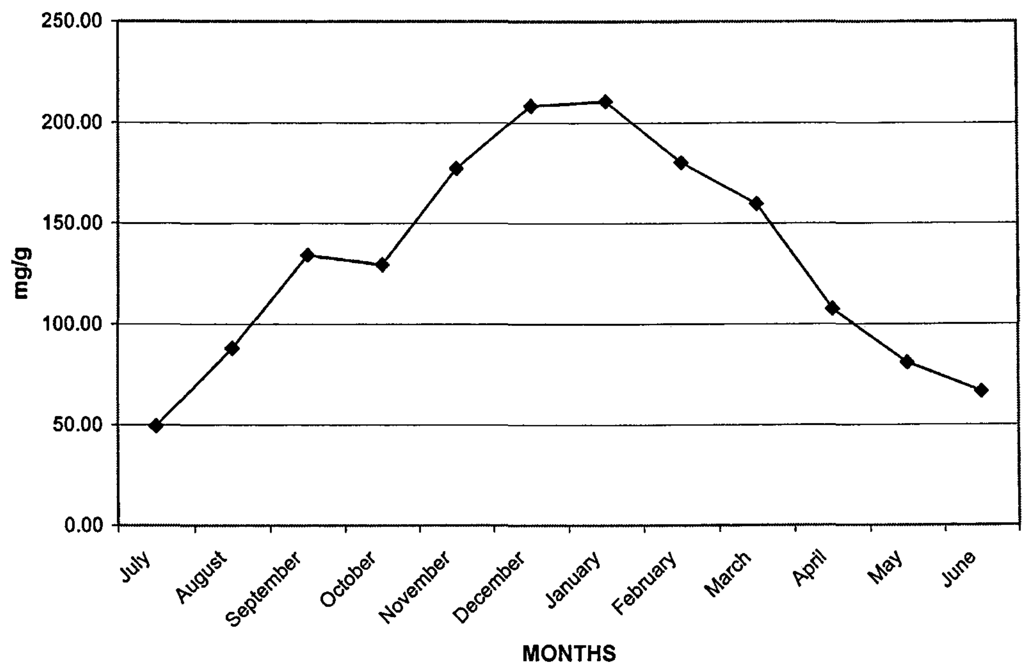


Table 31. Mean grass Ca concentration by months (mg/g, ash weight)

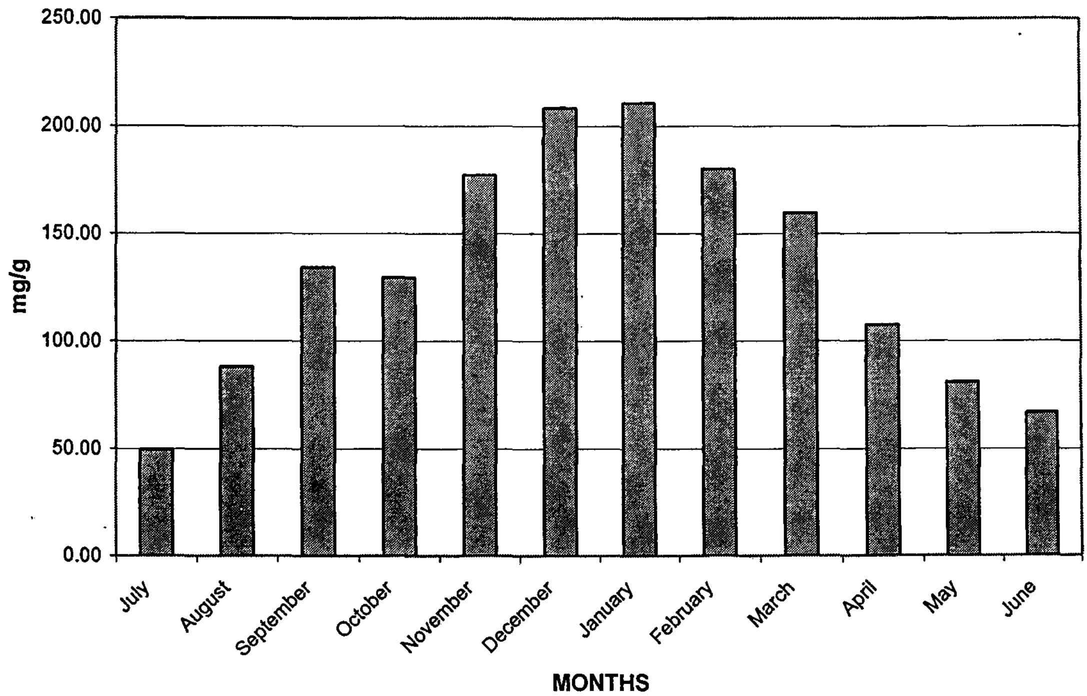
MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Grass Ca (mg/g, aw)	49.87	88.02	134.09	129.39	177.08	208.34	210.59	180.05	159.52	107.38	80.90	66

Figure 60. Mean grass Ca concentration by months (mg/g, ash weight)



The grass Ca concentration (mg/g) by months measured on a fresh weight basis increased from July until January, and declined from February until June. July month had the lowest grass Ca concentration (49.87 mg/g) and January had the highest value (210.59 mg/g) (Table 31 and Figures 60 and 61).

Figure 61. Mean grass Ca concentration by months (mg/g, ash weight)



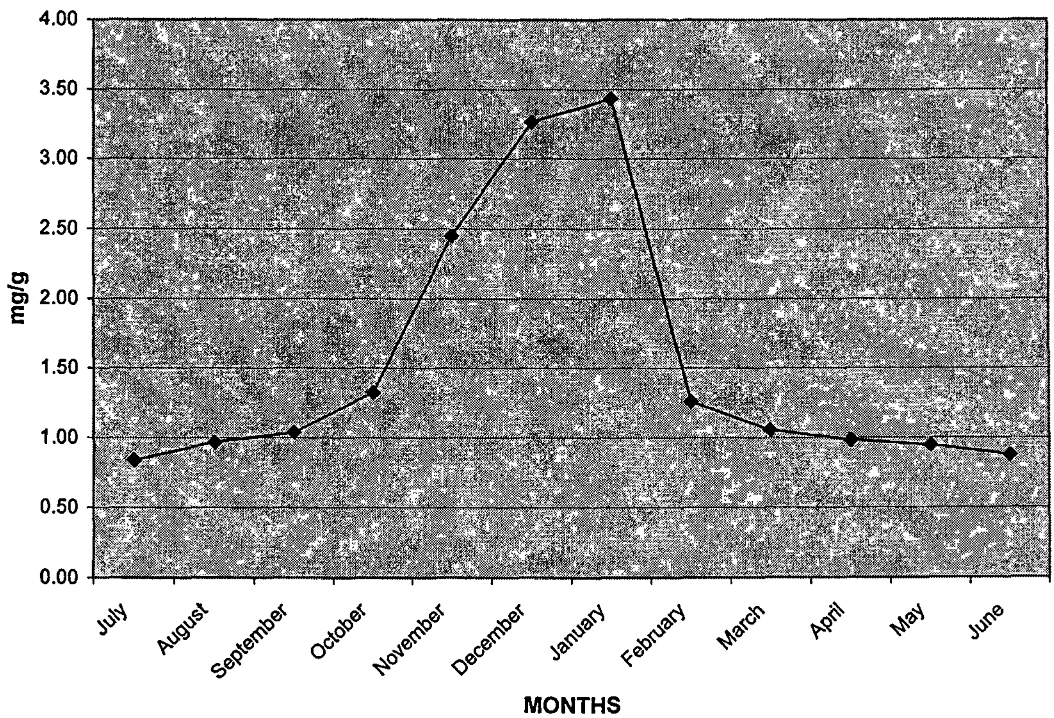
The mean concentration of Ca in the grass showed a very similar pattern to the one in P when plotted against months (Figures 52 and 58) with the highest mineral concentration being seen in the rainy season during the summer months and its lowest being seen in the dry season during the winter months.

6.4.3 Mean grass Mg concentration by months

Table 32. Mean grass Mg concentration by months (mg/g, fresh weight)

MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Grass Mg (mg/g, fw)	0.84	0.97	1.04	1.32	2.45	3.26	3.43	1.26	1.05	0.98	0.95	0.8

Figure 62. Mean grass Mg concentration by months (mg/g, fresh weight)



The grass Mg concentration (mg/g) by months measured on a fresh weight basis increased from July until January, and declined from January until June. July month had the lowest grass Mg concentration (0.84 mg/g) and January had the highest value (3.43 mg/g) (Table 32 and Figures 62 and 63).

Figure 63. Mean grass Mg concentration by months (mg/g, fresh weight)

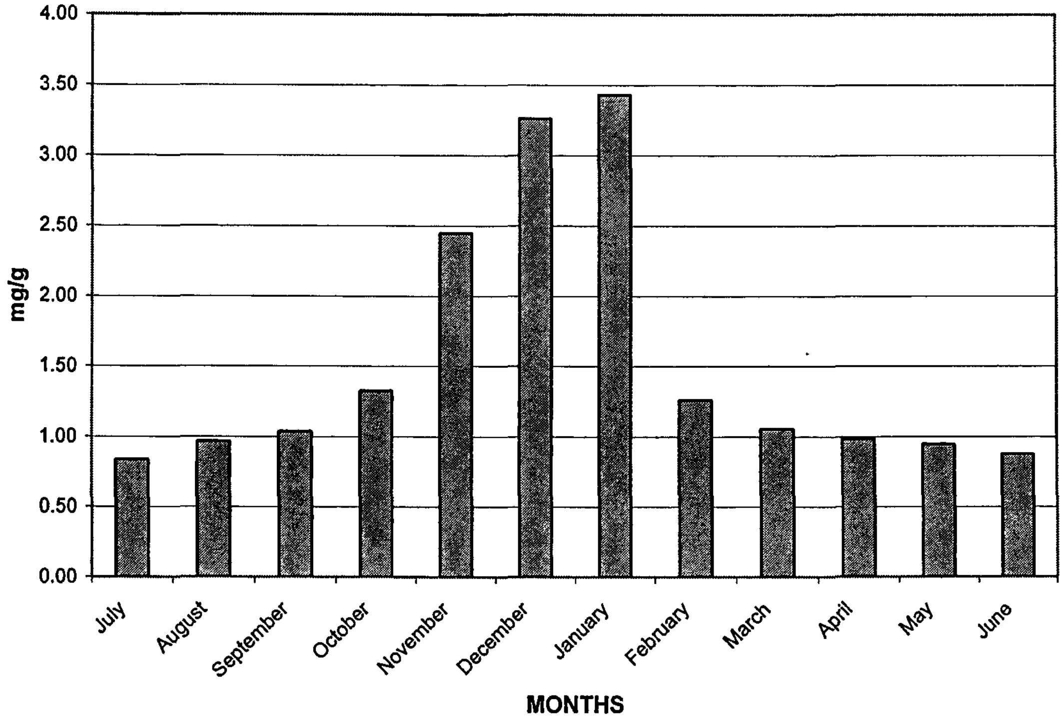
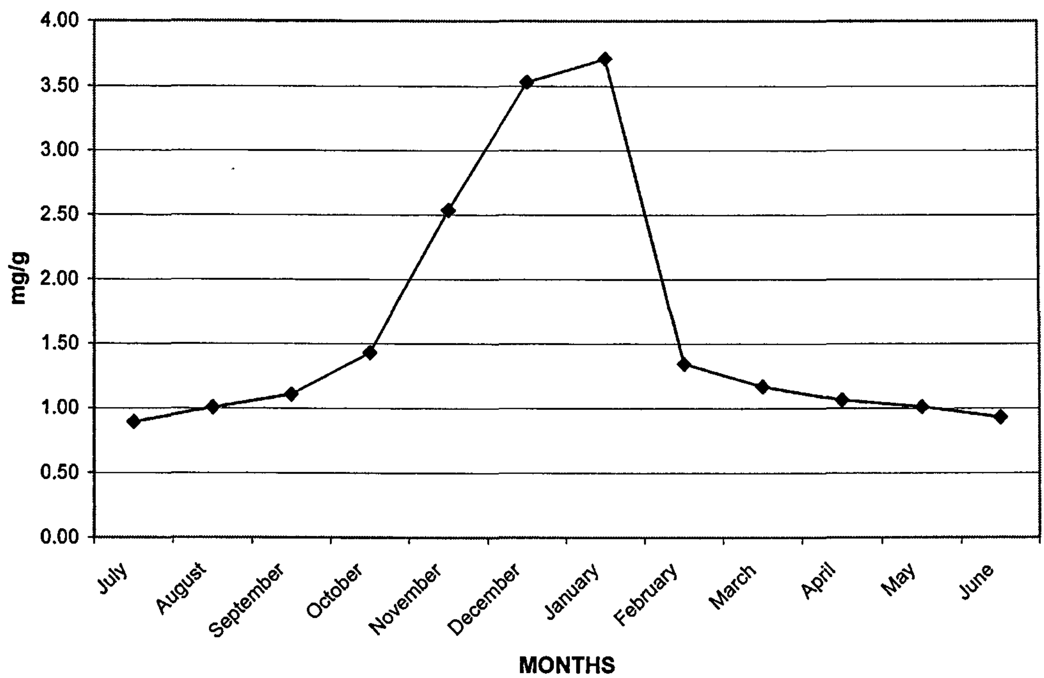


Table 33. Mean grass Mg concentration by months (mg/g, dry weight)

MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Grass Mg (mg/g, dw)	0.89	1.00	1.11	1.43	2.54	3.53	3.71	1.34	1.17	1.06	1.01	0.

Figure 64. Mean grass Mg concentration by months (mg/g, dry weight)



The grass Mg concentration (mg/g) by months measured on a dry weight basis is shown in Table 33 and illustrated in Figures 64 and 65. The concentration increased from July until January, and declined from January until June. July month had the lowest grass Mg concentration (0.89 mg/g) and January had the highest value (3.71 mg/g).

Figure 65. Mean grass Mg concentration by months (mg/g, dry weight)

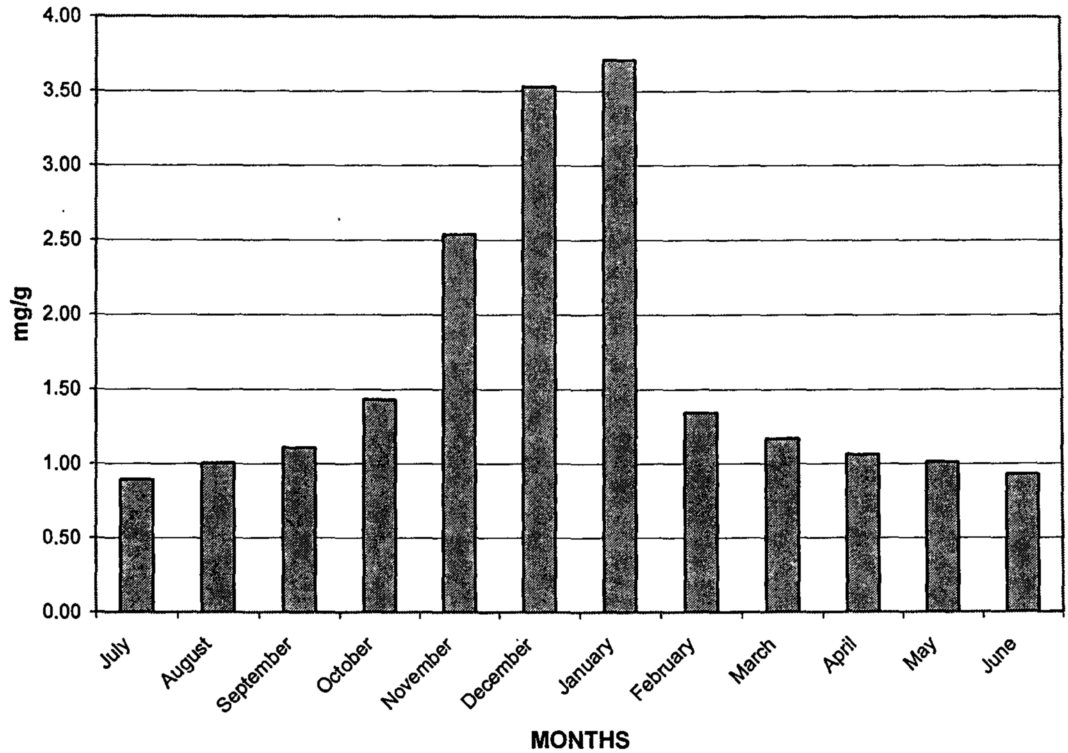
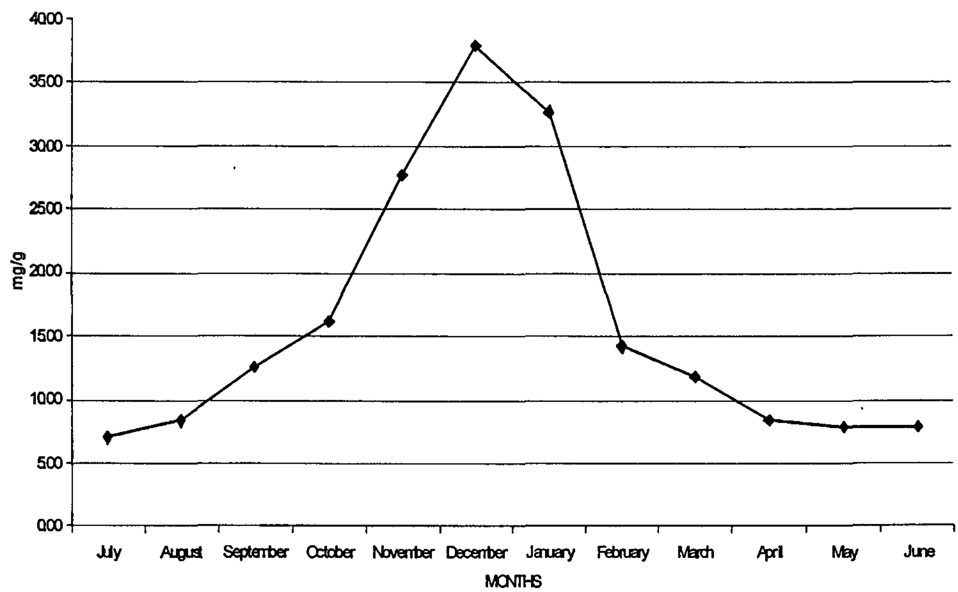


Table 34. Mean grass Mg concentration by months (mg/g, ash weight)

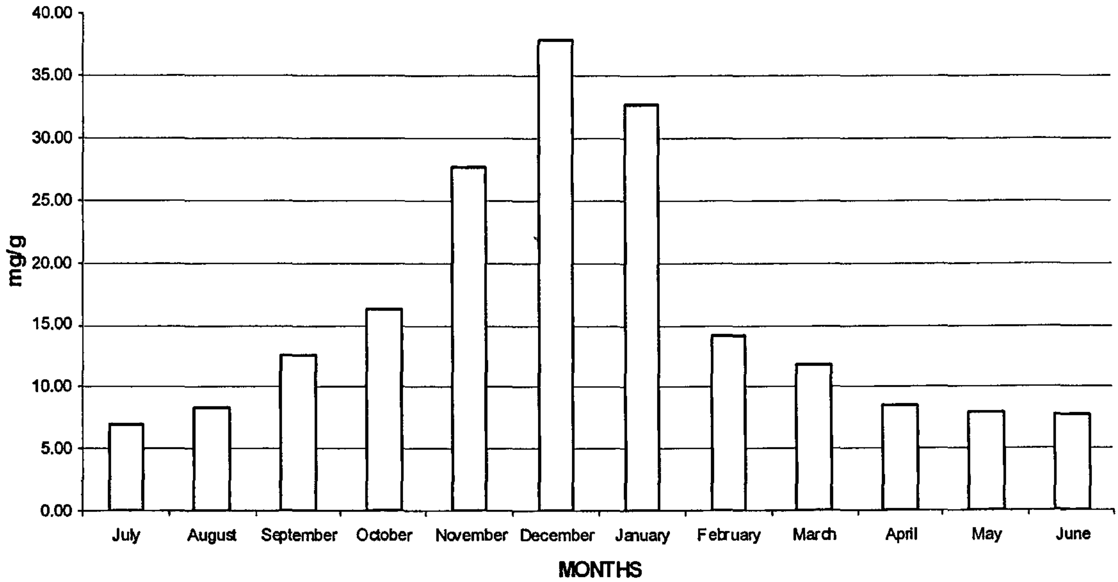
MONTHS	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	Jun
Grass Mg (mg/g, aw)	6.98	8.33	12.59	16.19	27.66	32.68	37.91	14.18	11.80	8.44	7.86	7.7

Figure 67 Grass Mg concentration by months (mg/g, ash weight)



The grass Mg concentration (mg/g) by months measured on an ash weight basis is shown in Table 34 and illustrated in Figures 66 and 67. The concentration increased from July until January, and declined from January until June. July month had the lowest grass Mg concentration (6.98 mg/g) and January had the highest value (37.91 mg/g).

Figure 67. Grass Mg concentration by months (mg/g, ash weight)



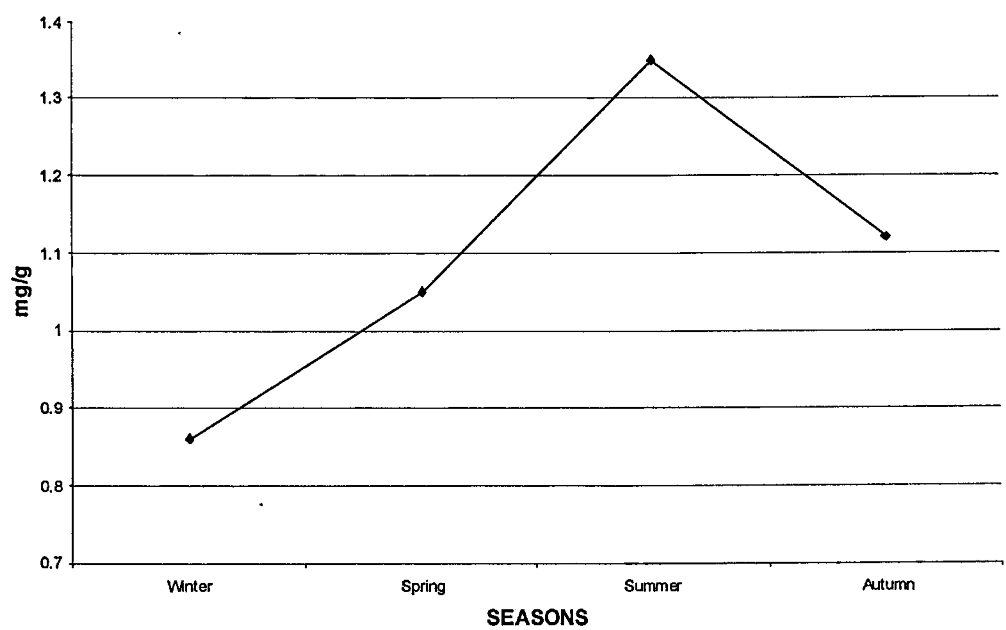
6.4.4 Mean grass P concentration by seasons

Table 35. Mean grass P concentration by seasons (mg/g, fresh weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass P (mg/g, Fw)	0.86[a]	1.05[b]	1.35[c]	1.12[b]

[a,b,c] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 68. Mean grass P concentration by seasons (mg/g, fresh weight)



The grass P concentration (mg/g) by seasons measured on a fresh weight basis is given in Table 35 and illustrated in Figures 68 and 69. The mean concentration increased from winter to summer, and declined in autumn. The winter season had the lowest value of 0.86 mg/g of grass P concentration and the concentration was significantly (P< 0.05) higher during summer than other seasons and the concentration was significantly (P< 0.05) higher in spring and autumn than in winter. The difference between the highest values and the lowest values was 0.49 mg/g of grass P concentration.

Figure 69. Mean grass P concentration by seasons (mg/g, fresh weight)

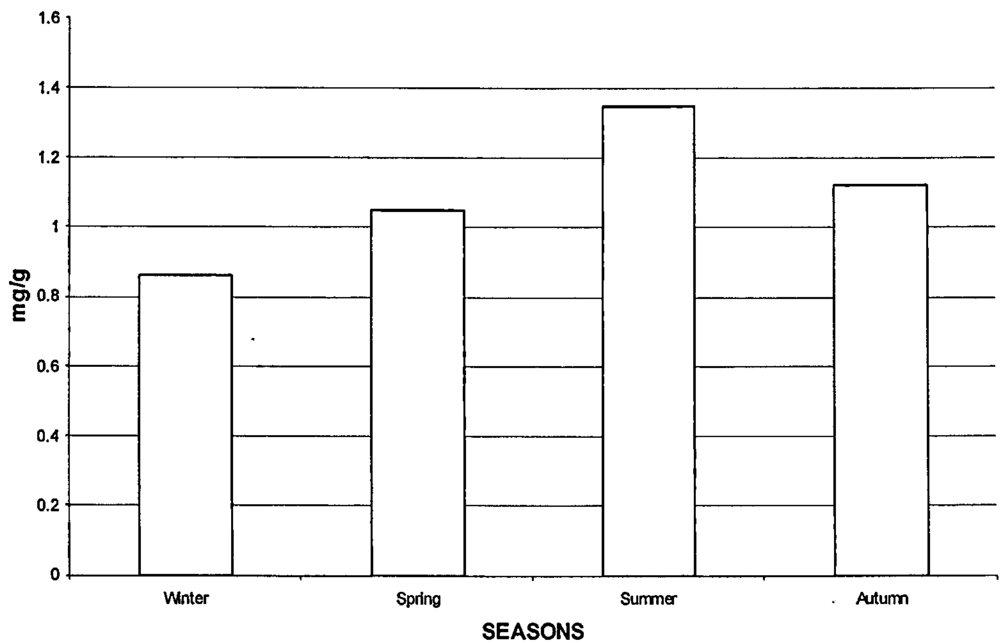
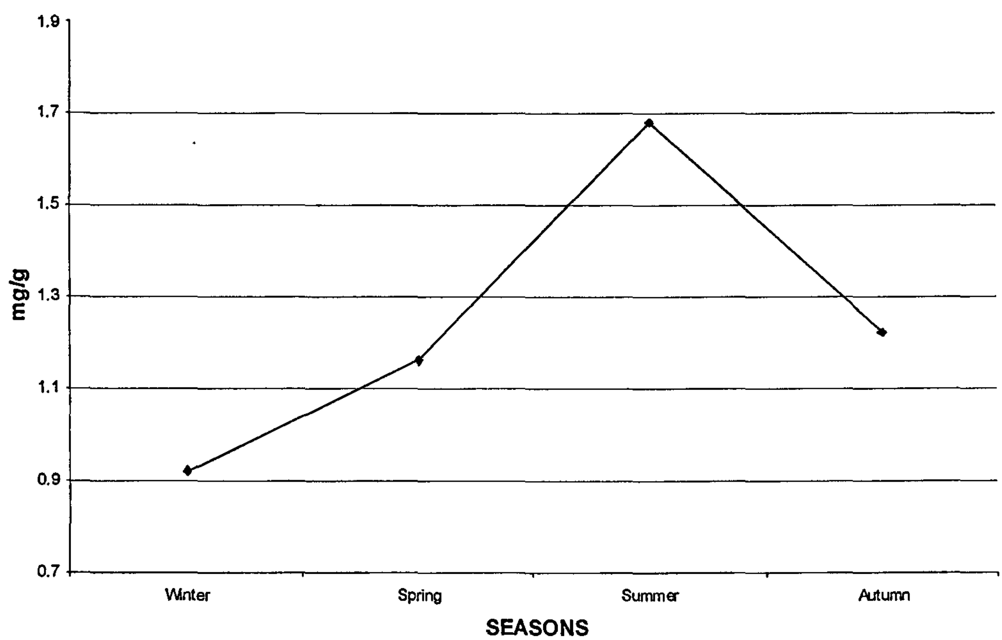


Table 36. Mean grass P concentration by seasons (mg/g, dry weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass P (mg/g, dw)	0.92[a]	1.16[a]	1.68[b]	1.22[a]

[a,b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 70. Mean grass P concentrarion by seasons (mg/g, dry weight)



The grass P concentration (mg/g) by seasons measured on a dry weight basis increased from winter to summer, and declined in autumn. The winter season had the lowest value of 0.92 mg/g of grass P concentration and the concentration was significantly ($P < 0.05$) higher during summer when compared with all other seasons. The difference between the highest values and the lowest values was 0.76 mg/g of grass P concentration (Table 36 and Figures 70 and 71).

Figure 71. Mean grass P concentration by seasons (mg/g, dry weight)

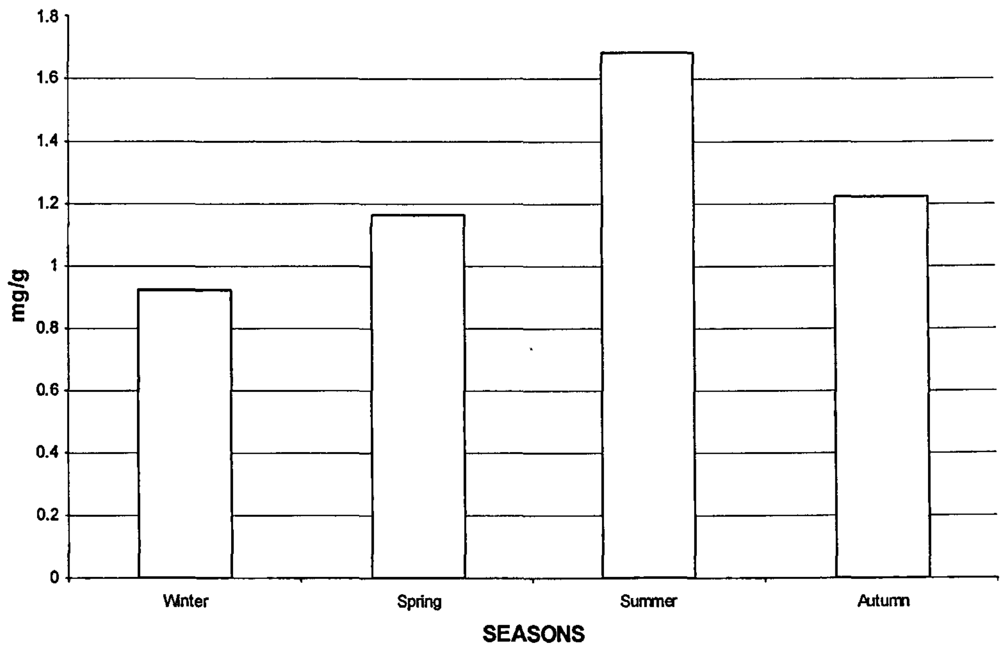
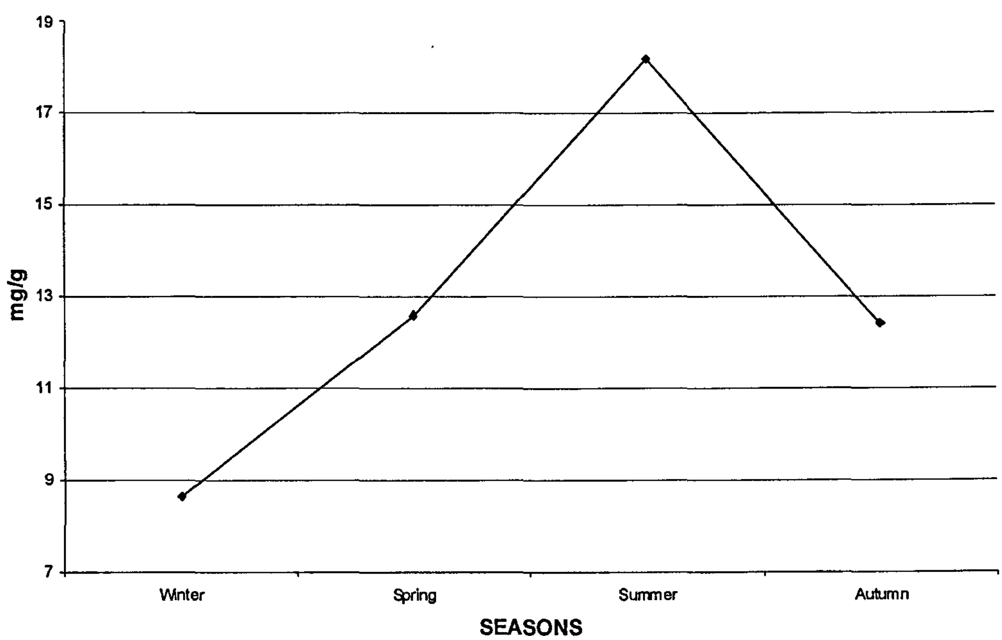


Table 37. Mean grass P concentration by seasons (mg/g, ash weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass P (mg/g, aw)	8.63[a]	12.57[b]	18.17[c]	12.39[b]

[a,b,c] means with the same letter in a row are not significantly ($P< 0.05$) different between the seasons

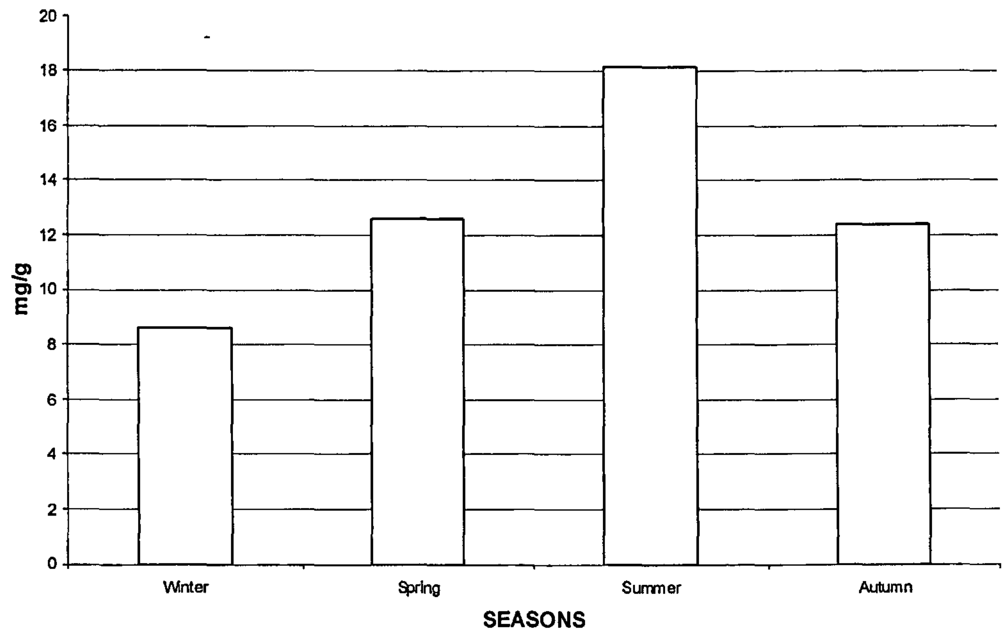
Figure 72. Mean grass P concentration by seasons (mg/g, ash weight)



The grass P concentration (mg/g) by seasons measured on an ash weight basis is given in Table 37 and illustrated in Figures 72 and 73. The concentration increased from winter to summer, and declined in autumn. The winter season had the lowest value of 8.63 mg/g of grass P concentration that was significantly ($P< 0.05$) lower than the values seen in the other three seasons. The concentration was significantly ($P< 0.05$) higher during summer compared with winter, spring and autumn, and significantly ($P< 0.05$) higher during spring and autumn than in winter.

The degree of difference between the highest values and the lowest values was 9.54 mg/g of grass P concentration.

Figure 73. Mean grass P concentration by seasons (mg/g, ash weight)



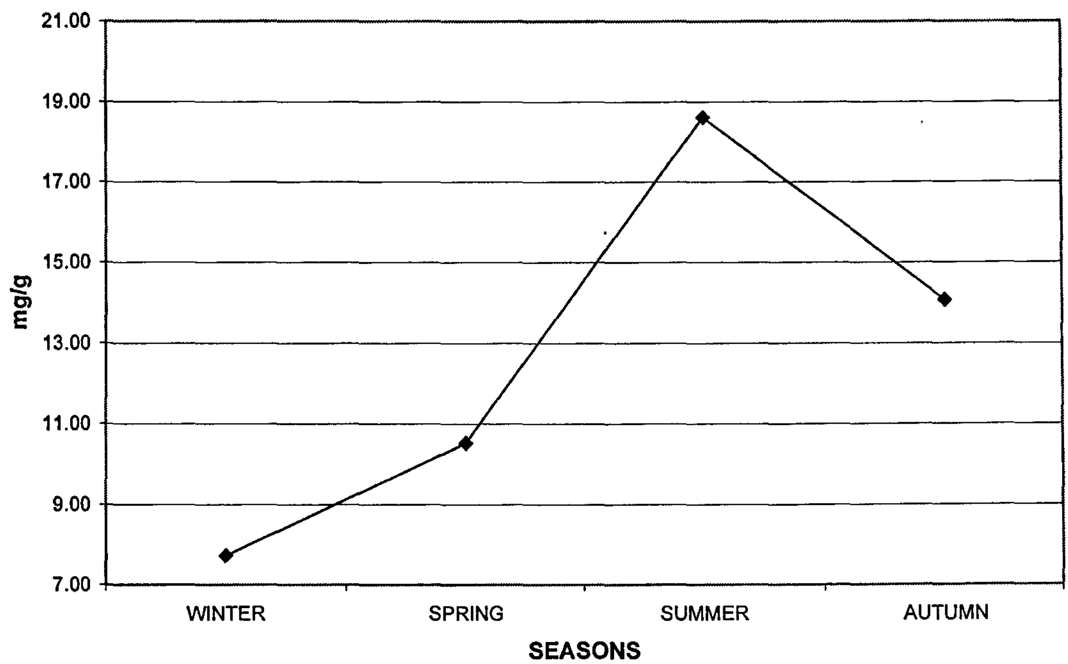
6.4.5 Mean grass Ca concentration by seasons

Table 38. Mean grass Ca concentration by seasons (mg/g, fresh weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass Ca (mg/g, fw)	7.73[a]	10.52[a]	18.61[a]	14.06[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 74. Mean grass Ca concentration by seasons (mg/g, fresh weight)



The grass Ca concentration (mg/g) by seasons measured on a fresh weight basis increased from winter to summer, and declined in autumn. The winter season had the lowest value of 7.73 mg/g of grass Ca and although there were no significant differences in concentrations among the seasons, summer had the highest value of 18.61 mg/g of grass Ca.

The difference between the highest values and the lowest values was 10.88 mg/g of grass Ca (Table 38 and Figures 74 and 75).

Figure 75. Mean grass Ca concentration by seasons (mg/g, fresh weight)

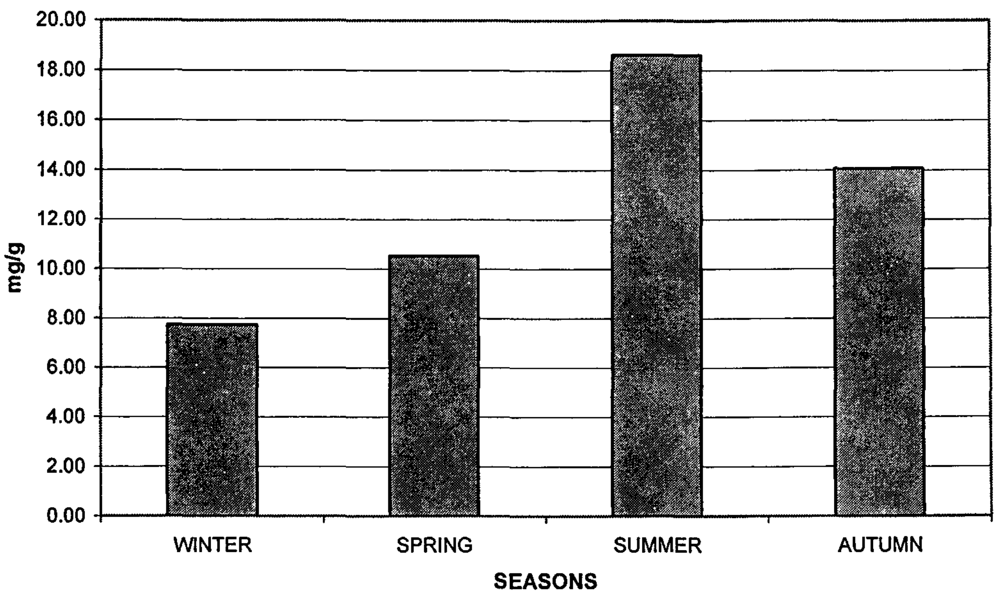
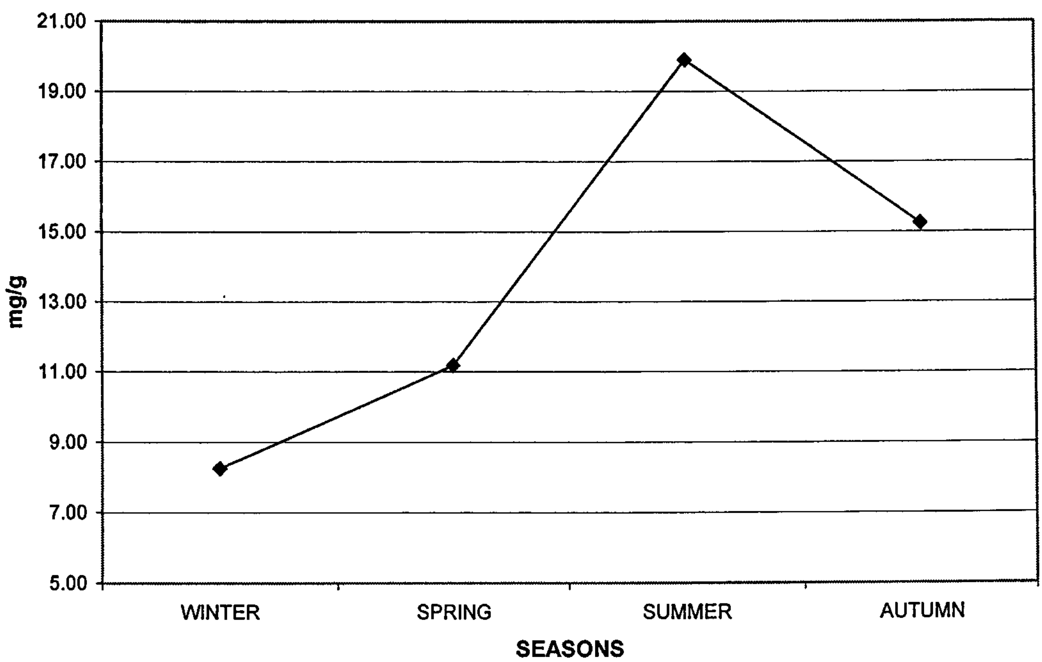


Table 39. Mean grass Ca concentration by seasons (mg/g, dry weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass Ca (mg/g, dw)	8.24[a]	11.18[a]	19.89[a]	15.24[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 76. Mean grass Ca concentration by seasons (mg/g, dry weight)



The grass Ca concentration (mg/g) by seasons measured on a dry weight basis is given in Table 39 and illustrated in Figures 76 and 77. The concentration increased from winter to summer, and declined in autumn. The winter season had the lowest value of 8.24 mg/g of grass Ca and summer had the highest value of 19.89 mg/g of grass Ca. The difference between the highest values and the lowest values was 11.65 mg/g of grass Ca.

Figure 77. Mean grass Ca concentration by seasons (mg/g, dry weight)

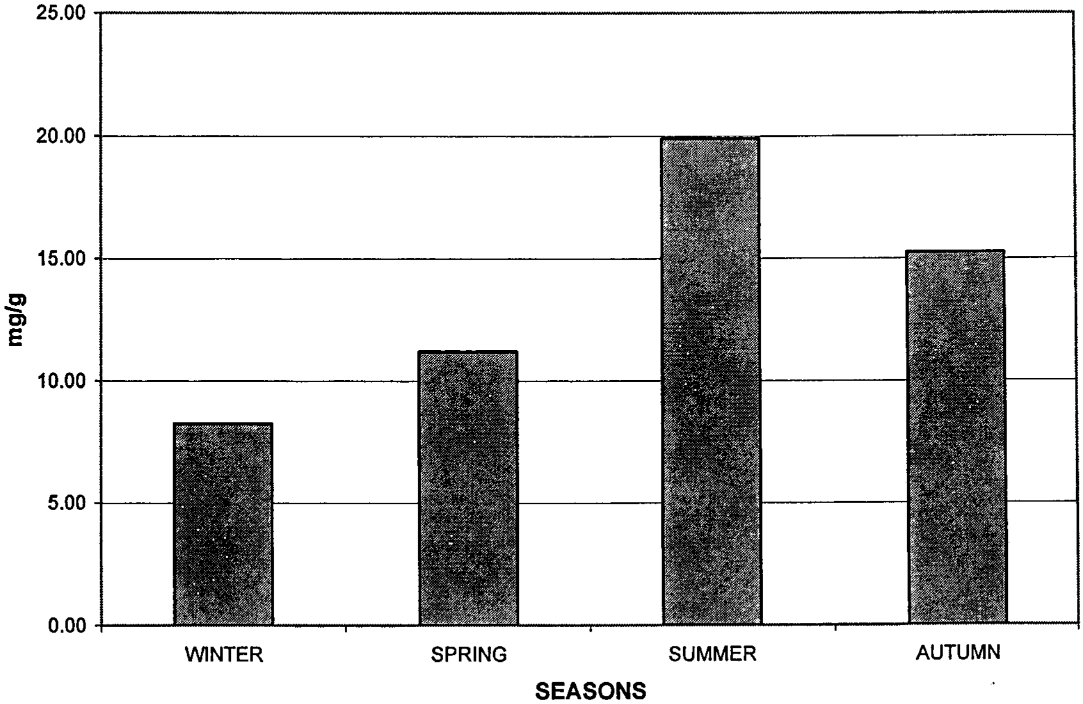
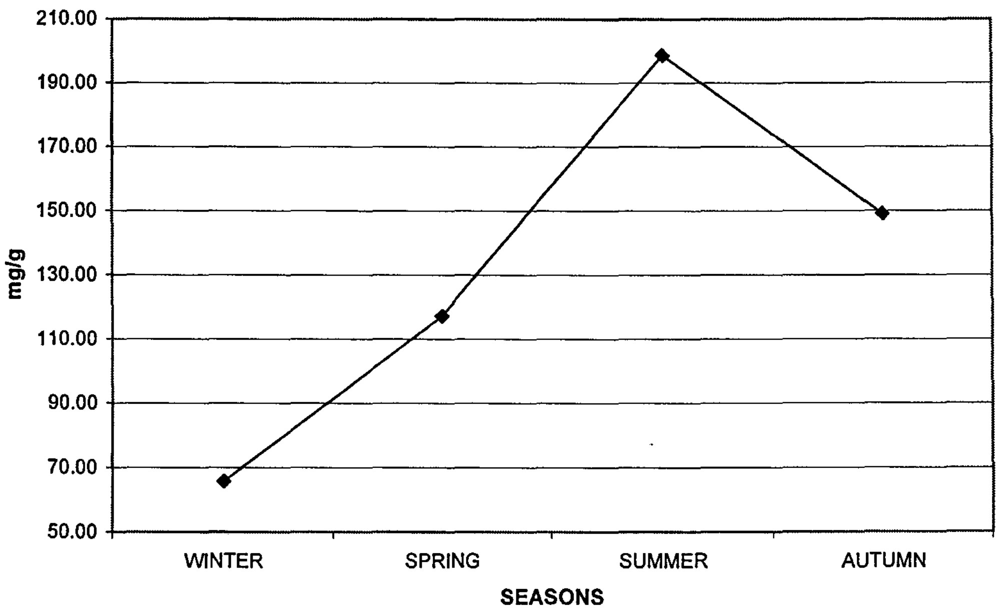


Table 40. Mean grass Ca concentration by seasons (mg/g, ash weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass Ca (mg/g, aw)	65.66[a]	117.16[a]	198.67[a]	148.98[a]

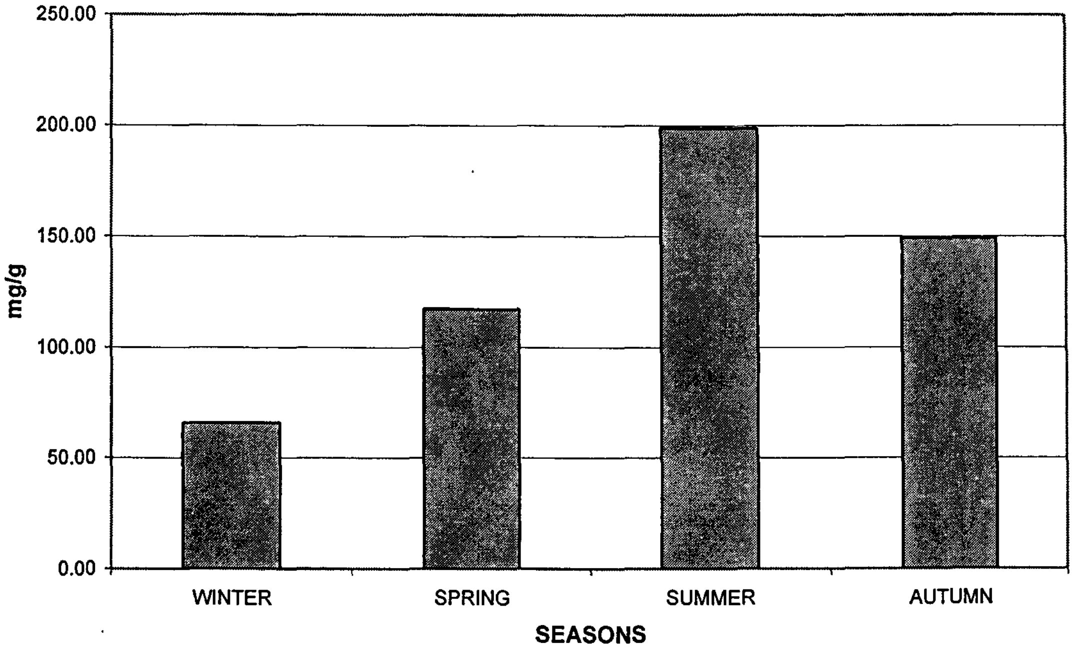
[a,b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 78. Mean grass Ca concentration by seasons (mg/g, ash weight)



The grass Ca concentration (mg/g) by seasons measured on an ash weight basis increased from winter to summer, and declined in autumn. The winter season had the lowest value of 65.66 Mg/g of grass Ca and summer had the highest value of 198.67 mg/g of grass Ca. The difference between the highest values and the lowest values was 133.01 mg/g of grass Ca (Table 40 and Figures 78 and 79).

Figure 79. Grass Ca concentration by seasons (mg/g, ash weight)



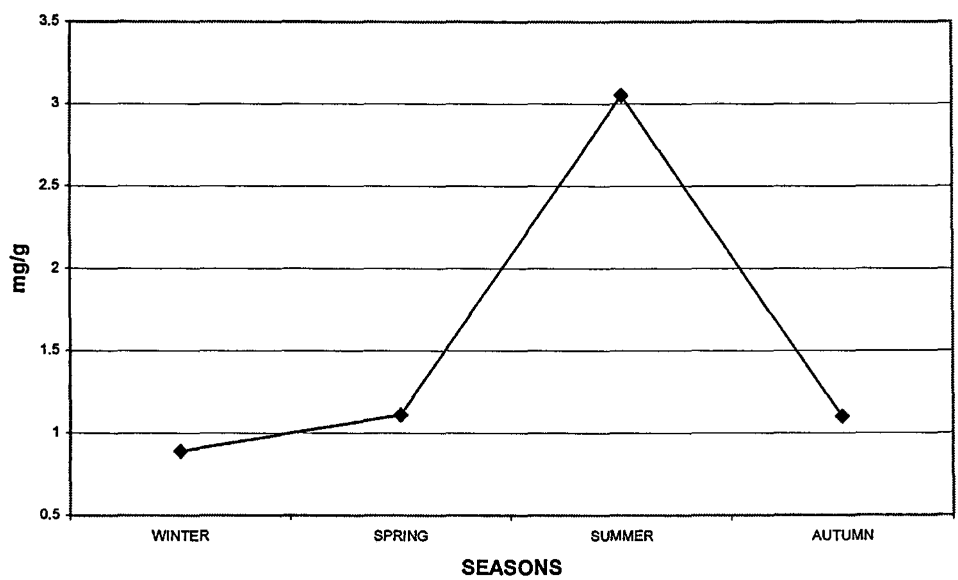
6.4.6 Mean grass Mg concentration by seasons

Table 41. Grass Mg concentration by seasons (mg/g, fresh weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass Mg (mg/g, fw)	0.89[a]	1.11[a]	3.05[b]	1.1[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 80. Mean grass Mg concentration by seasons (mg/g, fresh weight)



The grass Mg concentration (mg/g) by seasons measured on a fresh weight basis is given in Table 41 and Illustrated in Figures 80 and 81. The mean concentration increased from winter to summer, and declined in autumn. The winter season had the lowest value of 0.89 mg/g of grass Mg and was significantly (P< 0.05) higher during summer compared with that in the other seasons. The difference between the highest values and the lowest values was 2.16 mg/g of grass Mg.

Figure 81. Mean grass Mg concentration by seasons (mg/g, fresh weight)

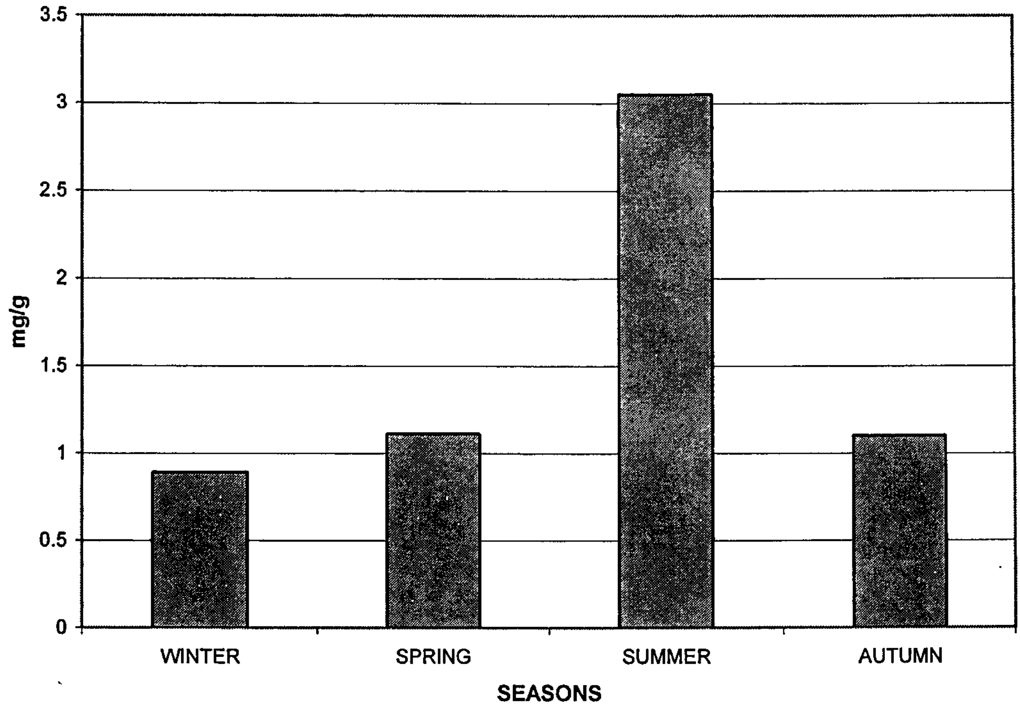
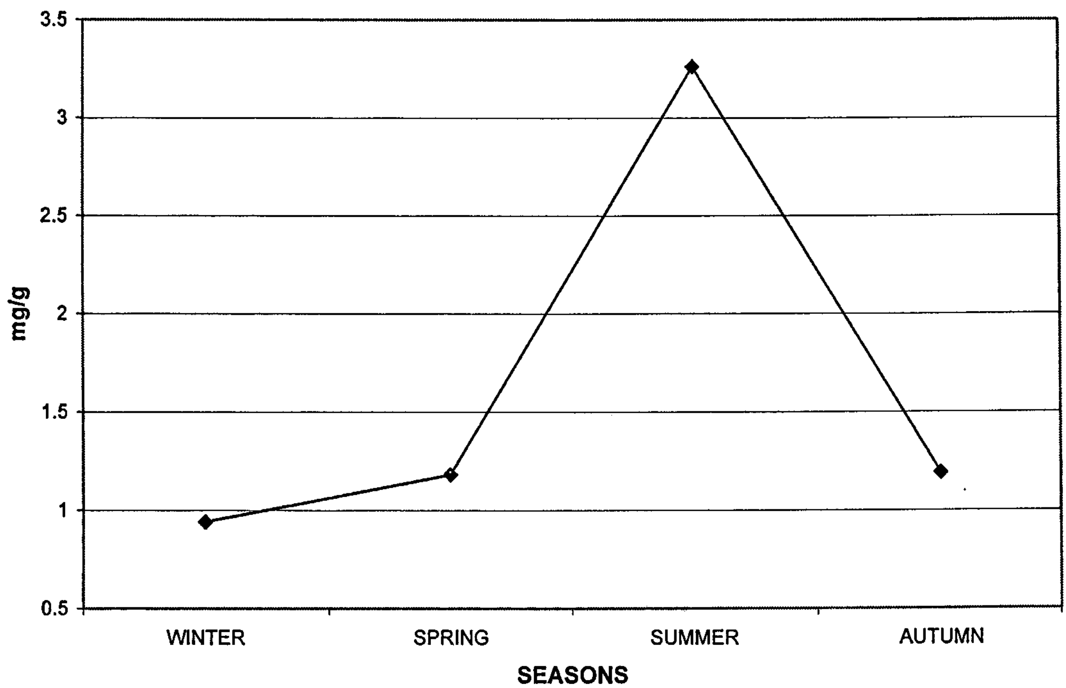


Table 42. Mean grass Mg concentration by seasons (mg/g, dry weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass Mg (mg/g, dw)	0.94[a]	1.18[a]	3.26[b]	1.19[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 82. Mean grass Mg concentration by saesons (mg/g, dry weight)



The grass Mg concentration (mg/g) by seasons measured on a dry weight basis increased from winter to summer, and declined in autumn. The winter season had the lowest value of 0.94 mg/g of grass Mg and was significantly (P<0.05) higher in summer compared with the concentrations in other seasons. The difference between the highest values and the lowest values was 2.32 mg/g of grass Mg (Table 42 and Figures 82 and 83)

Figure 83. Mean grass Mg concentration by seasons (mg/g, dry weight)

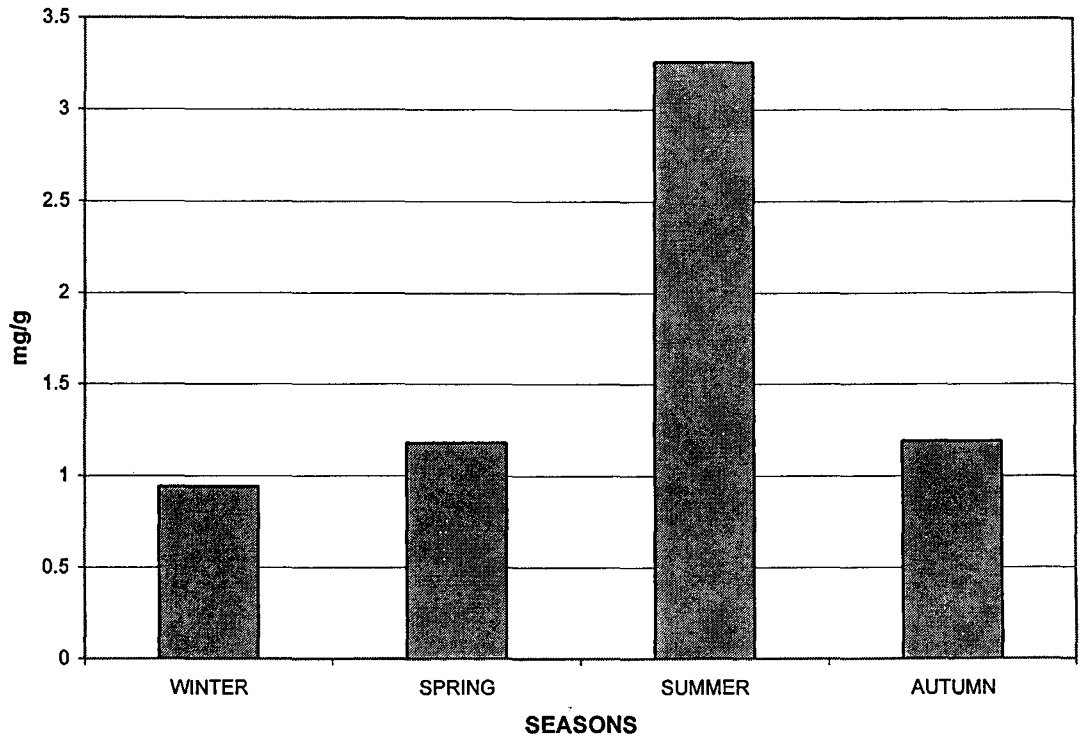
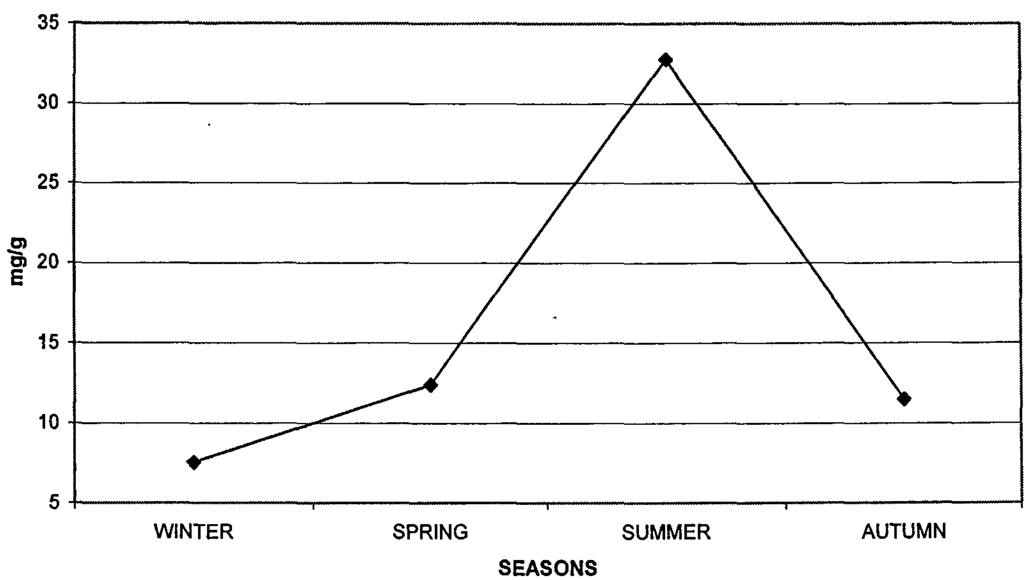


Table 43. Mean grass Mg concentration by seasons (mg/g, ash weight)

SEASONS	Winter	Spring	Summer	Autumn
Grass Mg (mg/g, ash)	7.54[a]	12.37[a]	32.75[b]	11.47[a]

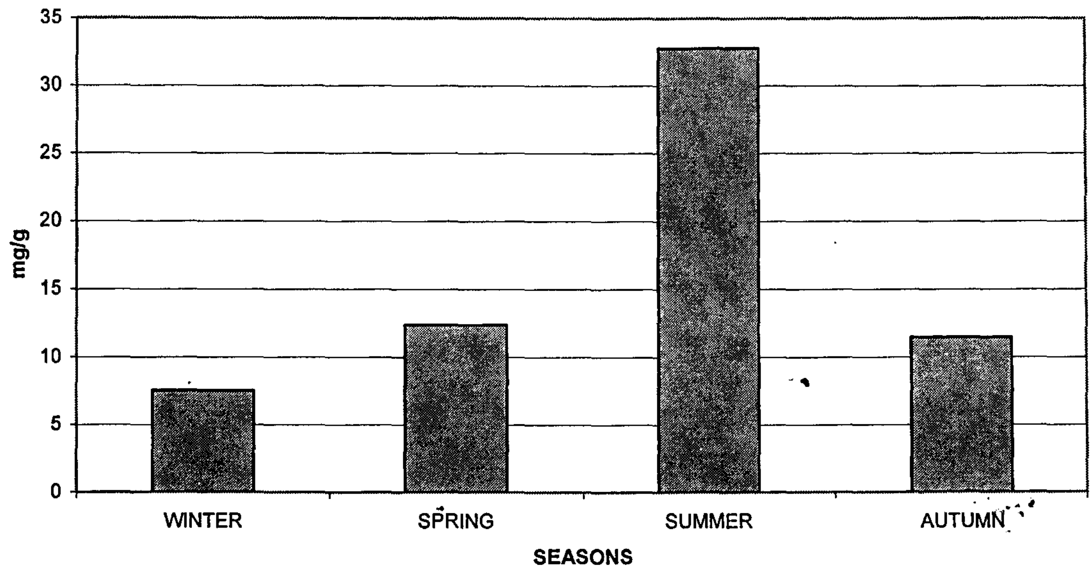
[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 84. Mean grass Mg concentration by seasons (mg/g, ash weight)



The grass Mg concentration (mg/g) by seasons measured on an ash weight basis is given in Table 43 and illustrated in Figures 84 and 85. The mean concentration increased from winter to summer, and declined in autumn. The winter season had the lowest value of 7.54 mg/g of grass Mg concentration and the concentration was significantly (P< 0.05) higher in summer compared with the concentrations in other seasons. The difference between the highest values and the lowest values was 25.21 mg/g of grass Mg.

Figure 85. Mean grass Mg concentration by seasons (mg/g, ash weight)



The grass samples had very low mineral contents during winter and these findings are in agreement with McDowell et al. (1983) in which they reported the same results.

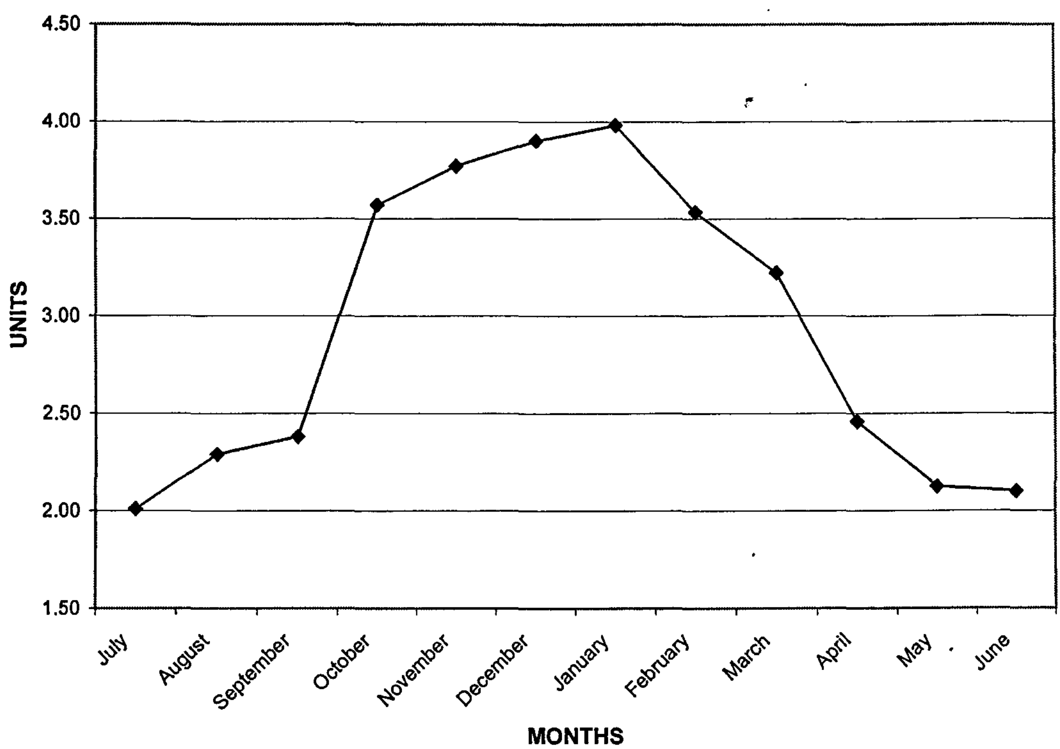
6.5 Condition score

6.5.1 Mean condition score recorded by months

Table 44. Mean condition score recorded by months

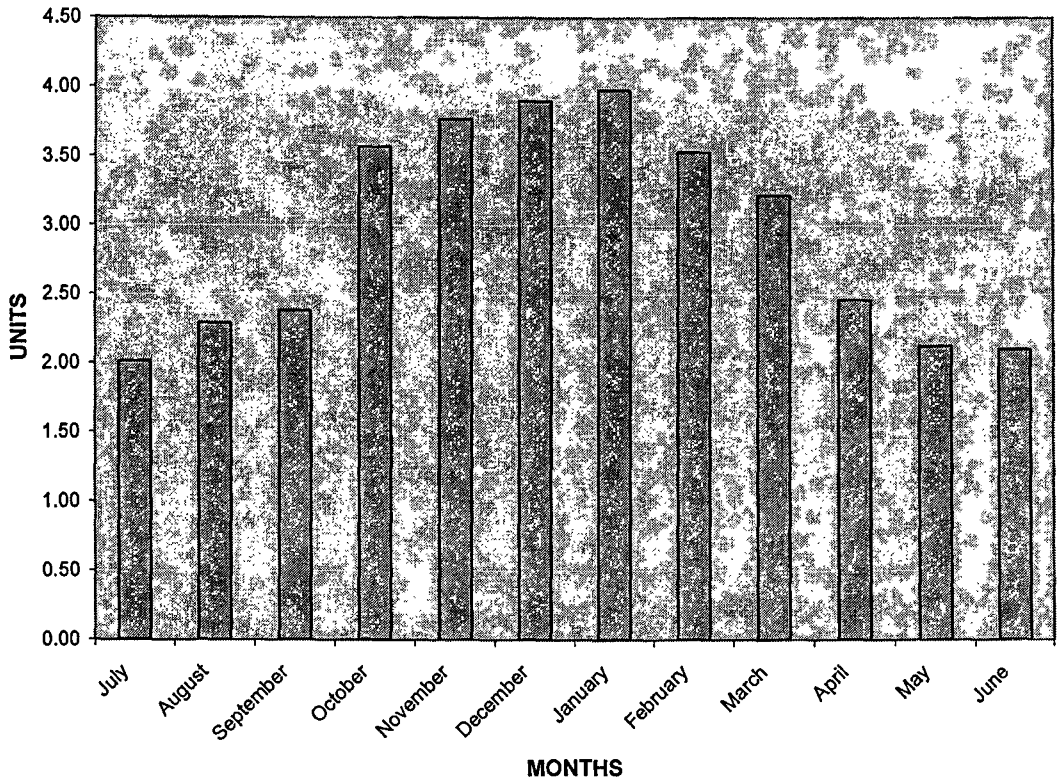
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Condition scores	2.01	2.29	2.38	3.57	3.77	3.90	3.98	3.53	3.22	2.46	2.13	2.10

Figure 86. Mean condition score values recorded by months



The mean condition scores of the animals sampled by months are shown in Table 44 and illustrated in Figures 86 and 87. The scores increased from July until January and decreased from January to June and the condition scores recorded in January were very high with 3.98 units and the one recorded in July were very low with 2.01 units.

Figure 87. Mean condition score values recorded by months



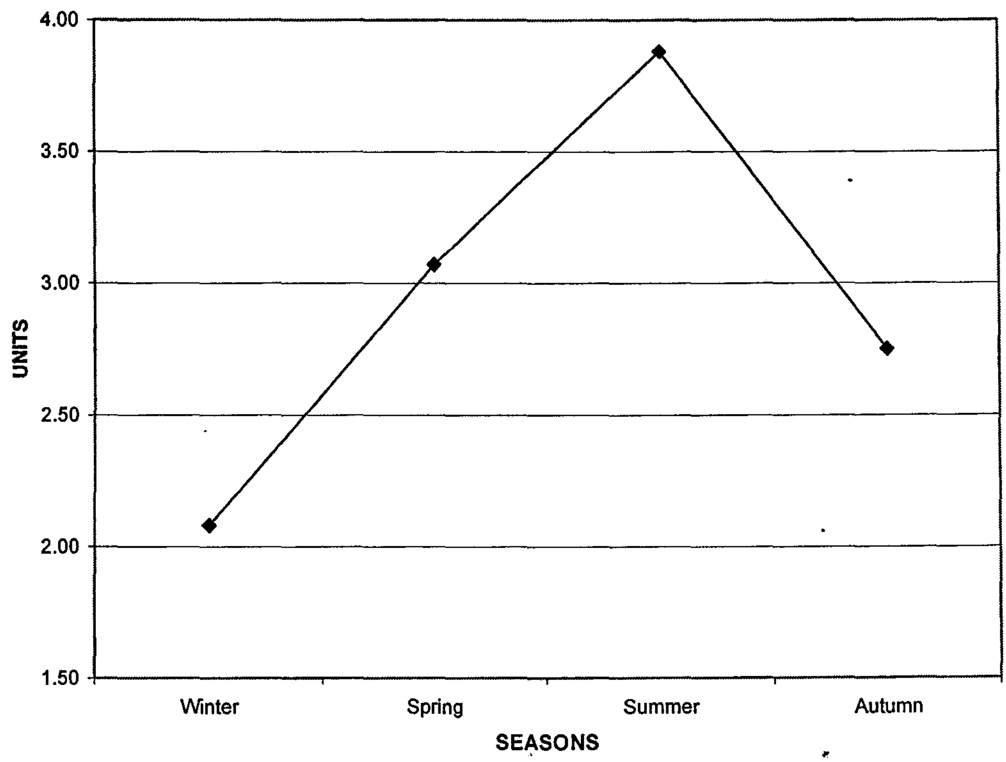
6.5.2 Mean condition score recorded by seasons

Table 45. Mean condition score recorded by seasons

SEASONS	Winter	Spring	Summer	Autumn
Condition scores	2.08[a]	3.07[a]	3.88[a]	2.75[a]

[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 88. Mean condition score recorded by seasons



The mean condition scores of the animals evaluated by seasons are shown in Table 45 and Figures 88 and 89. The scores increased from winter to summer and decreased during autumn. Even though there were no significant differences in condition scores, the scores recorded during summer were very high with 3.88 compared with the ones recorded in the other three seasons and these results are in agreement with the ones reported by Holroyd et al. (1983) in which body conditions recorded during their trial were lower throughout the dry season.

Figure 89. Mean condition score recorded by seasons

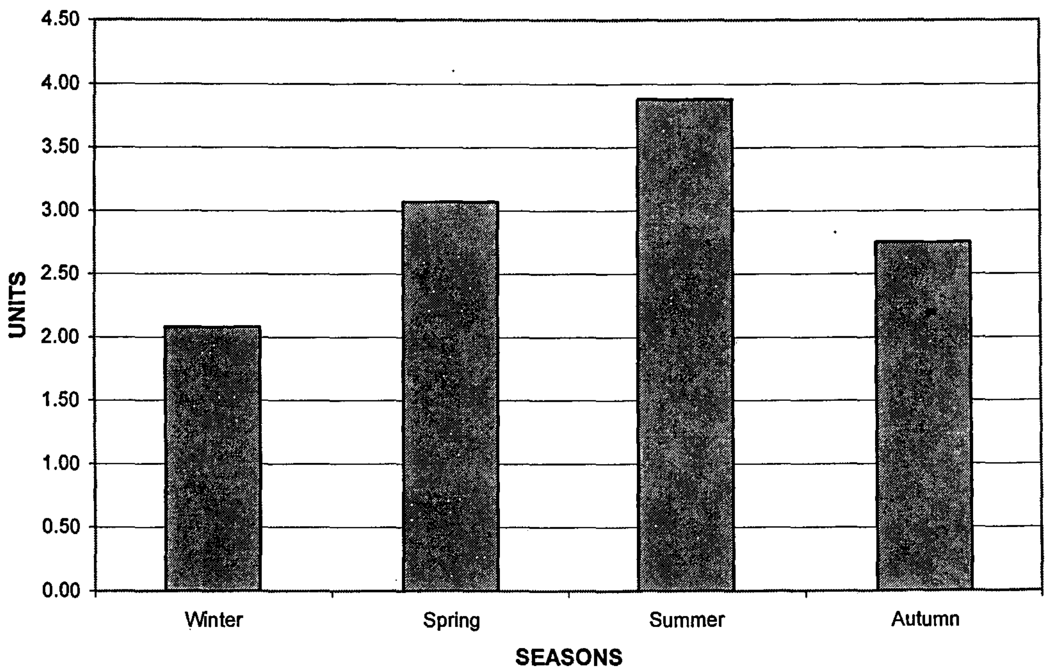
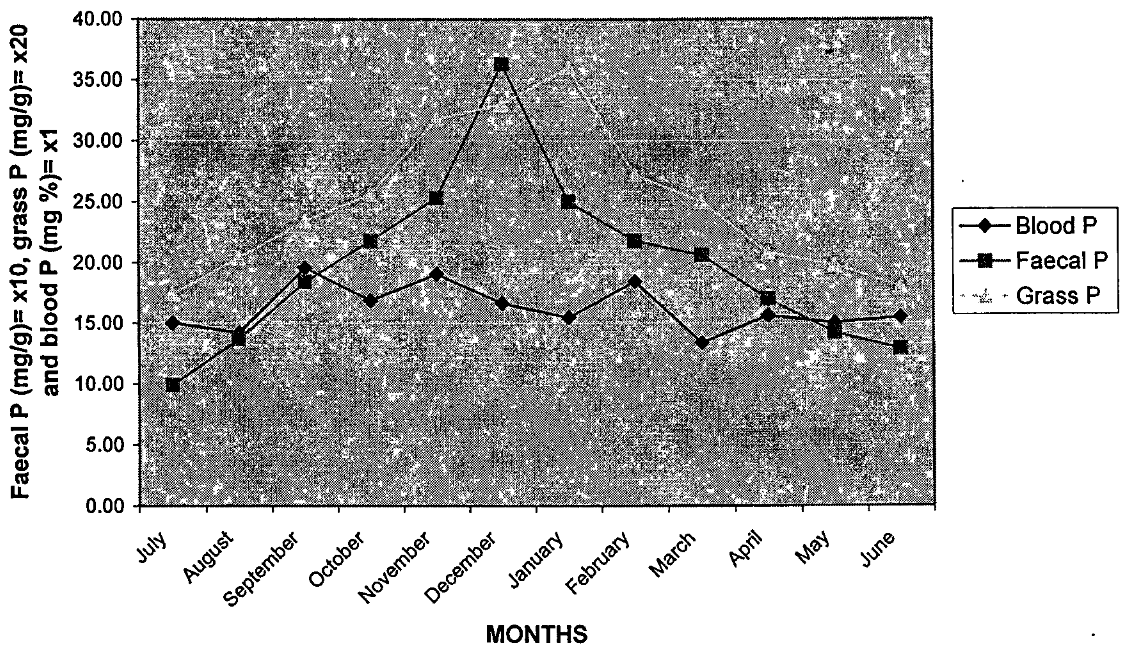


Table 46. Mean faecal P and mean grass P concentrations (mg/g, dry weight) and blood P concentration (mg %) by months

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal P (mg/g, dw)	0.99	1.37	1.84	2.18	2.53	3.63	2.5	2.18	2.06	1.7	1.42	1.29
Grass P (mg/g, dw)	0.87	1.02	1.17	1.28	1.59	1.65	1.80	1.36	1.25	1.04	0.99	0.90
Blood P (mg %)	15.03	14.21	19.55	16.87	19.03	16.64	15.46	18.44	13.37	15.62	15.01	15.48

Figure 90. Mean faecal P and mean grass P concentrations (mg/g, dry weight) and mean blood P concentration (mg %)



The faecal P and grass P concentrations measured on a dry weight basis and mean blood P concentrations by months are given in Table 46 and illustrated in Figures 90 and 91. The concentrations peaked in December, January and September respectively. Beighle et al. (1990) have reported that faecal P reflects the dietary P, and Karn (2001) said that the amount of faecal P depends on dietary P and this research has also shown that the concentration of P in the grass was reflected by faecal P concentration with the exception of the months of December and January. Faecal P values peaked in December but grass P values only peaked in January. It was expected that just the reverse would have been the case.

It is possible that the young growing grass was consumed in greater quantities during December and this raised the faecal P due to a large amount of P being taken in by the animals. A month later in January the condition score and live mass were at highest and that would have taken a month to show up as a result of improved dietary P. In January the grass would have matured and become less palatable so less could have been consumed but maturing seeds would have increased the P concentration in the grass in samples collected in January. This difference in the peaks for faecal and grass P shows that it is difficult to estimate the amount of P taken in by the animals by measuring the P in the grass. When these results are plotted against seasons the faecal P very clearly reflects the dietary P throughout the four seasons (Figure 92).

Holroyd et al. (1983) found that although not grossly deficient, soils were low in available phosphorus and low faecal P levels occurred in the dry season. According to Holroyd et al. (1983) faecal phosphorus levels followed a seasonal pattern with highest levels occurring between November and April and lowest levels from July to October, findings that are not greatly different from those reported from this research.

Figure 91. Mean faecal P and grass P concentrations (mg/g, dry weight) and blood concentration (mg %) by months

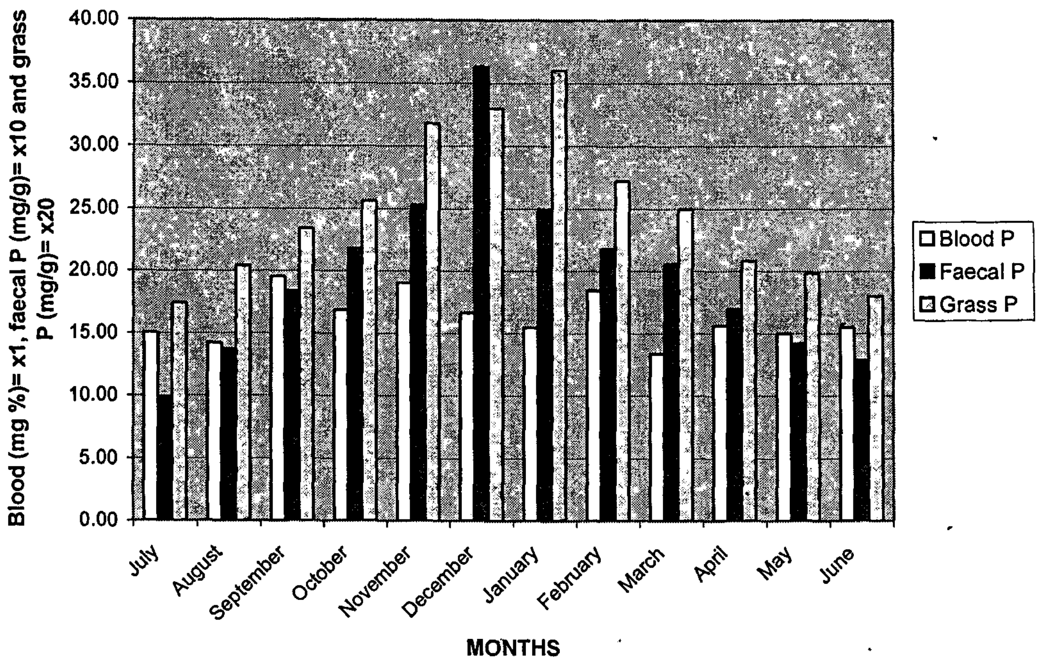
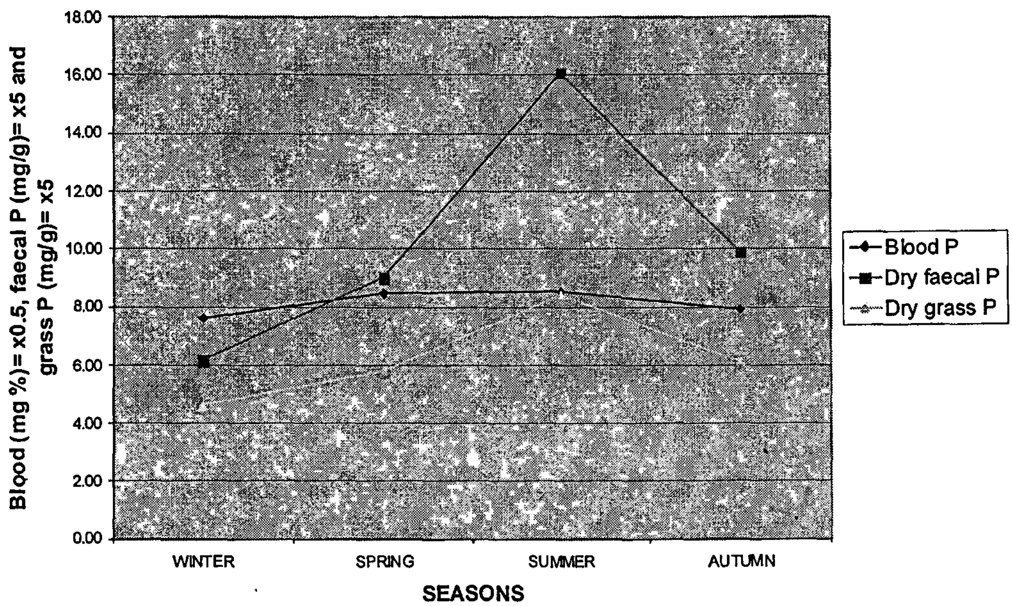


Table 47. Mean faecal P and mean grass P concentrations (mg/g, dry weight) and mean blood P concentration (mg %) by seasons

SEASONS	Winter	Spring	Summer	Autumn
Blood P x0.5 (mg %)	15.17[a]	16.88[a]	17.04[a]	15.81[a]
Faecal P x5 (mg/g, dw)	1.23[a]	1.8[a]	3.22[b]	1.98[a]
Grass P x5 (mg/g, dw)	0.92[a]	1.16[a]	1.68[b]	1.22[a]

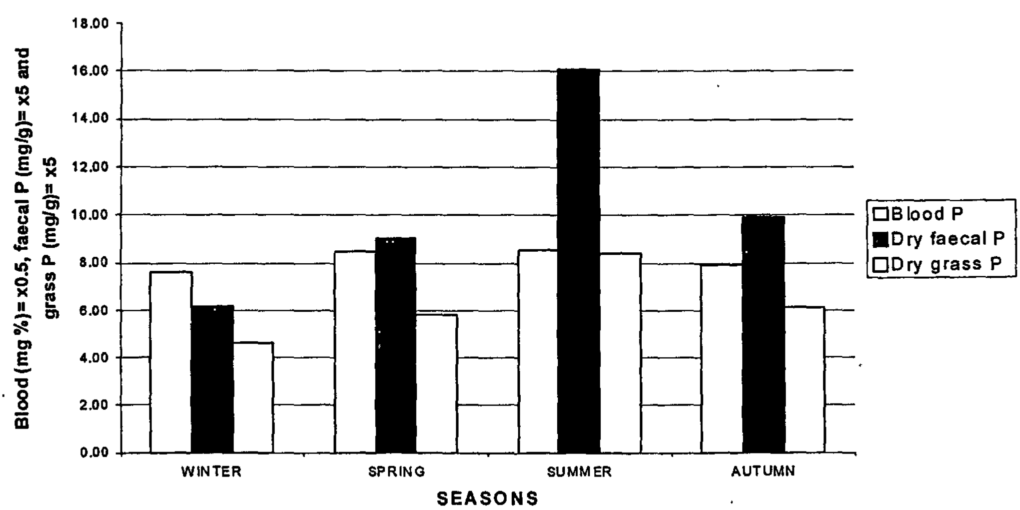
[a, b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure 92. Mean faecal P and grass P concentrations (mg/g, dry weight) and blood P concentration (mg %) by seasons



The faecal P and grass P concentrations measured on a dry weight basis and mean blood P concentration by seasons peaked during the rainy season and both declined during the dry season. Dry faecal P concentration and dry grass P concentration were significantly (P< 0.05) greater in summer compared with other seasons. Even though there was no significant difference in the blood P concentration, blood samples collected during summer season had the highest value of 17.04 Mg % when compared with the other three seasons (Table 47 and Figures 92 and 93). It can easily be seen in Figures 92 and 93 that the concentration of P in faeces varied greatly compared to that of the grass and blood and that the P concentration in the blood was very stable among the seasons compared with the faeces and grass. From these findings, the faecal P and blood P concentrations were directly proportional to grass P concentration and these findings are similar to the ones found out by Kincaid et al. (1981) whereby they found that inorganic phosphorus in blood plasma was reduced by low phosphorus intake, and also Hemingway (1967) had the similar results that under conditions of insufficiency of phosphorus in the soil, legumes might fail and grasses might have reduced phosphorus concentrations.

Figure 93. Mean faecal P and grass P concentrations (mg/g, dry weight) and blood P concentration (mg %) by seasons

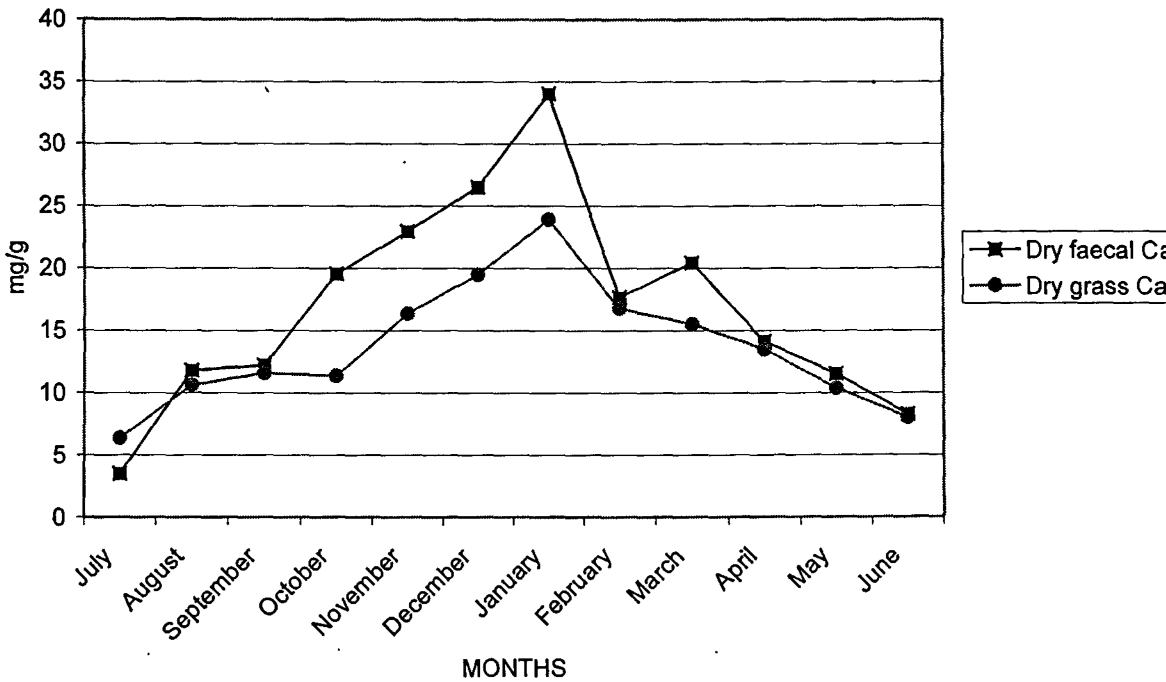


Further research is needed which can explain the wide variation between blood, faecal and grass P concentrations. The P homeostatic mechanism includes not only blood and faecal P but also bone P. Further research, which evaluates bone P along with blood and faecal P, could help to explain this variation.

Table 48. Mean faecal Ca and mean grass Ca concentrations (mg/g, dry weight) by months

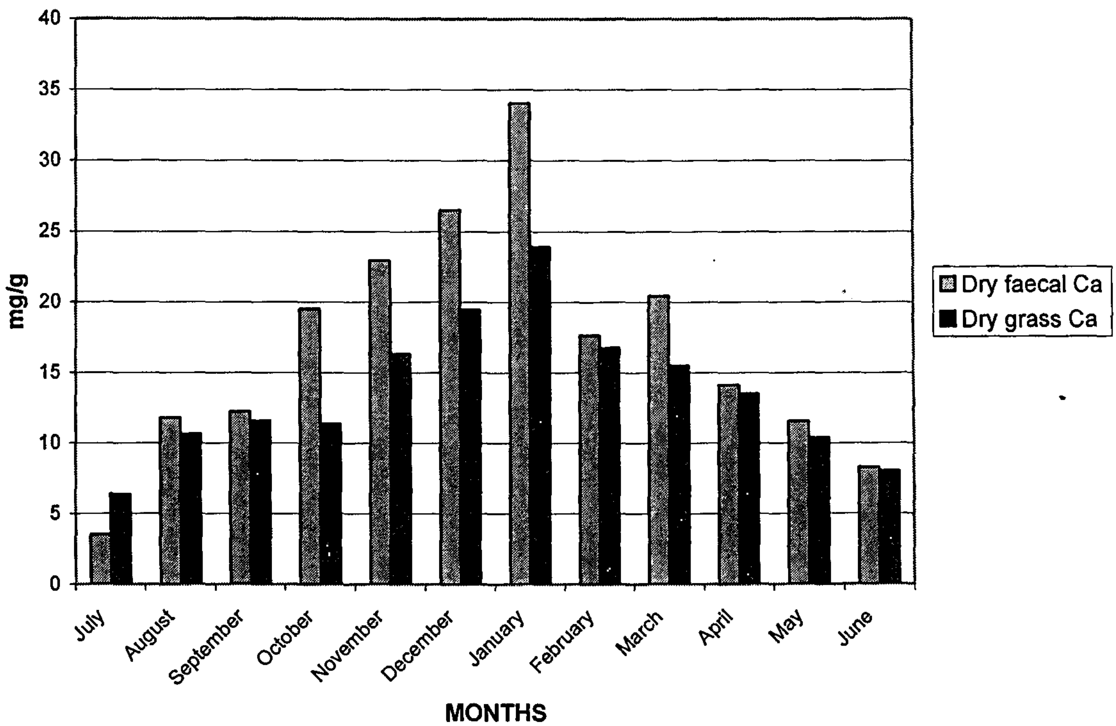
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	Ju
Faecal Ca (mg/g, dw)	3.25	11.78	12.2	19.52	22.94	26.5	34.02	17.64	20.42	14.12	11.52	8
Grass Ca (mg/g, dw)	6.36	10.61	11.58	11.34	16.33	19.45	23.89	16.76	15.49	13.48	10.36	8

Figure 94. Mean faecal Ca and mean grass Ca concentrations (mg/g, dry weight)



The faecal Ca and grass Ca concentrations measured on a dry weight basis are given in Table 48 and illustrated in Figures 94 and 95. The mean concentrations increased from August to January but the dry grass Ca concentration in September had a higher value than October. Both the concentrations declined from January to July but the faecal Ca concentration in March had a higher value than in February. January samples had the highest values of both faecal Ca and grass Ca concentrations and July had the lowest values of the two concentrations.

Figure 95. Mean faecal Ca and mean grass Ca concentrations (mg/g, dry weight)

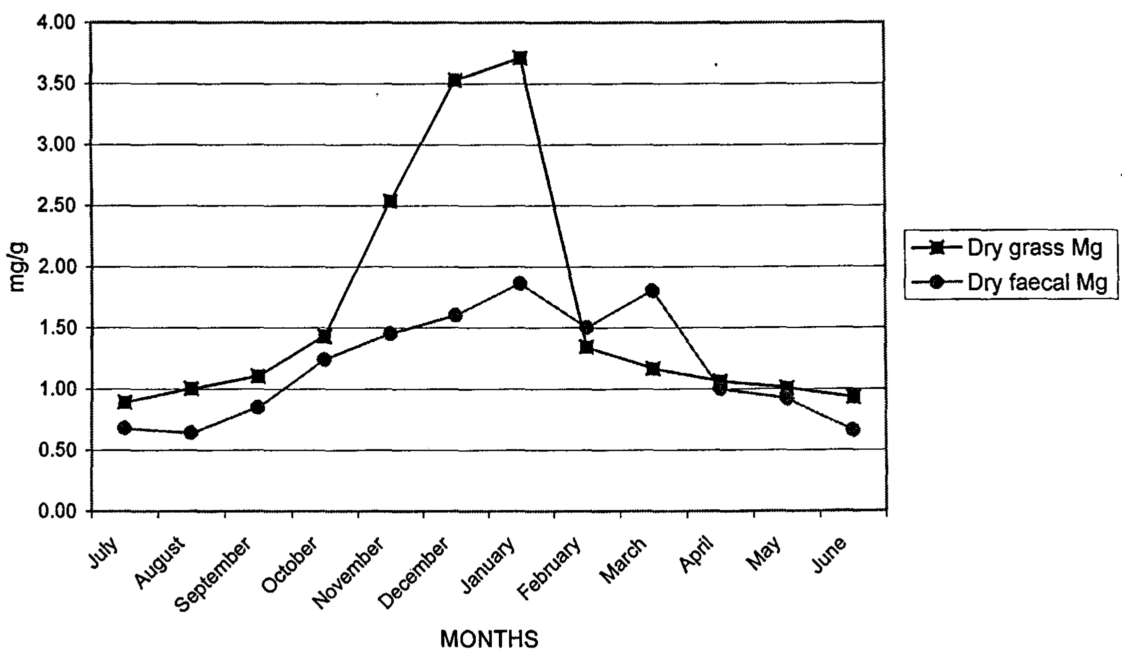


The content of calcium in grass measured on a dry basis and the content of calcium in faeces measured on a dry basis almost follow the same flow of the graph, and they are mostly like the results found by Moir (1960) in which the percentage of calcium in dry-matter pasture and in organic-matter faeces appeared to be adequately defined by linear regression.

Table 49. Mean faecal Mg and mean grass Mg concentrations (mg/g, dry weight) by months

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal Mg (mg/g, dw)	0.68	0.64	0.85	1.24	1.45	1.6	1.86	1.5	1.8	1	0.92	0.66
Grass Mg (mg/g, dw)	0.89	1.00	1.11	1.43	2.54	3.53	3.71	1.34	1.17	1.06	1.01	0.93

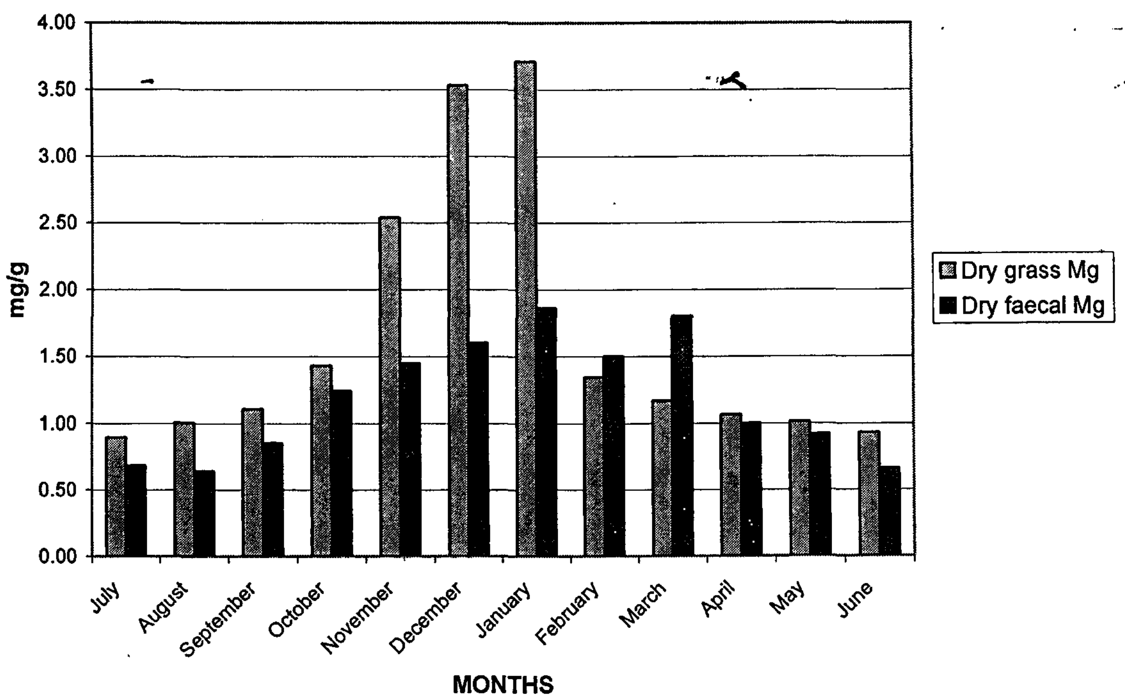
Figure 96. Mean faecal Mg and mean grass Mg concentrations (mg/g, dry weight)



The faecal Mg concentration and grass Mg concentration measured on a dry weight basis are shown in Table 49 and illustrated in Figures 96 and 97. When grass Mg concentration reached a peak in January, the faecal Mg concentration also peaked. The faecal Mg concentration was very low in August while grass Mg concentration had the lowest value in July.

Faecal Mg concentrations during the months of November, December, January, February and March did not change to any great extent but grass Mg concentrations during those months changed greatly with very high values during November, December and January but much lower values during February and March. During the dry season the faecal and grass Mg values mirror one another but during the wet season they do not. Further research is needed to investigate the reason for this phenomenon. Further research into the effects of dry and wet seasons on blood and bone Mg may help to explain these results.

Figure 97. Mean faecal Mg and mean grass Mg concentrations (mg/g, dry weight)



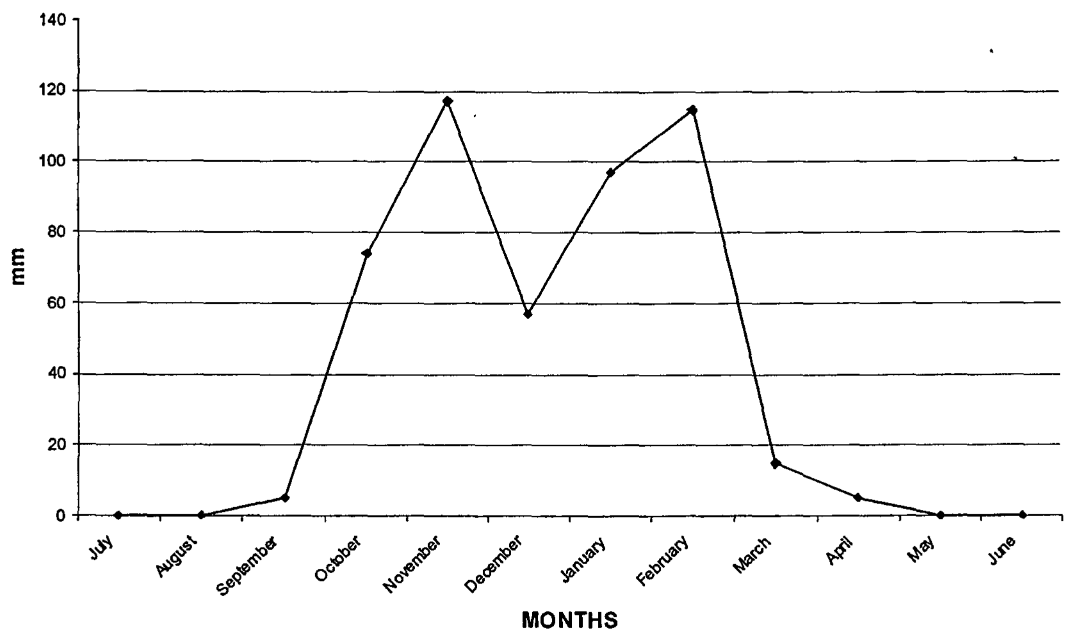
6.5 Rainfall Data

6.5.1 Rainfall (mm) recorded by months

Table 50. Actual rainfall (mm) recorded by months

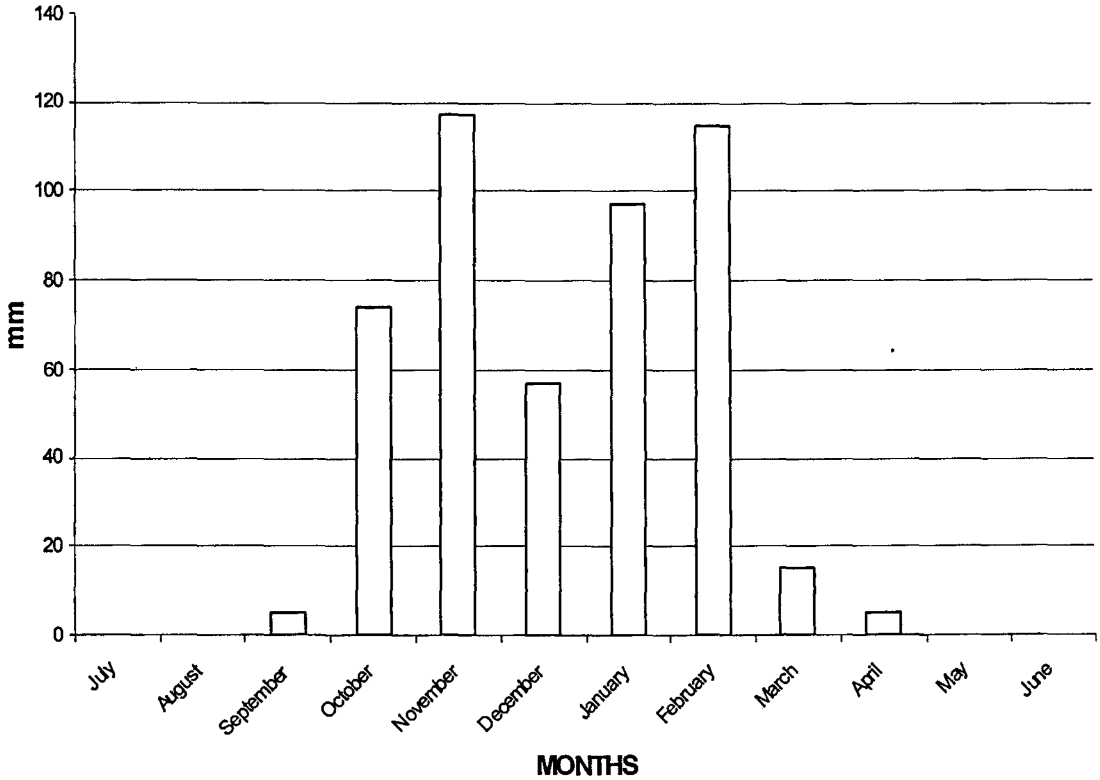
MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Rainfall (mm)	0	0	5	74	117	57	97.2	114.5	15	5	0	0

Figure 98. Rainfall (mm) data recorded by months



Actual rainfall (mm) recorded by months is given in Table 50 and illustrated in Figures 98 and 99. There was no rainfall from May to August and the rainfall recorded in November and February was very high with the value of 117 mm and 114 mm respectively. The rainfall recorded here is directly proportional to the grass except that in December the rainfall dropped but the grass continued with its increment path.

Figure 99. Rainfall (mm) recorded by months



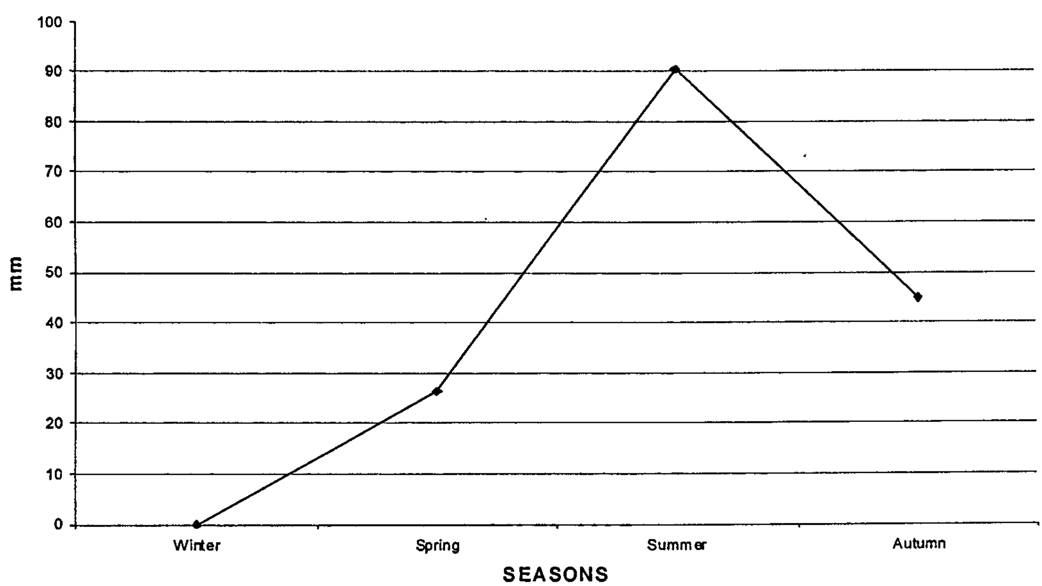
6.5.2 Actual rainfall recorded by seasons

Table 51. Actual rainfall (mm) recorded by seasons

SEASONS	Winter	Spring	Summer	Autumn
Rainfall (mm)	0[a]	26.33[a]	90.4[b]	44.83[a]

[a,b] means with the same letter in a row are not significantly ($P < 0.05$) different between the seasons

Figure 100. Rainfall (mm) recorded by seasons



Mean rainfall per month (mm) recorded by seasons had zero reading in winter months, and the rainfall recorded in summer months had the highest value of 90.4 mm and was significantly ($P < 0.05$) higher when compared with the other three seasons (Table 51 and Figures 100 and 101)

Figure 101. Rainfall (mm) recorded by seasons

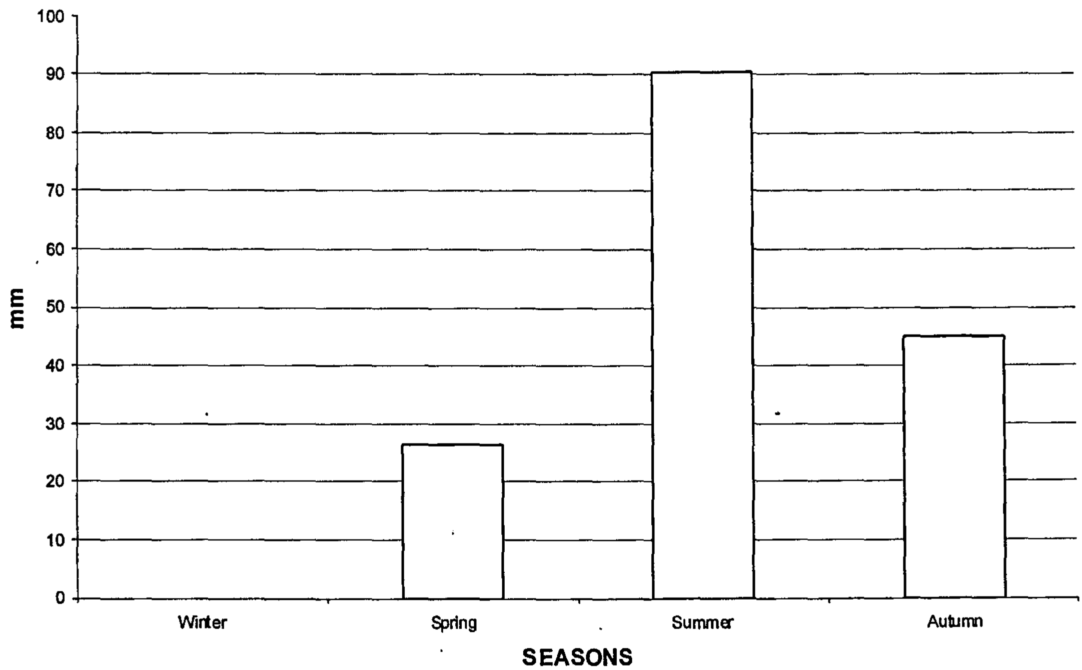
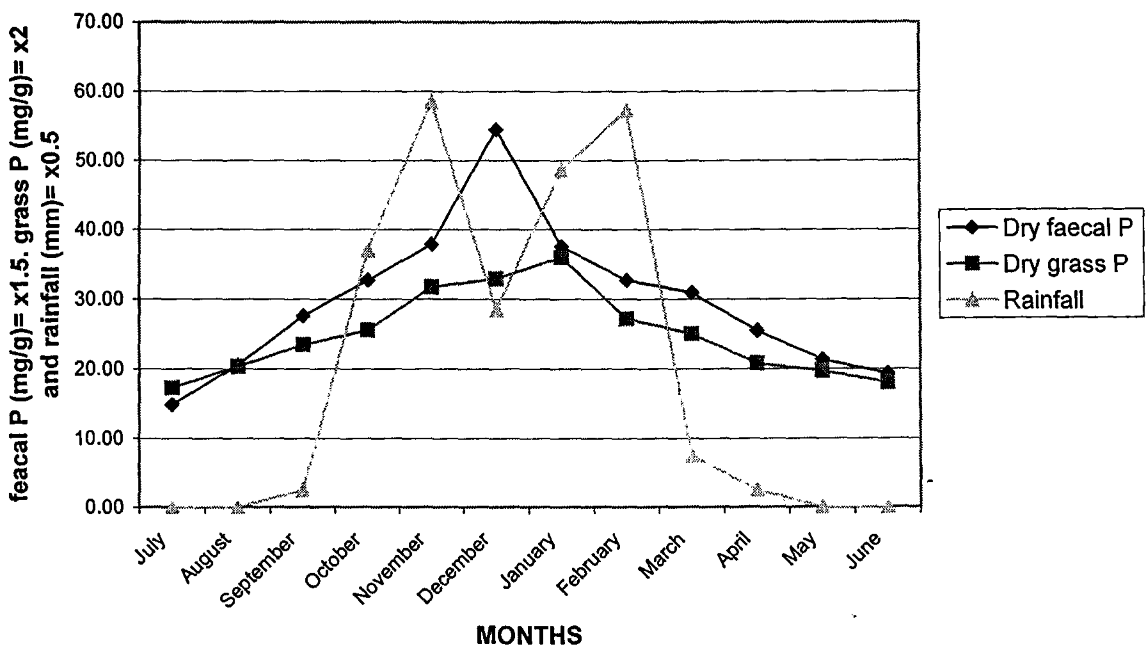


Table 52. Mean faecal and grass P concentrations (mg/g, dry weight) and actual rainfall (mm) recorded by months

MONTHS	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June
Faecal P (mg/g, dw)	0.99	1.37	1.84	2.18	2.53	3.63	2.5	2.18	2.06	1.7	1.42	1.29
Grass p (mg/g, dw)	0.87	1.02	1.17	1.28	1.59	1.65	1.80	1.36	1.25	1.04	0.99	0.90
Rainfall (mm)	0	0	5	74	117	57	97.2	114.5	15	5	0	0

Figure102. Mean faecal P and grass P concentrations (mg/g, dry weight) and actual rainfall (mm) by months



The comparison between mean faecal P, mean grass P concentrations (Mg/g, dry weight) and actual rainfall (mm) by months is given in Table 52 and illustrated in Figures 102 and 103. The rainfall dropped in December while faecal P and grass P concentrations continued to increase until December and January respectively. From July to November, the grass P and faecal P followed the same pattern and showed increases along with increases in rainfall during September to November and continued to increase despite a drop in rainfall in December. This is not unexpected because there was enough moisture to provide for some pasture growth even if it was not optimal.

Figure 103. Mean faecal and grass P concentrations (mg/g, dry weight) and actual rainfall (mm) by months

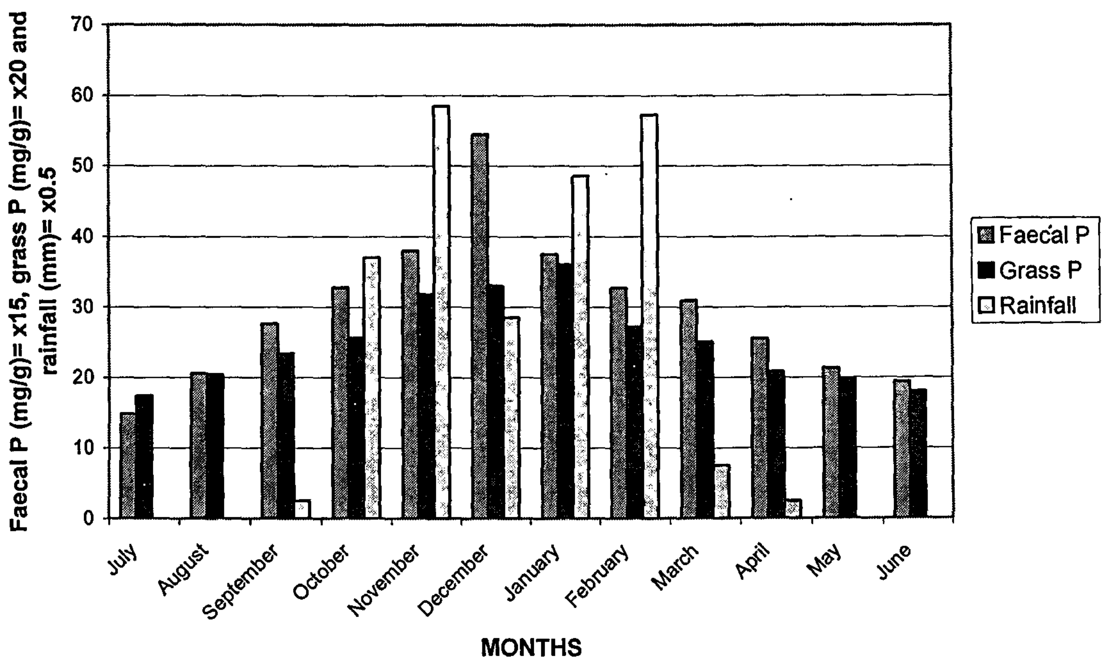
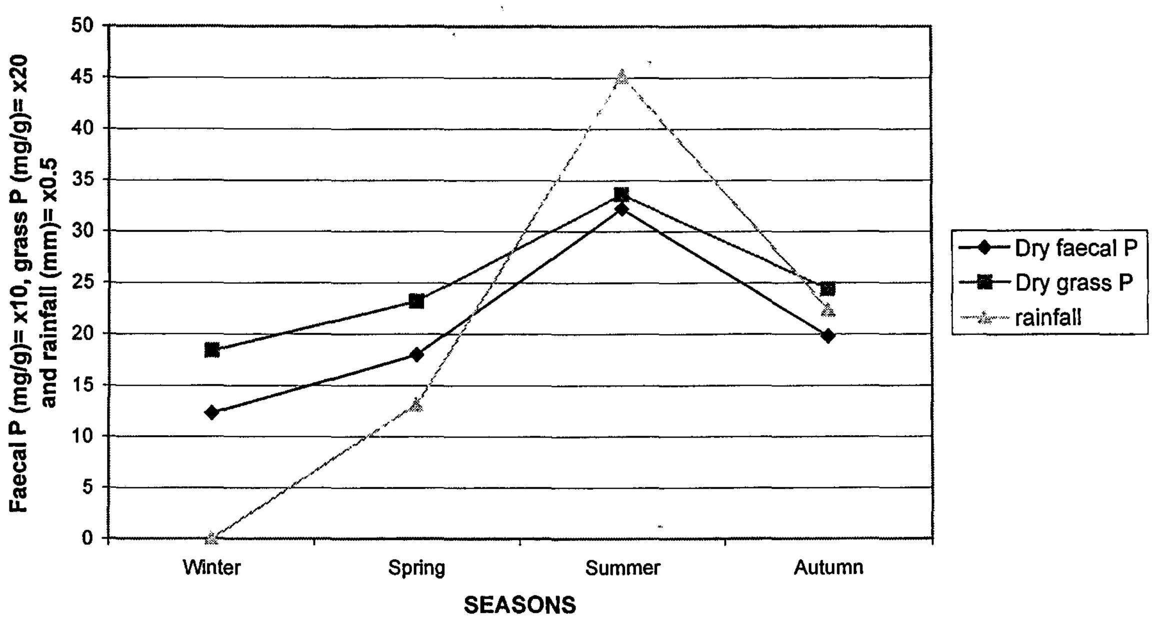


Table 53. Mean faecal and grass P concentrations (mg/g, dry weight) and actual rainfall (mm) recorded by seasons.

SEASONS	Winter	Spring	Summer	Autumn
Faecal P x10 (mg/g, dw)	1.23[a]	1.8[a]	3.22[b]	1.98[a]
Grass P x20 (mg/g, dw)	0.92[a]	1.16[a]	1.68[b]	1.22[a]
Rainfall x0.5	0[a]	13.17[a]	45.2[b]	22.42[a]

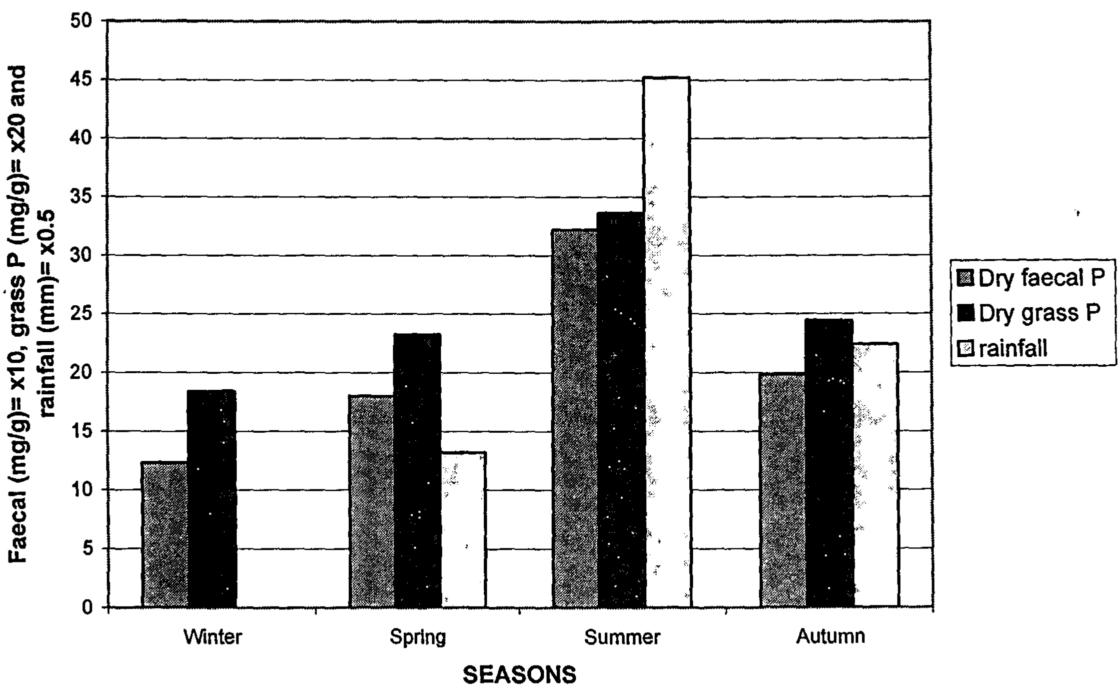
[a,b] means with the same letter in a row are not significantly (P< 0.05) different between the seasons

Figure104. Mean faecal and grass P concentrations (mg/g, dry weight) and actual rainfall (mm) by seasons



The comparison between mean faecal P, mean grass P concentrations (mg/g, dry weight) and rainfall (mm) by seasons is given in Table 53 and illustrated in Figures 104 and 105. The concentrations of P in faeces and grass increased from winter and peaked in the wet season and the concentrations recorded during the dry winter season had the lowest values. The mean faecal P, mean grass P concentrations and rainfall in the summer season were significantly ($P < 0.05$) higher compared to the other three seasons. The results showed that mineral content in the grass is related to the rainfall and are directly proportional to the mineral in the faeces.

Figure 105. Mean faecal and grass P concentrations (mg/g, dry weight) and actual rainfall (mm) by seasons



CHAPTER 7

CONCLUSIONS

When the seasonal mineral (P, Ca and Mg) status in ruminants feeding exclusively in a communal grazing area was investigated in blood, faeces and pasture, it was found that the mineral content in pasture followed the pattern set by the rainfall, and the mineral content in faeces was directly proportional to the mineral content in the grass and reflected both live mass and body condition of the animals.

Even during the dry winter season when grass and faecal P concentrations were at their lowest concentrations animals were able to maintain blood P values during some winter months similar to those during the wet summer months when grass and faecal P concentrations were at their highest. In addition animals were unable to maintain higher blood P concentrations during some summer months when grass and faecal P concentrations were at their peaks. These very erratic and inconsistent in blood P concentrations emphasize the unreliability of blood P as an indicator of P status in the cow.

Faeces and grass indicators were curvilinear increasing from winter months to spring months peaking in summer months significantly ($P< 0.05$) greater when grazing was best and declining as the grazing became worse during autumn and winter months. It is probable that these animals would suffer minerals deficiencies during dry seasons in agreement with McDowell et al. (1983) who said that because tropical forages contain less minerals during the dry seasons it is logical to assume that cattle would suffer mineral inadequacies during this time. Results from this research confirm that animals grazing communally are consuming less P during the dry winter season due to low concentrations of P in the grass and are therefore in danger of suffering P deficiencies during these months. In addition animals lost live mass and condition during this time indicating that they were consuming less food. This would further reduce the amount of P that the animals would have available for metabolism.

It is concluded from this research that animals grazing communally in this area of the Molopo District would benefit from supplements that contain P during the winter months. Further research is needed among these animals in this area to evaluate the role of bone in the P homeostatic mechanism in maintaining blood P levels during the dry season.

CHAPTER 8
APPENDIX

1. Faecal Samples
Appendix A

Means of faecal P, Ca and Mg concentrations (mg/g, fresh weight) by months

MONTHS	Fresh P (mg/g)	Fresh Ca (mg/g)	Fresh Mg (mg/g)
July	0.92	1.47	0.58
August	1.29	5.65	0.61
September	1.72	5.48	0.61
October	2.05	9.08	1.17
November	2.29	11.36	1.4
December	3.16	13.54	1.4
January	2.34	15.66	1.71
February	1.99	8.08	1.37
March	1.85	9.2	1.02
April	1.55	6.43	0.92
May	1.32	4.85	0.57
June	1.21	2.97	0.47

Appendix B
Means of faecal P, Ca and Mg concentrations (mg/g, dry weight) by months

MONTHS	Dry P (mg/g)	Dry Ca (mg/g)	Dry Mg (mg/g)
July	0.99	1.76	0.62
August	1.37	5.89	0.64
September	1.84	6.1	0.85
October	2.18	9.76	1.24
November	2.53	11.47	1.45
December	3.63	13.25	1.6
January	2.5	17.01	1.86
February	2.18	8.82	1.5
March	2.06	10.21	1
April	1.7	7.06	0.9
May	1.42	5.76	0.8
June	1.29	4.13	0.66

Appendix C

Means of faecal P, Ca and Mg concentrations (mg/g, ash weight) by months

MONTHS	Ash P (mg/g)	Ash Ca (mg/g)	Ash Mg (mg/g)
July	5.77	24.06	1.34
August	6.09	45.55	3.35
September	6.53	39.69	3.98
October	7.04	41.62	4.17
November	7.27	44.36	4.37
December	10	49.39	4.5
January	9.04	52.01	5.15
February	8.59	42.26	5.82
March	7.04	51.48	8.69
April	6.99	29.77	4.05
May	6.74	28.05	2.73
June	6.03	26.44	2.78

Appendix D

Means of faecal P, Ca and Mg concentrations (mg/g, fresh weight) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Fresh P (mg/g)	Fresh Ca (mg/g)	Fresh Mg (mg/g)
Winter	1.15 ± 0.12	3.1 ± 0.20	0.54 ± 0.023
Spring	1.69 ± 0.22	6.74 ± 0.25	0.8 ± 0.030
Summer	2.91 ± 0.28	13.25 ± 0.35	1.5 ± 0.067
Autumn	1.8 ± 0.13	7.9 ± 0.30	1.31 ± 0.042

Appendix E

Means of faecal P, Ca and Mg concentrations (mg/g, dry weight) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Dry P (mg/g)	Dry Ca (mg/g)	Dry Mg (mg/g)
Winter	1.23 ± 0.13	3.88 ± 0.28	0.75 ± 0.030
Spring	1.8 ± 0.06	7.25 ± 0.30	0.91 ± 0.031
Summer	3.22 ± 0.12	14.1 ± 0.42	1.64 ± 0.067
Autumn	1.98 ± 0.14	8.7 ± 0.38	1.43 ± 0.042

Appendix F

Means of faecal P, Ca and Mg concentrations (mg/g, ash weight) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Ash P (mg/g)	Ash Ca (mg/g)	Ash Mg (mg/g)
Winter	4.59 ±0.29	26.18 ± 1.10	2.28 ± 0.20
Spring	6.55 ± 0.36	42.29 ± 2.17	3.83 ± 0.23
Summer	9.47 ± 0.48	48.59 ± 3.66	6.19 ± 0.26
Autumn	8.48 ± 0.42	41.17 ± 2.27	4.67 ± 0.41

2. **Blood samples**

Appendix G

Means of blood P concentration (mg %) by months

MONTHS	Blood P (mg %)
July	15.03
August	14.21
September	19.55
October	16.87
November	19.03
December	16.64
January	15.46
February	18.44
March	13.37
April	15.62
May	15.01
June	15.48

Appendix H

Means of blood P concentration (mg %) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Blood P (m %)
Winter	15.17 ± 0.28
Spring	16.88 ± 0.30
Summer	17.04 ± 0.45
Autumn	15.86 ± 0.37

3. **Live body mass**

Appendix I

Means of live body mass (Kg) recorded by months

MONTHS	Body mass (Kg)
July	183.5
August	252.33
September	287.21
October	277.33
November	340.33
December	373.2
January	401.33
February	372.02
March	253.13
April	234.75
May	219.17
June	200.96

Appendix J

Means of body mass (Kg) recorded by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Body mass (Kg)
Winter	201.4 ± 10.47
Spring	272.29 ± 14.90
Summer	371.62 ± 17.48
Autumn	286.65 ± 15.60

4. Grass

Appendix K

Means of grass P, Ca and Mg concentrations (mg/g, fresh weight) by months

MONTHS	Fresh P (mg/g)	Fresh Ca (mg/g)	Fresh Mg (mg/g)
July	0.80	5.96	0.84
August	0.96	10.22	0.97
September	1.02	10.50	1.04
October	1.17	10.85	1.32
November	1.34	15.76	2.45
December	1.34	17.98	3.26
January	1.36	22.09	3.43
February	1.22	15.71	1.26
March	1.15	14.01	1.05
April	1.00	12.47	0.98
May	0.90	9.70	0.95
June	0.87	7.53	0.88

Appendix L

Means of grass P, Ca and Mg concentrations (mg/g, dry weight) by months

MONTHS	Dry P (mg/g)	Dry Ca (mg/g)	Dry Mg (mg/g)
July	0.87	6.36	0.89
August	1.02	10.61	1.00
September	1.17	11.58	1.11
October	1.28	11.34	1.43
November	1.59	16.33	2.54
December	1.65	19.45	3.53
January	1.80	23.89	3.71
February	1.36	16.76	1.34
March	1.25	15.49	1.17
April	1.04	13.48	1.06
May	0.99	10.36	1.01
June	0.90	8.00	0.93

Appendix M

Means of grass P, Ca and Mg concentrations (mg/g, ash weight) by months

MONTHS	Ash P (mg/g)	Ash Ca (mg/g)	Ash Mg (mg/g)
July	7.76	49.87	6.98
August	10.21	88.02	8.33
September	12.57	134.09	12.59
October	14.93	129.39	16.19
November	15.75	177.08	27.66
December	18.77	208.34	37.91
January	20.01	210.59	32.68
February	13.14	180.05	14.18
March	12.57	159.52	11.80
April	11.47	107.38	8.44
May	9.69	80.90	7.86
June	8.46	66.61	7.79

Appendix N

Means of grass P, Ca and Mg concentrations (mg/g, fresh weight) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Fresh P (mg/g)	Fresh Ca (mg/g)	Fresh Mg (mg/g)
Winter	0.86 ± 0.03	7.73 ± 1.08	0.89 ± 0.03
Spring	1.05 ± 0.06	10.52 ± 0.18	1.11 ± 0.11
Summer	1.35 ± 0.01	18.61 ± 1.86	3.05 ± 0.30
Autumn	1.12 ± 0.07	14.06 ± 0.94	1.1 ± 0.08

Appendix O

Means of grass P, Ca and Mg concentrations (mg/g, dry weight) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Dry P (mg/g)	Dry Ca (mg/g)	Dry Mg (mg/g)
Winter	0.92 ± 0.04	8.24 ± 1.16	0.94 ± 0.03
Spring	1.16 ± 0.08	11.18 ± 0.29	1.18 ± 0.13
Summer	1.68 ± 0.06	19.89 ± 2.19	3.26 ± 0.36
Autumn	1.22 ± 0.09	15.24 ± 0.95	1.19 ± 0.08

Appendix P

Means of grass P, Ca and Mg concentrations (mg/g, ash weight) by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Ash P (mg/g)	Ash Ca (mg/g)	Ash Mg (mg/g)
Winter	8.63 ± 0.56	65.66 ± 9.09	7.54 ± 0.28
Spring	12.57 ± 1.36	117.16 ± 14.64	12.37 ± 2.27
Summer	18.17 ± 1.27	198.67 ± 10.81	32.75 ± 2.96
Autumn	12.39 ± 0.49	148.98 ± 21.63	11.47 ± 1.66

5. Condition scores

Appendix Q

Means of condition scores recorded by months

MONTHS	CONDITION SCORES (UNITS)
July	2.01
August	2.29
September	2.38
October	3.57
November	3.77
December	3.90
January	3.98
February	3.53
March	3.22
April	2.46
May	2.13
June	2.10

Appendix R

Means of condition scores recorded by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	Condition Scores (Units)
Winter	2.08 ± 0.03
Spring	3.07 ± 0.06
Summer	3.88 ± 0.41
Autumn	2.75 ± 0.32

6. Rainfall

Appendix S

Rainfall (mm) recorded by months

MONTHS	RAINFALL (mm)
July	0
August	0
September	5
October	74
November	117
December	57
January	97.2
February	114.5
March	15
April	5
May	0
June	0

Appendix T

Rainfall recorded by seasons and their respective standard error means (SEMs). Standard error means were calculated by using the Microsoft Excel statistical software on the tools menu- Data analysis (Two Samples Assuming Equal Variances).

SEASONS	RAINFALL (mm)
Winter	0 ± 0
Spring	26.33 ± 23.88
Summer	90.4 ± 17.65
Autumn	44.83 ± 34.95

CHAPTER 9

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