EFFECT OF PHOSPHORUS AND VITAMIN A ON BOVINE AND CAPRINE REPRODUCTION IN THE SAVANNA ZONE OF NIGERIA

BY

ELIEZER C.I. MOLOKWU

BSc. Tuskegee Institute, USA., 1968

DVM. Tuskegee Institute, USA., 1969

MSc. Iowa State University, USA., 1972

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THESIS APPROVAL

This thesis by Eliezer C.I. Molokwu meets the regulations governing the degrees of Doctor of Philosophy of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

Internal Examiners

Stanley M. Dennis
Professor and Head,
Department of Reproduction,
National Animal Production
Research Institute.

External Examiner

Peter G. Hignett
The Hampshire Cattle
Breeders Society Ltd;
A.I. Centre, Lyndhurst
Hampshire, England.

Nnanyelum N. Umunna
Senior Lecturer in
Animal Science

Date: 15th. November, 1976

DECLARATION

This is to certify that I carried out the work reported in this thesis in the Department of Veterinary Physiology and Pharmacology, Ahmadu Bello University under the supervision of Professor S.M. Dennis, Dr N.N. Umunna and Professor Mary Hallaway.

The work of other investigators is acknowledged and referred to. No part of this thesis has been submitted elsewhere for a degree or diploma.

E.C.I. Molokwu

Eliezer C.I. Molokwu

Ahmadu Bello University

November, 1976.

DEDICATION

This thesis is dedicated to my wife, Nwakego and children, Uzoamaka, Ifeyinnwa, Obiora and Chidiebele for their patience, understanding, and encouragement throughout the whole period of my PhD studies.

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ABSTRACT

INTRODUCTION

"The need to increase the world's food supply is generally acknowledged to improve the present position of semi-starvation and malnutrition from which many millions of the human population suffer. There is a serious shortage of protein of animal origin, the lack of which is evident in the health of people in many regions".[1] This statement is applicable to Nigeria to-day with a daily protein intake per capita of 5 to 8 g in contrast to the recommended minimum of 20 g.[2,3] Nigeria is among the lowest 5 of 83 countries in the amount of protein in the national food supply. The 1980 intake target is at least 10 g, a level still too low but an improvement of approximately 50%. If this target is to be met, animal production must be improved. Causes of inadequate animal protein supply in Nigeria include low reproductive efficiency, poor and inadequate nutrition, and traditional nomadic husbandry. Reproductive performance is the single most important factor determining production efficiency of livestock (Zemjanis, 1974).

Lowered reproductive efficiency is a major constraint confronting the cattle industry in Nigeria. It results from infections and non-infectious factors, or by their interactions.

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1 Dalling, T. (1963). In Livestock Infertility, FAO Monograph No.5, United Nations, Rome.
2 Anon. (1966). Agricultural development in Nigeria 1965-80. FAO, United Nations, Rome.
3 FAO (1971). The state of food and agriculture. FAO, United Nations, Rome.

Results of the little work done suggests that non-infectious factors are more important, especially methods of husbandry and nutrition. The 1979/80 target for the meat supply for Nigeria in tons for beef, goat, and mutton is 300,000, 180,000, and 70,000, respectively[2] - an anticipated increase of 62%, 93% and 59%, respectively. An economist in the Nigerian Federal Livestock Department stated that cattle production could be raised by 300% by increasing the annual calf crop from the present 30 to 40% to 75% without any increase in the national herd (Zemjanis, 1974). Unless the reproductive efficiency of indigenous livestock is improved, it will be impossible to meet the meat targets. Unfortunately, the ratio of animals to man is falling and the average carcase weight of Nigerian cattle, goats and sheep appears to be decreasing.[4]

Livestock indigenous to West Africa have a low rate of growth and reproduction compared to temperate zone breeds (Lansbury, 1962). In spite an early study in Northern Nigeria incriminating malnutrition in low productivity, he commented

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4 Oyenuga, V.A. (1974). Proc. Ann. Mtg. Nig. Soc. Anim. Prod. Lake Bagauda, Kano State, April, 1974.

that there is still a tendency to attribute low production to inherent characteristics. He emphasized that the animal's nutritional environment was more important in restricting productivity than generally appreciated, and warned that attempts to raise productivity by developing or selecting animals for more rapid growth and development and faster reproduction are bound to be disappointing unless the nutritional environment is simultaneously raised. Evidence for protein and phosphorus deficiency is provided by analytic and supplementation results. The immediate problem is to supply these nutrients in cheap simple forms; Lansbury recommended investigating urea and phosphate supplements.

The long dry season in the savanna and Sahelian zones of Nigeria predisposes to avitaminosis A in livestock, which is likely to depress reproductive efficiency. This is important as over 90% of Nigerian cattle are located in these grazing zones.

Goats deserve greater attention in the development of the Nigerian livestock industry than they presently receive. Because of anti-caprine literature and beliefs, goats have received little attention during the past 50 years. Goats, in comparison with other domestic animals, are more adaptable for

survival in harsh environments.[5] This is due to a higher digestive efficiency for cellulose, high fertility, and a shorter generation interval. Goats are better adapted to the climate and ecological environments of Nigeria than sheep.[2] As goat meat is expected to contribute 20.6% of the meat supply of Nigeria by 1979/80, the effect of nutrition and mineral supplementation on caprine reproductive efficiency urgently needs investigating. Regarding the nutritional requirements of goats, Devendra and Burns[5] wrote: "In tropical regions goats have, for the most part, been neglected by scientists and left to acquire their own nourishment as best they can. However, since one of the best ways of achieving greater productivity and restraining their destructive tendencies is to have greater individual control, stall-feeding is now being increasingly used, and knowledge of nutritional requirements and feeding standards for goats has become an important consideration."

With the increasing demand for more animal protein in Nigeria, this investigation was undertaken to determine the effect of phosphorus and vitamin A supplementation on the reproductive efficiency of Bunaji (White Fulani) cattle and Kano Brown goats. The objectives were to study the:

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5 Devendra, C. and Burns, M. (1970). Goat production in the Tropics C.A.B., Farnham Royal, Bucks, England.

1. Seasonal changes in plasma levels of phosphorus, calcium and magnesium, and plasma and hepatic values of vitamin A in Bunaji cattle and Kano Brown goats.
2. Effect of phosphorus supplementation in cattle and goats.
3. Effect of vitamin A supplementation in Kano Brown goats.

Introduction

Infertility is a major economic problem confronting the livestock industry. An animal failing to produce and rear an offspring to weaning within a time period characteristic for the species is a source of economic loss in terms of feed, labour and other aspects of production.

Infertility may result from infectious agents or non-infectious factors, or by their interaction. It is manifested by anoestrous, repeat breeding, abortions, stillbirths, or neonatal deaths. Frank (1963) indicated that the exact figures of the economic loss to the livestock industry due to infertility were unobtainable but concluded that about 20 percent of the economic loss from diseases of livestock was due to infertility.

Infectious infertility in cattle may be due to brucellosis, leptospirosis, vibriosis, trichomoniasis, viruses and fungi. In sheep and goats brucellosis, vibriosis, listeriosis and toxoplasmosis are incriminated and are usually characterized by abortion (Frank, 1963; Roberts, 1971). Mackenzie (1970), however, concluded that goats are free from the highly infectious diseases that afflict the genital tract of cattle. Occasionally there is sporadic abortion among goats as a result of contagious

abortion in associated cattle, but goats are relatively resistant.

Non-infectious infertility may result from heat stress, hereditary factors, nutritional deficiencies, hormonal imbalances, plants, particularly phytoestrogenic, and ageing of ova and spermatozoa.

Van Heerden (1963) suggested that the adverse influence of high ambient temperature on female reproduction may be as a result of:

1. suppression of oestrus, resulting in periods of anoestrus;
2. interference with ovulation; and
3. interruption of early pregnancy by embryonic resorption and even occasional abortion of a well-grown foetus.

Dutt et al. (1956) found that exposing ewes before breeding to 90°F temperature (a rectal temperature of 105.0°F) reduced the number of fertilized ova to 42.9% compared to 92.9% for the control ewes with rectal temperatures of 102.4°F. Percentage of abnormal ova rose from 7.1 for the controls to 57.1 for the experimental ewes. In an identical experiment with the ewes being bred before exposure to high temperature, they found that

32-35 days after breeding 100% of the controls and 90% of the experimental ewes were pregnant. They concluded that elevated environmental temperature affected the fertility and normalcy of ovine ova more severely than embryonic survival. Stott and Williams (1962) concluded that low rate of fertilization and a high rate of embryonic mortality were major factors causing the low seasonal breeding efficiency associated with high ambient temperature and humidity. Gangwar et al. (1965) found that in cattle, under high ambient temperatures such as are found in the tropics and subtropics, expression of oestrus was depressed, oestrus was shortened, and anoestrus became a more important problem than under cool climatic conditions. Ulberg and Burfening (1967) demonstrated that stress of a slight increase in temperature for a short period acted on either the ova or spermatozoa before fertilization to cause the death of the resulting embryo sometime later in its development. Gutierrez et al. (1968) depressed ovarian activities in both Brahman and Hereford heifers by exposing them to 32°C and 96% relative humidity.

Hereditary factors that may cause infertility include ovarian hypoplasia, nymphomania, prolapse of the vagina, and segmental aplasia of the Mullerian ducts (Lagerlof, 1963;

Dawson, 1970). Treatment of any such cases is contraindicated (Lagerlof, 1963).

Level of Feeding

Undernutrition prevents or retards maturation of reproductive organs in immature animals. In mature female adults it causes ovarian atrophy with decreased number of vesicular follicles, which in turn leads to anoestrus (Leathem, 1966). He indicated gonadal hypofunction during acute and chronic starvation was primarily due to diminished levels of gonadotropins. Allen and Lamming (1961) suggested that the effect of undernutrition on reproduction in ewes involved reduced gonadotropin release by the hypophysis. Dawson (1970), based on studies on the effect of low protein intake on reproduction, pointed out that since follicle maturation and hence oestrus depends on gonadotropins, which are protein in nature, that anoestrus in animals on low energy diets was unlikely to be a direct effect, but secondary to protein deficiency.

Several studies have demonstrated the effect of undernutrition on reproductive efficiency in ruminants.

McClure (1965) improve the fertility in a lactating dairy herd by supplementing pastures with daily intake of 12-14 lb of oat, clover and ryegrass hay from parturition until three weeks after mating. The supplementation did not affect oestrus which occurred about the same time in both supplemented and control groups. Carroll and Hoerlein (1966) in Colorado noted that the conception rate in beef cattle fell to less than half under drought conditions. The rate more than doubled the following year due to above-average rainfall. They attributed the low reproductive efficiency to reduced feed intake. Hill et al. (1970) observed that reduced energy and protein intake from day 5 of oestrous cycle to day 18 after mating lengthened the oestrous cycle, decreased the number of medium-sized ovarian follicles, reduced the weight of corpora lutea and plasma level of progesterone, and decreased fertility. They found no significant effect on the level of luteinizing hormone. Little (1975) hastened post-partum oestrus in a pastured beef herd by protein and phosphorus supplements and less so by phosphorus alone.

Reid (1960) summarized the effect of overfeeding on reproduction in cattle and sheep. In cattle, high energy intake hastens sexual maturity but such cows have shorter reproductive

life than those raised on low energy intake. In both cattle and sheep once the oestrous cycle has started, its regularity is not affected by level of energy intake although severe restriction leads to cessation of oestrus. High energy intake shortens the length of the oestrous cycle. The birth weight of calves varies directly with the level of energy intake of their dams. High energy intake by heifers from time of birth to first calving increased the number of services required for the next pregnancy.

Lamond et al. (1973) found that ewes on high energy intake had lower fertility than those on pasture which they attributed to low fertilization rates. Poor fertility was also noted in ewes on low energy intake but this was due to low ovulation rate.

Vitamin Deficiency

Vitamin A.

Vitamin A is a compound that exerts a number of important biological effects. It is necessary for vision and reproduction and it is involved in maintenance of epithelial integrity.

Mitchell (1967) regarded vitamin A as the most important vitamin to be considered in feeding ruminants, especially cattle.

Marks (1974) summarized absorption of vitamin A from the intestines. The vitamin is obtained in the diet either as preformed vitamin A or as its precursor, carotene, which is then converted into vitamin A in the intestinal epithelium. The most important and effective carotenoid is β-carotene which is cleaved into two molecules of retinal by β-carotene-15, 15'dioxygenase. The resulting retinal is reduced to retinol by a non-specific aldehyde reductase. Dietary retinyl esters, mainly retinyl palmitate, are hydrolyzed by both pancreatic retinyl ester hydrolase and a hydrolase associated with the outer surface of the brush border of the absorptive cells. The free retinol is then absorbed into the intestinal mucosal cells. Peterson et al. (1974) stated that newly absorbed vitamin A (retinol) is transported together with chylomicrons from the intestines to the liver, the main storage site for vitamin A. It is virtually all stored in the hepatocytes. From the liver, vitamin A in its alcoholic form is transported in plasma to various target cells by a specific carrier protein, retinol-binding protein. The dog, pig, rat, monkey, and man

have similar retinol transport systems (Goodman, 1974). These species have retinol-binding protein with molecular weight of about 20,000, same mobility on electrophoresis, and similar ultraviolet absorption spectra.

The main active form of vitamin A in mammalian tissues is all-trans-retinol, and this is the form in which it is presented to target tissues. It is oxidized to aldehyde retinol and combined with opsin for scotopic vision in the rods. There is further oxidation to retinoic acid for maintenance of epithelial integrity. For reproductive activity, it appears the active form is retinol itself (Marks, 1974). Retinol and retinal are interconvertible in vivo. The reaction to retinoic acid is irreversible, the acid cannot be stored in the body so that it cannot provide total protection against vitamin A deficiency.

Roberts (1971) indicated that vitamin A deficiency adversely affects reproduction in most species. In the goat, deficiency does not affect regularity of oestrus, but causes changes in the lining of the endometrium which makes conception difficult and early abortion probable (Mackenzie, 1970). Roberts (1971) stated that vitamin A-deficient cows cycle normally, ovulate, conceive, and early fetal development is normal. Later, however,

there may be keratinization and degeneration of the placenta. There could be foetal death, abortion, dystocia, retained placenta and septic metritis. In breeding cows, oestrus may continue but fertility is impaired. Deficiency in pregnant animals, if sufficiently severe, could result in abortion, stillbirths, or birth of weak or blind calves. Retained placenta is common (Anon., 1970). Branton (1970) included anoestrus as a manifestation of vitamin A deficiency. Church (1971) stated that cows depleted of vitamin A remain fertile although breeding efficiency may drop. These cows tend to calve earlier than expected and there is a greater incidence of retained placenta. Abortions may occur several weeks to two to three months before term. Byers et al. (1956) found that calves from vitamin A-depleted cows had degeneration of the optic nerve and hydrocephalus. Such calves often are stillborn or weak at birth and die shortly after. Nicholson and Cunningham (1965) produced abortion and placenta retention in cows by feeding barley alone combined with inadequate daily vitamin A supplementation. Bargai and Egyed (1964) observed that 39% of calves in an Israeli beef herd were born dead during a six-month period. Serum carotene and vitamin A levels in the cows were found to be low. A severe vitamin A

deficiency in sheep can result in stillborn, weak or malformed lambs (Anon. 1968).

Carotene is abundant in good pastures and well-cured hay. It is also available in good silage. Animals having access to these are not likely to suffer from vitamin A deficiency. Deficiency can develop in range cattle during or following dry seasons or during prolonged drought if the cattle are maintained solely on sun-dried and bleached grasses (Branton, 1970; Dawson, 1970). For the northern grazing areas of Nigeria this would be an important factor since rainfall, sufficient to support green grass, falls for four to six month of the year. Ruminants in these areas are likely to be low in vitamin A during the latter part of the dry season.

The long dry season also affects the protein content of grasses so that grazing animals would also be low on protein. Since transport of vitamin A is dependent on a specific binding protein (Peterson et al., 1974), inadequate protein could contribute towards vitamin A deficiency. Marks (1974) stated that since protein is associated with vitamin A transport and that protein deficiency commonly coexists with vitamin A deficiency, retinol deficiency is accentuated. Such a situation is likely to be prevalent in the Sahelian and Guinea savanna zones of Nigeria.

Vitamin C

Vitamin C deficiency does not occur in cattle (Roberts, 1971) and no deficiency has ever been reported in goats (Mackenzie, 1970). Ruminants synthesize an abundance of vitamin C in the rumen so that it is not a limiting factor to reproduction (Anon., 1968, 1970).

Vitamin D

Some authorities indicate that vitamin D is necessary for normal health and reproduction. In pregnant dairy cows, vitamin D deficiency may result in birth of dead, weak or deformed calves (Anon., 1970). Wallis (1938) found that a deficiency of vitamin D resulted in rickets in calves, decline in health of older cattle, and anoestrus in cows. Hignett and Hignett (1953), however, suggested that the effect of vitamin D on reproduction was indirect, and that deficiency affected reproductive efficiency only when the intake of phosphorus and calcium was out of balance. Furthermore, as vitamin D reserve becomes depleted, the effect of sub-optimal intakes of phosphorus and calcium begin to show. This view was shared by Meites (1953) who stated that an uncomplicated

deficiency of vitamin D did not impair mammalian reproductive efficiency.

Animals are able to synthesize enough vitamin D if given free access to sunlight. Mackenzie (1970) stated that for goats on a moderate diet with a moderate yield that we need look no further than open air for vitamin D supply. A deficiency of vitamin D is unlikely in the tropics because of long hours of annual sunshine. Sun-cured hay is also good source of vitamin D.

Vitamin E

Roberts (1971) expressed the doubt that the herbivores' need of vitamin E for reproduction exceeds the quantity liberally available in the natural feed. He stated that cows reproduce on a vitamin E-deficient diet. Gullickson et al. (1949) also demonstrated that this vitamin is not necessary for normal reproduction in cattle.

Mineral Deficiency

The problem of mineral deficiency and its limitation on reproduction usually become apparent as other causes of infertility - protein and energy shortages, infectious and parasitic diseases - are brought under control. As these limitations are increasingly recognized and rectified, local mineral deficiencies will inevitably be brought into sharper focus (Underwood, 1966).

Underwood (1966) pointed out that mineral malnutrition problems arise as a result of interplay between soil, feed, climate, and animal and as a result of some alterations imposed by man on these factors.

Phosphorus

Phosphorus deficiency occurs in natural pastures in many parts of the world (Underwood, 1966; Dawson, 1970; Church, 1971). It results from soils low in phosphorus. Animals grazing these pastures become phosphorus-deficient if grazing constitutes the only source of feed as it does for beef cattle in many parts of the world and especially in the tropics. The situation is aggravated by prolonged dry periods during the year. Since

phosphorus is associated with the active vegetative growth stage of plants, the phosphorus content of forage diminishes with maturity. This leaves the animal, as its only source of phosphorus, forage which is mature, dormant and very low in phosphorus. Phosphorus deficiency can also occur in animals, not as a result of low content in the diet, but due to a superabundance of calcium in the diet, which prevents the digestion of available phosphorus (Mackenzie, 1970).

The universality of phosphorus deficiency is illustrated by related but independent studies conducted in various parts of the world: South Africa (Theiler et al., 1928; Malan et al., 1928); Scotland (Dunlop, 1947); Brazil (Sutmoller, 1961); U.S.A. (Morrow, 1969); Botswana (Reed et al., 1974), and Australia (Little, 1975). These studies demonstrated low levels of phosphorus in animal or plant tissues, and elevated blood phosphorus levels and improved reproductive performance of farm animals by phosphate supplementation. With respect to West Africa, limited studies in Ghana and Nigeria of feeding trials, chemical analyses of herbage, and soil fertilization trials confirmed the existence of phosphorus deficiency. Lansbury (1962) refers to unpublished work of Rose-Innes and Lansbury on chemical composition of natural savannah herbage of

Accra plains in Ghana. They obtained a mean digestible protein content of 2% and mean phosphorus content of 0.06%, both regarded as very low levels. Analyses of Shika (ABU farm, Nigeria) roughages and bush grass revealed lower phosphorus values than normal for similar roughages and grass (Umoh and Koch, 1971). Kapu (1975) found that, in general, the mean values for phosphorus in grasses, browse and standing hays from various parts of Northern Nigeria were inadequate to meet the nutritional needs of cattle. He suggested phosphate supplementation. Goldsworthy and Heathcote (1966) by applying superphosphate to soil in Samaru, Nigeria, noted a yield in sorghum grain that more than doubled the yield from untreated soil. Hagger (1969) in Shika, observed that each pound of superphosphate applied to sown Gamba grass (Andropogon gayanus) gave a mean return of 37 lb dry matter per acre. Hagger (1971), again in Shika, obtained a significant increase in dry matter yield from Stylasanthes gracilis and Chloris gayana pasture when phosphate was applied at rates up to 60 lb superphosphate per acre.

The first evidence of phosphorus deficiency in livestock is a fall in plasma level of inorganic phosphorus (Simesen, 1963; Underwood, 1966; Church, 1971). The reason for this is

that bone phosphorus is less readily mobilized to maintain serum level of phosphorus than bone calcium. Plasma or serum inorganic phosphorus determination is, therefore, the most sensitive index and the most satisfactory single diagnostic tool for early detection of phosphorus deficiency in animals.

Phosphorus is intimately associated with the normal function of all animal tissues by virtue of its role in energy transfer. It is also involved in various aspects of absorption and it is an integral part of protein molecules that make up soft tissues of the body as well as being a constituent of nucleic acid (Underwood, 1966; Church, 1971). The consequences of phosphorus deficiency are depressed feed intake, depraved appetite, poor food utilization, slow growth rate, weak bones, low milk production, and poor reproductive performance (Underwood, 1966; Little, 1970). With relative or sub-clinical deficiency, essential body functions continue. Severe and prolonged deficiency leads to a call on skeletal reserves to maintain the essential functions and this leads to skeletal disorders if depletion persists. Depraved appetite may lead to osteophagia and possibly botulism (Blood and Henderson, 1968).

There are conflicting views on the effects of phosphorus on reproduction and on the possible mechanisms involved.

Eckles et al. (1935) found no evidence that phosphorus deficiency caused abnormal oestrus although it admittedly reduced breeding efficiency. They concluded that oestrous disturbance and low calf crop in phosphorus-deficient areas under natural conditions should not be attributed to phosphorus deficiency alone. They suggested that the lowered fertility was probably due to complicated nutritive deficiencies which exist under such conditions. Underwood (1966), however, is unequivocal about the reproductive disturbance that accompanies phosphorus deficiency. He emphasized that poor lamb and calf crops are a regular feature of flocks and herds confined to phosphorus-deficient grazing. He attributed the lowered fertility to inhibition, depression or irregularity of oestrus which prevented or delayed conception. He maintained that this was a specific effect of phosphorus deficiency.

Hignett and Hignett (1952) found that a minimum daily intake of about 50 g P_2O_5 by housed heifers was necessary for satisfactory fertility. High phosphorus intake of 45 g P_2O_5 was necessary to reduce the incidence of anoestrus and irregular oestrus and to establish pregnancy at first insemination. They concluded that with constant carbohydrate and protein intakes, ovarian activity is influenced markedly by the amount of

phosphorus consumed. In an earlier study, Hignett and Hignett (1951) observed 70% conception rate at first service in cows receiving 50 g P_2O_5 daily for maintenance compared with 53% conception rate in cows receiving only 23 g. The improvement in fertility became more striking when the daily maintenance intake was increased to 60 g and the production intake increased from 19 to 31 g. Dunlop (1947) obtained higher calf birth weights and improved general fertility rate when he fed steamed bone meal to cattle on hill grazing. Theiler et al. (1928) obtained 80% calf crop by giving bone meal ration to cows, compared to 51% calf crop in the non-supplemented control herd. Little (1970) cited Bisschop's study with 67% mean calving in phosphorus-supplemented cows compared with 48% for the controls. Morrow (1969) reduced the number of services per conception from 3.7 to 1.3 and increased conception rate from 27% to 76% by feeding dicalcium phosphate ad lib. to dairy heifers grazing on phosphorus-deficient pastures. Little (1975) by supplying sodium dihydrogen phosphate (NaH_2PO_4) to cows during pregnancy reduced the interval between calving and the first post-partum oestrus. This treatment also increased the percentage of cows in oestrus by 8 weeks post-partum. Protein in addition to phosphorus, however, gave better results than phosphorus alone.

In Nigeria, Adegbola (1971) referred to infertility in a Bunaji (White Fulani) herd at Moore Plantation, Ibadan, which was corrected by calcium and phosphate mineral supplements. This treatment also reduced annual mortality rate from 60% to 25% and 10% in two succeeding years, respectively. Lansbury (1962) referred to two unpublished studies by Miller and by Lansbury and Montsma in Nigeria and Ghana, respectively, in which cattle gave substantial responses to phosphate supplementation. The nature of "response" obtained in these studies was not indicated. Lansbury (1962) pointed out that the low rates of reproduction, short heat periods, and slow growth observed in West African cattle have never been attributed officially to phosphorus deficiency, but that few serious attempts have been made to ascertain the importance of phosphorus deficiency. He warned that more acute phosphorus deficiency may arise as efforts are made to improve the size, growth rate, and reproduction of cattle of West Africa by improving breeding and management.

In goats, phosphorus deficiency is chronic and the signs are mild and temporary with lowered productivity being the main feature (Mackenzie, 1970).

Calcium

Calcium deficiency does not cause reproductive failure in cattle (Roberts, 1971). However, the Ca:P ratio influences fertility. Hignett and Hignett (1951) found that low phosphorus and high calcium intakes resulted in a low fertility rate, the same was true of high phosphorus and low calcium intakes. When phosphorus intake was high, a rising calcium intake improved fertility rate within a certain range of calcium increase. Littlejohn and Lewis (1960), however, found fertility in dairy heifers was not affected by calcium and phosphorus imbalance.

Magnesium

Magnesium has no direct bearing on fertility. Magnesium metabolism, however, is closely related to that of calcium and phosphorus (Anon., 1968; Mackenzie, 1970; Irving, 1973). Hypomagnesaemic tetany in cows and ewes is sometimes accompanied by hypocalcemia and by low, normal or high serum inorganic phosphorus (Underwood, 1966; Anon., 1968).

Iodine

Iodine deficiency affects foetal and neonatal survival in farm animals. Underwood (1966) stated that with iodine deficiency, foetal development may cease at any stage of pregnancy leading to early foetal death and resorption, abortion, stillbirth or the birth of weak, hairless or dead young. Newborn lambs frequently have enlarged thyroid glands or are born dead, weak or woolless (Anon., 1968). In cattle, deficiency is manifested by birth of weak goitrous, or dead calves (Anon., 1970). In goats, there is a sex difference in foetal response to iodine deficiency; female kids, are either stillborn or weak with early neonatal death while the males are born normal (Mackenzie, 1970). He attributed the difference to bigger thyroid glands and a greater need for iodine in the female. Underwood (1966) stated that iodine deficiency also leads to infertility or sterility in cattle as a result of irregular or suppressed oestrus. This view was shared by Mackenzie (1970). He suggested that iodine deficiency leads to some aspects of infertility as a consequence to vitamin A deficiency which may follow iodine deficiency since thyroid activity affects the animal's ability to assimilate vitamin A or carotene.

Manganese

Reproductive disorders in adult cows are among the early signs of manganese deficiency; these include delayed oestrus and conception, abortions and birth of deformed calves (Underwood, 1966; Anon., 1970). Wilson (1966) observed a marked improvement in conception rate in several herds following manganese sulphate supplementation. Analysis of soil on which these herds grazed revealed low available manganese. Signs of manganese deficiency also develop, as a result of environmental factors, such as high CaO intake, when cows are unable to absorb or utilize manganese available in the feed (Underwood, 1966; Wilson, 1966).

Copper

In cattle, gross deficiency of copper leads to inanition and anoestrus is common, although some herds with low blood copper levels have maintained high conception rates (Hignett, 1963). Copper deficiency does not affect the size of the lamb crop although it can lead to marked reduction in the number of viable lambs due to swayback (Hignett, 1963). Lambs may be born weak and subsequently die due to their inability to nurse

(Anon., 1968). In goats copper deficiency is characterized by irregular lengths of oestrous cycle and return to service at irregular intervals (Mackenzie, 1970).

Pickering (1975) reported that copper deficiency lengthens the oestrous cycle and depresses fertility. Three weeks following copper administration, the oestrous cycle in a herd of about 100 Ayrshire copper-deficient cows was reduced from 24 days to 21 days. The same treatment increased the conception rate from less than 5% to 60% within four months.

Cobalt

Cobalt deficiency in cattle leads to loss of appetite, inanition, secondary failure of oestrus, and delayed onset of puberty (Roberts, 1971). In sheep it is accompanied by reduced fertility (Anon., 1968).

Selenium

Selenium is an essential nutrient but its exact metabolic function is uncertain. Studies on "selenium-responsive" diseases have revealed that selenium has a much wider and less specific effect on animal health than previously thought

(Blood and Henderson, 1968). These diseases include white muscle disease, neonatal mortality, unthriftiness in weaner ruminants, and foetal resorption in ewes. The ovine infertility syndrome can be prevented by pre-mating and pre-lambing treatment with selenium (Hartley, 1963). The effect of selenium on cattle reproduction is unknown.

Nutrition-Infectious Disease Interaction

Well-fed animals are more resistant to infection than those inadequately nourished (Whitehair, 1969). A notable exception to this is viral infections.

Nutrition aids protection against bacterial diseases by maintaining tissue integrity, enhancing antibody production since immune substances are proteins, sustaining the liver's ability to detoxify toxic substances from bacterial metabolism and maintaining reticulo-endothelial activity. Bacterial infections such as brucellosis, vibriosis, trichomoniasis and leptospirosis may cause infertility and reproductive failure because of direct effects on the genital tract. Other infections may affect fertility indirectly through their effects on the general health of the host.

Parasitic infestation may be a complicating factor to successful reproduction. Branton (1970) stated that there is no evidence that internal and external parasites have much direct effect on reproduction, but that reproduction is affected indirectly as a result of an adverse effect on the host's health. Internal parasites utilize the host's food and blood. Liver fluke and coccidia infestations may lead to vitamin A deficiency (Usui et al., 1960; Mackenzie, 1970). The former causes cirrhosis with a resultant reduced ability to store vitamin A while the latter may block carotene absorption. In this way, these organisms may induce infertility signs characteristic of vitamin A deficiency.

In many African crountries tsetse flies (Glossina spp.) continue to be a major constraint to the development of cattle and other livestock industries (Shaw, 1962). The blood parasites transmitted by the flies cause trypanosomiasis which is characterized by anaemia and general unthriftiness leading indirectly to reduced reproductive efficiency. The reproductive conditions considered to be associated with bovine trypanosomiasis include anoestrus, infertility, abortion, premature births, stillbirths, and non-viable calves (Nuru, 1974).

Reproductive Efficiency of Indigenous Ruminants

Reproductive efficiency of cattle indigenous to Nigeria is low (Wheat and Broadhurst, 1968, 1972; Lamorde and Weinman, 1972; Zemjanis, 1974; Nuru, 1974). This is considered to be due to nutritional, managerial, and disease factors, or by their interactions. Approximately 90 per cent of the national herd of approximately nine million cattle grazing in the savanna zone of Nigeria are owned by nomadic Fulanis. Because their traditional husbandry methods are non-production-oriented, the reproductive efficiency of Fulani cattle is low (Osori, 1976). The little that is known of the reproductive performance of Fulani cattle has resulted from a few surveys (Wheat and Broadhurst, 1968, 1972; Lamorde and Weinman, 1972; Nuru, 1974). Except for government livestock improvement breeding centres (LIBC), reproductive records are virtually non-existent.

The following information concerning Bunaji (White Fulani) cows came from analysis of LIBC records: average age at first calving 42 months, average calving interval of 436 days, annual calf crop of 60 per cent, total of four calves produced per cow, and a generation interval of 72 to 75 months (Wheat and Broadhurst,

1968; 1972). The age of nomadic Bunaji cows at first calving, however, ranged from four and half to seven years (Lamorde and Weinman, 1972). Nuru (1974) reported an average age at conception in the LIBC's of two and half years in contrast to three and half years in nomadic herds. The available survey information on the reproductive performance of cattle indigenous to Nigeria was summarized by Zemjanis (1974):

	Nomadic Cattle	LIBC'S
Age at First Calving (mths)	60	40
Calving Interval (mths)	17-24	16-18
Annual Calf Crop (%)	40	60
Total No. Calves Produced	2½	4

The percentage of Fulani herds with regular conception by Fulani criterion (mature cow having a calf every other year) varied from 60 to 97.1 and the percentage reporting repeat breeding varied from 16.6 to 58.8 (Nuru, 1974).

Information obtained by survey and analysis of LIBC records suggested a seasonal breeding pattern in cattle (Wheat and Broadhurst, 1968, 1972; Lamorde and Weinman, 1972; Nuru, 1974). Studies by Osori (1976) indicated that cows indigenous

to Nigeria are seasonal breeders with peak activity during the rainy and pre-dry seasons (June to December). For maximum reproductive efficiency under prevailing conditions of husbandry, he recommended that cows be bred during July and August.

Although sporadic abortions in cattle have been reported since 1930, the causes were usually unknown. Brucellosis and trypanosomiasis were considered to be the main causes (Nuru, 1974). The prevalence of bovine abortion and infertility from these and other causes have not been documented in Nigeria. Nomadic Fulanis consider trypanosomiasis to be an important cause of bovine abortion after nutritional deficiencies (MacGregor, 1962; Nuru, 1974).

From their survey, Lamorde and Weinman (1972) reported 12.4% abortions in Fulani herds and 3.9% in government herds but no information as to the possible causes. In a survey involving six Northern States of Nigeria, Nuru (1974) found that bovine abortion was more widespread in the savanna grazing areas than previously thought. The survey, however, gave no information as to causes or financial loss involved.

With exception of sporadic serologic surveys for brucellosis, there is little information on the causes of bovine abortion in Nigeria. The overall infection rate for bovine brucellosis in six Northern States was found to be 6.0%; 7.1% in Fulani herds and 3.6% in government herds (Nuru and Dennis, 1975).

Information on the reproductive efficiency of sheep and goats indigenous to Nigeria is lacking.

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PART II

SEASONAL CHANGES IN PLASMA PHOSPHORUS, CALCIUM AND MAGNESIUM, AND PLASMA AND HEPATIC VITAMIN A VALUES IN BUNAJI CATTLE AND GOATS

INTRODUCTION

Phosphorus and vitamin A deficiencies reduce reproductive efficiency in most species (Hignett and Hignett, 1951, 1952; Underwood, 1966; Anon., 1968; Mackenzie, 1970; Roberts, 1971). Phosphorus deficiency in livestock occurs in many countries and primarily results from phosphorus-deficient soils giving rise to phosphorus-deficient pastures (Underwood, 1966). The universality of phosphorus deficiency is illustrated by several documented studies in various parts of the world (Theiler, 1928; Dunlop, 1947; Sutmoller, 1961; Morrow, 1969; Reed et al., 1974; Little, 1975). The low phosphorus content of pastures diminishes further as plants attain maturity.

Feed and herbage analyses as well as soil fertilization trials, revealed that plants and soils in Nigeria are phosphorus-deficient (Goldsworthy and Heathcote, 1966; Hagger, 1969, 1971; Umoh and Koch, 1971; Kapu, 1975). The northern grazing areas of Nigeria are characterized by a long dry season which further reduces the phosphorus content of grasses and plants. Ruminants in these grazing areas are not only likely to be low in phosphorus but also subjected to seasonal fluctuations in the phosphorus

content of the pastures which constitutes the sole source of feed. The vitamin A status of ruminants in the northern grazing areas of Nigeria is also affected by seasonal variations since these animals are compelled to survive during the dry season on dry and bleached grasses which are low in carotene, the vitamin A precursor.

This study was carried out to determine seasonal variations in plasma phosphorus, calcium and magnesium and plasma and hepatic vitamin A levels of cattle and goats in the savanna area of Nigeria.

MATERIALS AND METHODS

Survey Area

The survey was carried out in Kano and Kaduna States from August 1975 to April 1976. Samples were collected from Kano and Kaduna abattoirs and from the Kano Government ranch at Bunkure, 32 km from Kano (Appendix 1). A preliminary study in July to September, 1974, involved a local cattle herd at Yakase, 13 km from Zaria, Kaduna State.

Kano and Bunkure are located in the Sudan savanna zone and Kaduna and Zaria in the Northern Guinea savanna zone. These areas are characterized by a rainy season of variable length; Kaduna 6 to 7 months, Zaria 5 to 6 months, and Kano 4 to 5 months. The first rains usually occur in March or April, April and May, respectively (Appendix 2, Table 1).

Animals

The animals were female Bunaji (White Fulani) cattle and Kano Brown goats slaughtered at Kano and Kaduna abattoirs, and Bunaji cows from the Bunkure ranch in Kano State and from a local herd at Yakase, Kaduna State. By dental examination, the cattle were estimated to be five years of age or over and the goats, one-and-half years or more. The cattle slaughtered at Kano and Kaduna were purchased from surrounding cattle markets and at Kano, some also came from Niger and Chad. Goats were purchased from markets in the vicinity of Kano and Kaduna.

Collection of Samples

Samples were collected in August/September 1975 (rainy season), January/February 1976 (early dry season), and April 1976 (late dry season). As animals were slaughtered 20 ml of blood was collected in sterile test tubes containing heparin as an anticoagulant and then gently mixed. Approximately 5 g from the ventral tip of the caudate lobe of the liver was removed, placed in a sterilized 30 g screw-capped bottle. Plasma from the blood samples was decanted into sterile test tubes following centrifugation in a small portable centrifuge. The plasma and liver samples were transported to the laboratory in an insulated, cool box containing ice, and then kept frozen at -20°C until used for biochemical analyses.

At Bunkure and Yakase, 20 ml of blood was collected from the cows with a sterile syringe via the jugular vein. The blood was transferred to a sterile test tube containing heparin, gently mixed, and placed in an insulated, cool box containing ice. The samples were taken to the laboratory, centrifuged at 3000 rpm for 10 minutes, the plasma decanted into sterile tubes, and then frozen at -20C until analyzed. All sampling began at 0800 hours.

All glassware was thoroughly washed and rinsed thrice in distilled water.

Biochemical Procedures

Inorganic Phosphorus: Samples were analyzed by the modified method described by Fiske and Subbarow (1925). The concentration of standards used was 0, 2, 4, 6, and 8 mg/100 ml. Each sample or standard was run in duplicate and the mean absorbance for each determined. Utilizing the absorbance for the standards, the slope of the regression line was calculated from the following formula:

$$b = \frac{\sum (x_i - \bar{x})\ (y_i - \bar{y})}{\sum (x_i - \bar{x})^2} \quad \text{..... Eq. 1}$$

where:

b = slope of the regression line

x_i = value of phosphorus concentration in different standard (mg/100 ml)

$\bar{x}$ = mean value of phosphorus concentration of all standards (mg/100 ml)

y_i = absorbance for different standards (nm)

$\bar{y}$ = mean absorbance for all standards (nm)

The mean phosphorus concentration for each sample was calculated from the regression equation:

$$Y_i - \bar{y} = b(X_i - \bar{x}) \quad \text{..... Eq.2}$$

Where:

Y_i = mean absorbance for the sample (nm)

$\bar{y}$ = mean absorbance for all standards (nm)

b = slope of the regression line

X_i = phosphorus concentration for the sample (mg/100 ml)

$\bar{x}$ = mean phosphorus for all standards (mg/100 ml)

Equation 2 was solved for X_i as follows:

$$X_i = \frac{Y_i - \bar{y} + b\bar{x}}{b} \quad \text{..... Eq. 3}$$

Calcium and Magnesium: Plasma calcium and magnesium were determined with an atomic absorption spectrophotometer as described by Willis (1960a, b, 1961). The samples were diluted 1:50 with 0.1% (w/v) strontium chloride to eliminate possible phosphate interference with calcium determination.

Plasma Vitamin A: Plasma vitamin A was determined spectrophotometrically[2] by the method of Sobel and Snow (1947). Colorimetric reaction was obtained by using 1, 3-dichloro-2-propanol[3]. Concentration of vitamin A standards[4] was 1, 2, 3, and 4ug/ml. Concentration of carotene standards[5] was 2, 4, 8, and 10ug/ml. The colorimetric readings of the carotene standards were used to calculate the carotene levels in the plasma and the interference of plasma carotene concentration on the colorimetric reaction between plasma vitamin A and 1, 3-dichloro-2-propanol. Concentrations of vitamin A and carotene in the plasma samples were calculated from the colorimetric readings of their respective standards by the same equations used for determining phosphorus. Absorbance interference by the presence of plasma carotene was calculated by the following equation:

$$Y_i = bX_i - b\bar{x} + \bar{y}$$

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1 Model 306, Perkin Elmer Corp., Norwalk, Conn., USA
2 Spectronic 20, Bausch and Lomb, Rochester, N.Y., USA
3 Eastman Kodak Company, Rochester, N.Y., USA
4 U.S.P. Reference Standards Rockville, Md., USA
5 Roche Products Ltd., Welwyn Garden City, Herts, England

where:

Y_i = sample absorbance at 550 nm

b = slope of carotene standard curve at 550 nm

X_i = carotene concentration in sample (µg/ml)

$\bar{x}$ = mean carotene concentration for all standards (µg/ml)

$\bar{y}$ = mean absorbance for all carotene standards at 550 nm

Hepatic Vitamin A: Liver vitamin A concentration was determined by the method of Ames et al. (1954) but modified by using 1, 3-dichloro-2-propanol instead of antimony trichloride. Concentration of vitamin A standards was 4, 8, 12, and 16µg/ml. Concentration of vitamin A in the liver samples was calculated by the regression equation used for determining inorganic phosphorus.

RESULTS

Seasonal mean values for plasma phosphorus, calcium and magnesium, and plasma and hepatic vitamin A, together with the mean monthly rainfall, are presented in Tables 1-6 and Figs. 1-11, and the individual values in Appendix 2 (Tables 2-12).

Cattle

A distinct seasonal variation was observed in the plasma phosphorus values from Bunkure and Kano; the peak occurred with pasture growth during the rainy season (August-September). The mean phosphorus values for August-September, January-February, and April for Bunkure were 5.7 $\pm$ 1.25, 4.88 $\pm$ 1.25, and 4.72 $\pm$ 0.92 and for Kano, 7.45 $\pm$ 1.93, 5.72 $\pm$ 1.51, and 5.07 $\pm$ 1.69, respectively. The higher rainy season values over those for the dry season in Bunkure and Kano were significant ($P < 0.01$). The Kaduna samples had a different pattern with a slight peak during February which was not significant.

Calcium levels increased significantly from the rainy to the dry season in the samples from Bunkure ($P < 0.01$) but not

from Kano and Kaduna.

Plasma magnesium levels increased significantly from the rainy to the dry season for Bunkure ($P< 0.01$) and Kano ($P<0.05$) but not for Kaduna.

Except for Bunkure, the highest plasma values for vitamin A were obtained in the rainy season. The decrease from September to January for Kano and from August to February for Kaduna was significant ($P<0.05$). Dry season changes were variable; it decreased significantly from January to April for Bunkure ($P<0.05$), and rose between February and April for Kaduna. There was little difference between August and April values for Kaduna.

The hepatic vitamin A level fell significantly from August to February for Kaduna ($P< 0.01$), and less so from February to April. For Kano, the fall occurred only within the dry season from January to April ($P< 0.05$).

Goats

There was no significant season variation in the plasma phosphorus and calcium levels for both Kaduna and Kano (Tables 5-6).

There was a slight but non-significant increase in the plasma magnesium levels from the rainy to the dry season. For Kaduna, the increase was from August to February and for Kano, it was from September to April.

The plasma vitamin A levels varied slightly between seasons. For Kaduna, it dropped 8% from August to February and remained at this level. The level for Kano rose 9% from January to April. The hepatic vitamin A levels for both Kaduna and Kano decreased significantly from the rainy to the dry season ($P < 0.001$).

Preliminary Yakase Study

The plasma phosphorus levels were below the normal minimum of 4 mg% for cattle (Table 4). The August level was significantly higher than that for both July and September ($P < 0.05$).

Plasma calcium and magnesium levels were similar to but a little higher than those obtained in Kaduna, Kano, and Bunkure. The Ca:P ratio was imbalanced and ranged from 3.36–5.30 (Fig.11).

DISCUSSION

The reproductive performance of nomadic cattle in the northern grazing areas of Nigeria with its long dry season suggests phosphorus deficiency; calf every other year, failure of oestrus, and heifers not exhibiting oestrus until over two years of age (Roberts, 1971). The results of this survey did not confirm this from the three areas sampled, but results in the local nomadic herd, however, indicate that sub-clinical to clinical phosphorus deficiency is a factor in the low reproductive performance of indigenous cattle. This is supported by deficiency of phosphorus in all types of forage in the savanna grazing areas (Kapu, 1975).

The plasma phosphorus levels varied seasonally with significantly higher values during the rainy season. The levels generally fell progressively as the plants matured with the approaching dry season (Underwood, 1966). Similar seasonal variations in plasma phosphorus levels were found in Northern Nigeria (Osori, 1976; Akerejola, 1976) and in Botswana (Reed et al., 1974). Seasonal results obtained were similar to but slightly lower than the values in healthy male and

female Bunaji cattle at the Shika Research Station, 16 km. north-west of Samaru (Akerejola, 1976). Results of Osori's study indicated that ovarian activity of indigenous cattle peaked during and immediately after the rainy season and this may be a result of the seasonal variation in the plasma phosphorus levels.

Phosphorus levels in the local nomadic herd used for the preliminary study were very low even though the study was carried out during the rainy season, the period for higher plasma levels. The difference between these levels and the other three sampling sites was striking, 3 mg% and less compared to 4.5 to 6.5 mg% which is within the normal range of 4 to 8 mg% for cattle (Rapoport and Guest, 1941) and for the Bunaji breed (Oduye and Fasanmi, 1971; Akerejola, 1976). Plasma phosphorus levels below 4 mg% usually indicate deficiency and are deleterious to satisfactory reproductive efficiency (Roberts, 1971).

Wagner (1962) found lowered conception rate in several dairy herds with plasma phosphorus levels in the low normal range. Schultz et al. (1971) carried out chemical analyses on the plasma and uterine fluid collected from 88 normal adult Friesian cows during the various days of the oestrous

cycle and found that inorganic phosphorus levels in the plasma were 5.9 mg% or above for everyday except day 2 and in uterine fluid, it ranged from 10.9 to 32.8 mg%. These two studies suggest that a plasma phosphorus level in the high normal range is necessary for satisfactory reproductive efficiency in Bos taurus breeds. Morrow (1969) found that 2.1 and 2.8 services per conception were required when plasma phosphorus levels were 3.9 and 4.0 mg%, respectively; this declined to 1.3 services when the plasma level was increased to 6.5 mg%.

The absence of seasonal change in cows at Kaduna abattoir is difficult to explain. Kaduna is further south than Zaria and Kano and has a slightly longer rainy season. Similar findings were found for goats at both Kaduna and Kano abattoirs. The plasma phosphorus levels for goats was lower than the 6.8 to 8.4 mg% in whole blood reported in two goats by Rapoport and Guest (1941).

Plasma calcium and magnesium levels were similar to but the peaks were lower than the values reported for male and female Bunaji cattle (Akerejola, 1976).

Vitamin A deficiency does not cause bovine infertility but adversely affects pregnancy during the second half by abortion or birth of weak or dead calves (Roberts, 1971).

Plasma vitamin A levels in cattle, except for Bunkure in August 1975, were all within the normal range of 20 to 40 µg% (Morrow, 1969). Several individual values, however, were in the low range. A plasma level of 20 to 25 µg% is borderline to deficient (Church, 1971). This means that the plasma vitamin A levels found in Kano and Kaduna during the dry season are borderline for maintaining bovine pregnancy during the second half of gestation. Due to periodic power failures, vitamin A content of many plasma samples collected during the rainy season and held over six months were or tended to be labile (Appendix 2; Tables 3, 5 and 7).

Hepatic vitamin A levels for Kaduna fell progressively during the dry season but not to depletion. For Kano, there was no inter-seasonal variation but only within the dry season. The mean hepa ic levels of vitamin A did not fall below 69.20 µg/g liver, a finding similar to that for cattle in Ghana (Wharton, 1966). From November to April there are no green pastures in Northern Nigeria, the only source of carotene, vitamin A percursor, being leaves from shrubs and trees.

Vitamin A changes were more consistent in goats. There was little or no seasonal variation in the plasma levels of vitamin A but the hepatic levels fell slowly and then sharply until the end of the dry season.

Hepatic stores of vitamin A of cattle indigenous to West Africa tend to be higher than that of Bos taurus breeds in temperate zones (Wharton, 1966). Reported levels for lactating Jersey cows are 134.1 to 201 µg/g (Byers et al., 1955) and for range Hereford cows, 75 to 117 µg/g (Wheeler et al., 1957). The highest and lowest individual values of vitamin A in fresh liver in cows in Ghana was 61.7 and 475.8 µg/g, respectively. With the longer dry season in the savanna zone of Northern Nigeria, the hepatic values tend to be lower.

Cattle indigenous to West Africa can survive for extended periods without dietary carotene (Miller, 1961). He maintained Zebu x N'Dama steers for 28 weeks during the dry season in Nigeria on supplemented pasture plus 0, 1, and 20 mg carotene/100 lb. body weight/day. Cattle slaughtered at the beginning of the trial had hepatic vitamin A and carotene levels ranging from 104 to 267 and 24 to 43 µg/100 g dry matter, respectively. At the conclusion of the trial, the steers receiving no supplemented carotene had 4.7 µg carotene and 0.1 µg vitamin A per 100 g dry liver. Despite this depletion, clinical avitaminosis A was not observed and the unsupplemented steers gained as well as those receiving 20 mg

carotene daily, an average of approximately 0.3 lb/head/day. Evidence from Miller's and Wharton's studies suggests that cattle indigenous to West Africa do not require supplemental vitamin A during the dry season for minimal growth gains.

Vitamin A deficiency has been described in cattle grazing dry bleached pastures where protein, phosphorus, and carbohydrate intake were also possibly deficient - these conditions are typical of the savanna grazing areas of Nigeria during the long dry season. As liver can store considerable amounts of vitamin A for some time, avitaminosis A takes months to develop. Results of this study and that of Miller (1961) and Wharton (1966) indicate that clinical avitaminosis A is not as common as would be expected from factors such as the dry season and traditional nomadic methods of husbandry.

SUMMARY

A survey was carried out in Kaduna and Kano States of Nigeria to determine the plasma levels of phosphorus, calcium and magnesium, and plasma and hepatic vitamin A levels of

Bunaji (White Fulani) cows and Kano Brown does. A distinct seasonal variation was observed in the bovine plasma phosphorus values from Kano but not Kaduna State; the peak occurred with pasture growth during the rainy season ($P < 0.01$). The mean phosphorus values for August-September, January-February, and April for Bunkure and Kano, Kano State, were 5.7 ± 1.25, 4.88 ± 1.25, and 4.72 ± 0.92 and 7.45 ± 1.93, 5.72 ± 1.51, and 5.07 ± 1.69, respectively. Calcium levels increased significantly from the rainy to the dry season in Bunkure ($P < 0.01$) but not Kano and Kaduna. Plasma magnesium levels increased significantly in cows from the rainy to dry season for Bunkure ($P < 0.01$) and Kano ($P < 0.05$) but not for Kaduna. There was no significant seasonal variation in the caprine phosphorus calcium and magnesium levels.

Except for Bunkure, the highest plasma values for vitamin A in the cows occurred during the rainy season. The decrease from September to January for Kano and from August to February for Kaduna was significant ($P < 0.05$). Dry season changes were variable; it decreased significantly from January to April for Bunkure ($P < 0.05$), and rose between February and April for Kaduna. There was little difference between August and April values for Kaduna. The caprine plasma vitamin A level varied

slightly between seasons. The bovine hepatic vitamin A levels fell significantly from August to February for Kaduna ($P < 0.01$), and less so from February to April. For Kano, the fall occurred only within the dry season from January to April ($P < 0.05$). The hepatic vitamin A levels in goats decreased significantly from the rainy to the dry season ($P < 0.001$).

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Reed, J. B. H., Smith, S. D., Forbes, A. B., Finlay, R. S., Geering, I. W., Wright, J. D. and Doxey, D. L. (1974): A note on seasonal changes in serum inorganic phosphate levels of cattle in Botswana. Trop. anim. hlth. Prod. 6: 37-38.

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Table 1: Monthly rainfall, mean plasma mineral and vitamin A levels in cows from Bunkure.

Month	Rainfall (mm)	Phosphorus (mg/100ml)	Calcium (mg/100ml)	Ca:P ratio	Magnesium (mg/100ml)	Plasma Vit. A. (ug/100ml)
Aug.'75	224.0	5.70±1.25	9.30±1.34	1.63	1.79±0.18	6.92±13.63
Sept.	180.4	-	-		-	-
Oct.	0.0	-	-		-	-
Nov.	0.0	-	-		-	-
Dec.	0.0	-	-		-	-
Jan.'76	0.0	4.88±1.25	9.28±0.93	1.90	1.86±0.28	71.36±31.59
Feb.	2.3	-	-		-	-
Mar.	0.0	-	-		-	-
Apr.	0.0	4.72±0.92	11.86±1.67	2.51	3.24±0.66	45.85±23.05

Table 2: Monthly rainfall, mean plasma mineral levels and plasma and hepatic levels of vitamin A in cows from Kano abattoir.

Month	Rainfall (mm)	Phosphorus (mg/100ml)	Calcium (mg/100ml)	Ca:P ratio	Magnesium (mg/100ml)	Plasma Vit. A. (ug/100ml)	Liver Vit. A. (ug/g)
Aug.'75	224.0	-	-		-	-	-
Sept.	180.4	7.45±1.93	8.85±0.82	1.19	1.43±0.38	33.23±11.70	137.87±34.70
Oct.	0.0	-	-		-	-	-
Nov.	0.0	-	-		-	-	-
Dec.	0.0	-	-		-	-	-
Jan.'76	0.0	5.72±1.51	9.17±0.65	1.60	1.91±0.31	20.00±7.71	192.34±73.12
Feb.	2.3	-	-		-	-	-
Mar.	0.0	-	-		-	-	-
Apr.	0.0	5.07±1.69	8.86±0.96	1.75	1.94±0.31	21.23±11.29	137.87±88.45

Table 3: Monthly rainfal, mean and standard deviations for plasma and hepatic vitamin A, plasma minerals and levels in cows from Kaduna abattoir.

Month	Rainfall (mm)	Phosphorus (mg/100ml)	Calcium (mg/100ml)	Ca:P ratio	Magnesium (mg/100ml)	Plasma Vit. A (ug/100ml)	Liver Vit. A (ug/g)
Aug.'75	298.3	5.06±0.82	8.98±0.94	1.80	1.74±0.23	30.26±8.57	109.79±62.85
Sept.	293.8	-	-		-	-	-
Oct.	8.4	-	-		-	-	-
Nov.	0.0	-	-		-	-	-
Dec.	0.0	-	-		-	-	-
Jan.'76	0.0	-	-		-	-	-
Feb.	0.0	6.13±1.21	9.35±0.51	1.59	1.96±0.26	20.00±9.88	74.71±36.06
Mar.	0.0	-	-		-	-	-
Apr.	103.1[a]	5.78±1.84	9.51±0.82	1.89	2.09±0.30	28.79±16.09	69.30±33.84

[a] Sample was collected on April 5 before commencement of the wet season.

Table 4: Monthly rainfall and mean plasma levels of phosphorus, calcium and magnesium mg/100ml in nomadic cows in the preliminary trial at Kakase.

Month	Rainfall (mm)	Phosphorus	Calcium	Ca:P	Magnesium
July '74	399.3	2.48±0.75	10.16±0.61	4.10	2.09±0.27
Aug.	226.5	3.25±1.06	10.91±0.83	3.36	1.86±0.43
Sept.	189.9	2.14±0.88	11.35±0.96	5.30	2.47±0.20
Oct.	62.5				

Table 5: Monthly rainfall, mean plasma mineral levels and plasma and hepatic levels of vitamin A in goats from Kaduna abattoir.

Month	Rainfall (mm)	Phosphorus (mg/100ml)	Calcium (mg/100ml)	Ca:P ratio	Magnesium	Plasma Vit. A (ug/100ml)	Liver Vit. A (ug/g)
Aug.'75	298.3	6.34±1.70	9.03±0.73	1.42	1.93±0.15	28.4±5.6	183.8±114.0
Sept.	293.8	-	-		-	-	-
Oct.	8.4	-	-		-	-	-
Nov.	0.0	-	-		-	-	-
Dec.	0.0	-	-		-	-	-
Jan.'76	0.0	-	-		-	-	-
Feb.	0.0	6.39±1.82	9.41±2.22	1.47	2.29±0.58	26.2±0.0	158.9± 97.3
Mar.	0.0	-	-		-	-	-
Apr.	103.1*	6.66±1.53	9.30±0.79	1.40	1.98±0.29	26.8±7.7	67.2± 48.2

* Sample was collected on April 5, before first measurable rain.

Table 6: Monthly rainfall, mean plasma mineral levels and plasma and hepatic levels of vitamin A in goats from Kano abattoir.

Month	Rainfall (mm)	Phosphorus (mg/100ml)	Calcium (mg/100ml)	Ca:P ratio	Magnesium (mg/100ml)	Plasma Vit. A (ug/100ml)	Liver Vit. A (ug/g)
Aug.'75	224.0	-	-		-	-	-
Sept.	180.4	6.36±1.35	9.24±0.44	1.45	1.91±0.43	34.36±18.27	217.87±83.40
Oct.	0.0	-	-		-	-	-
Nov.	0.0	-	-		-	-	-
Dec.	0.0	-	-		-	-	-
Jan.'76	0.0	6.28±1.33	9.38±0.95	1.49	1.80±0.27	34.36±18.27	185.53±87.97
Feb.	2.3	-	-		-	-	-
Mar.	0.0	-	-		-	-	-
Apr.	0.0	6.08±1.62	9.27±0.83	1.52	2.02±0.38	37.43±10.83	79.99±40.34

Fig. 1. Mean plasma levels of phosphorus, calcium and magnesium (mg/100ml) in cows from Bunkure, Kano State.

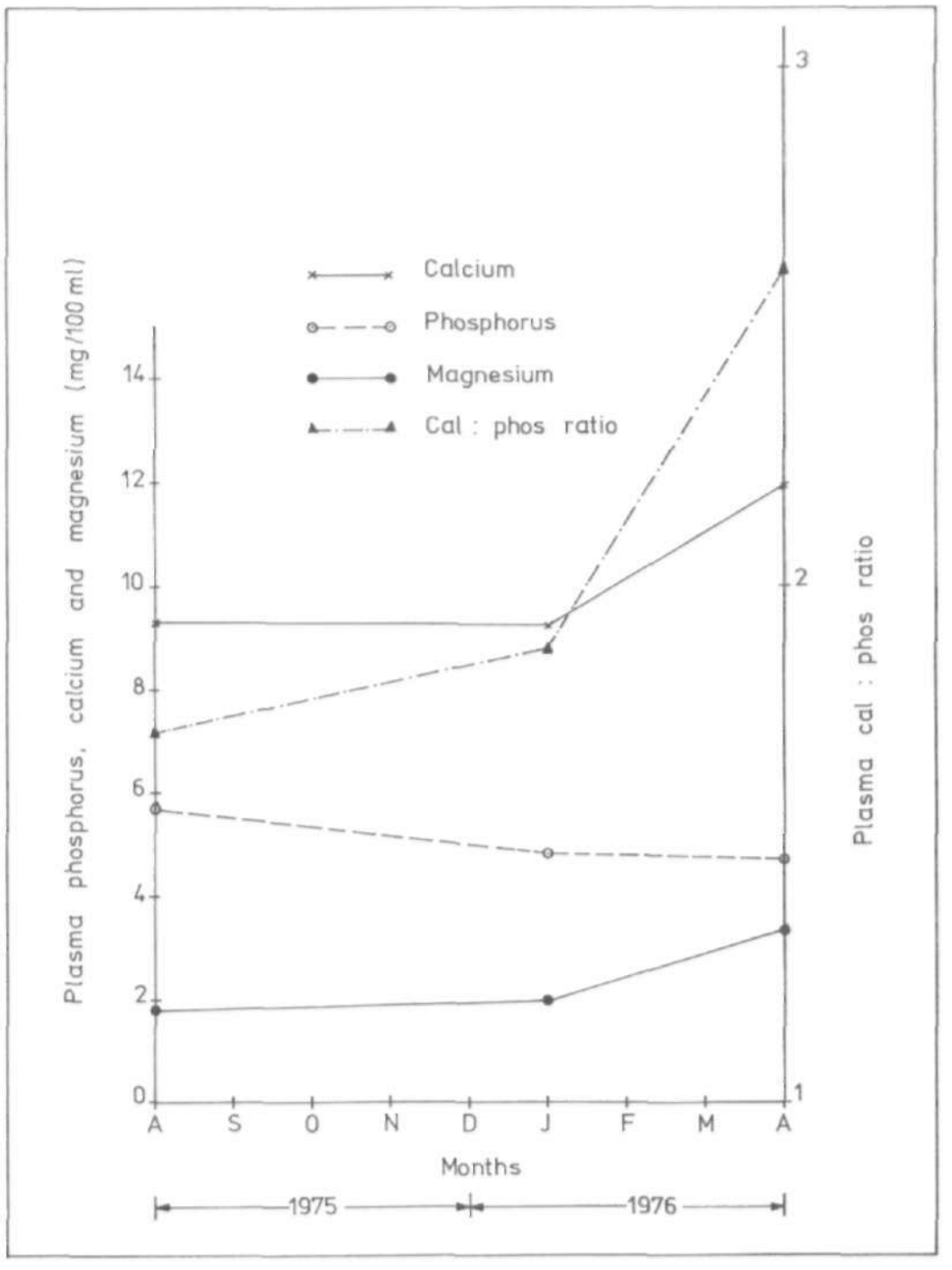

Calcium
Phosphorus
Magnesium
Cal : phos ratio
Plasma phosphorus, calcium and magnesium (mg/100 ml)
Plasma cal : phos ratio
0
2
4
6
8
10
12
14
1
2
3
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 2. Mean plasma vitamin A levels in cows from Bunkure, Kano State.

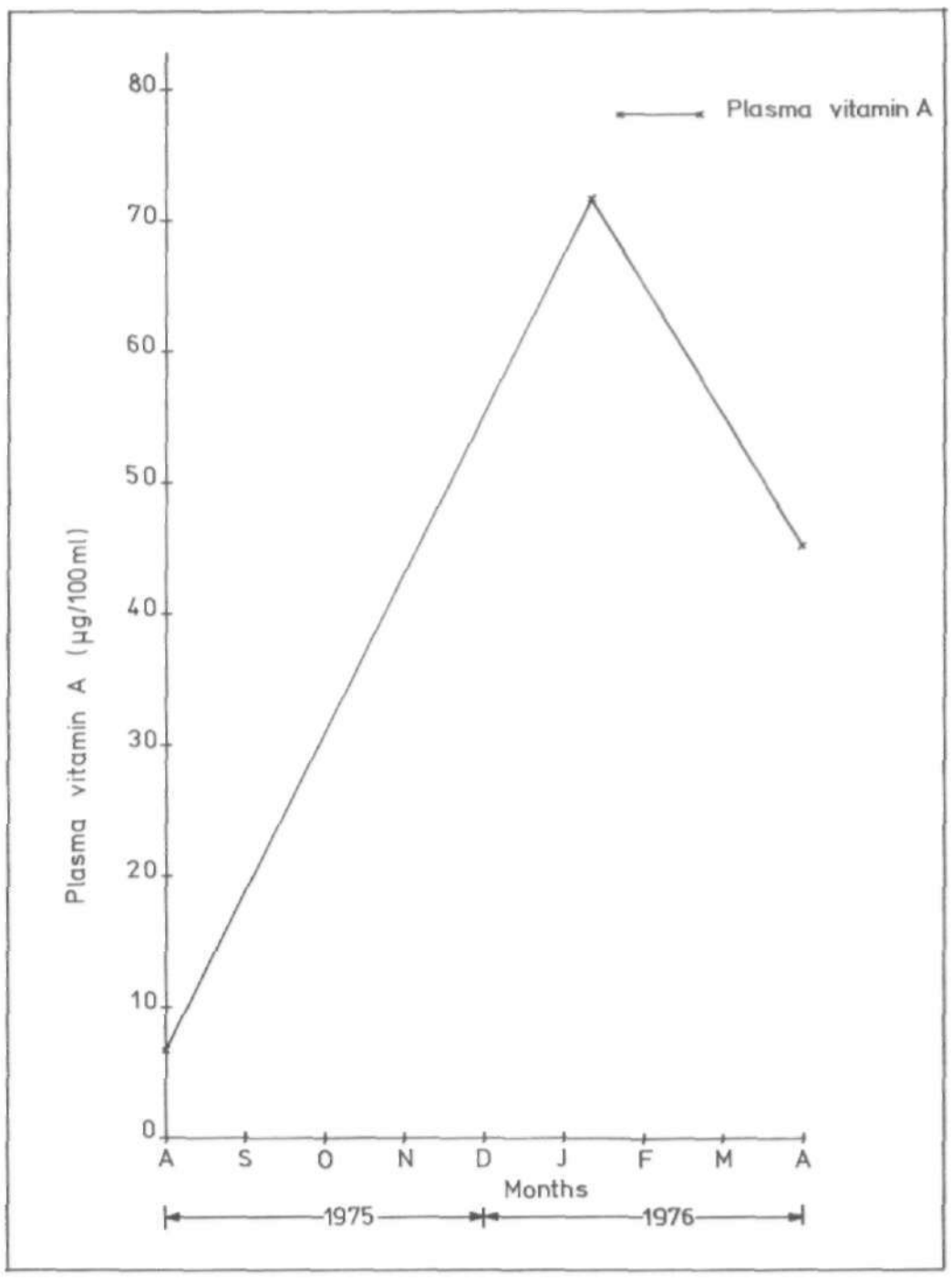

Plasma vitamin A
80
70
60
50
40
30
20
10
0
Plasma vitamin A (µg/100 ml)
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 3. Mean plasma levels of phosphorus, calcium, and magnesium in cows from Kano abattoir.

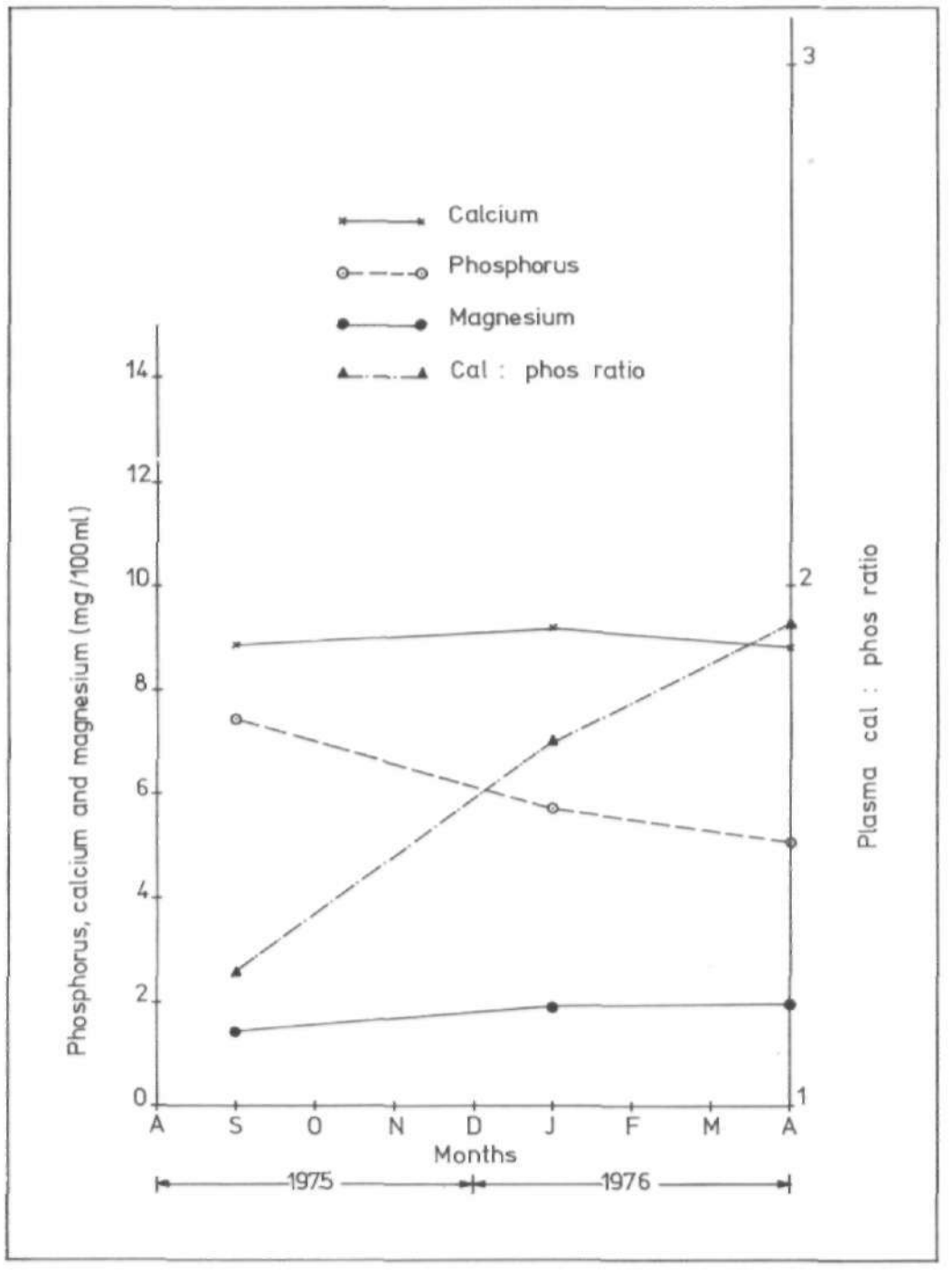

Calcium
Phosphorus
Magnesium
Cal : phos ratio
Phosphorus, calcium and magnesium (mg/100ml)
Plasma cal : phos ratio
0
2
4
6
8
10
12
14
1
2
3
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 4. Mean plasma and liver vitamin A values in cows from Kano abattoir.

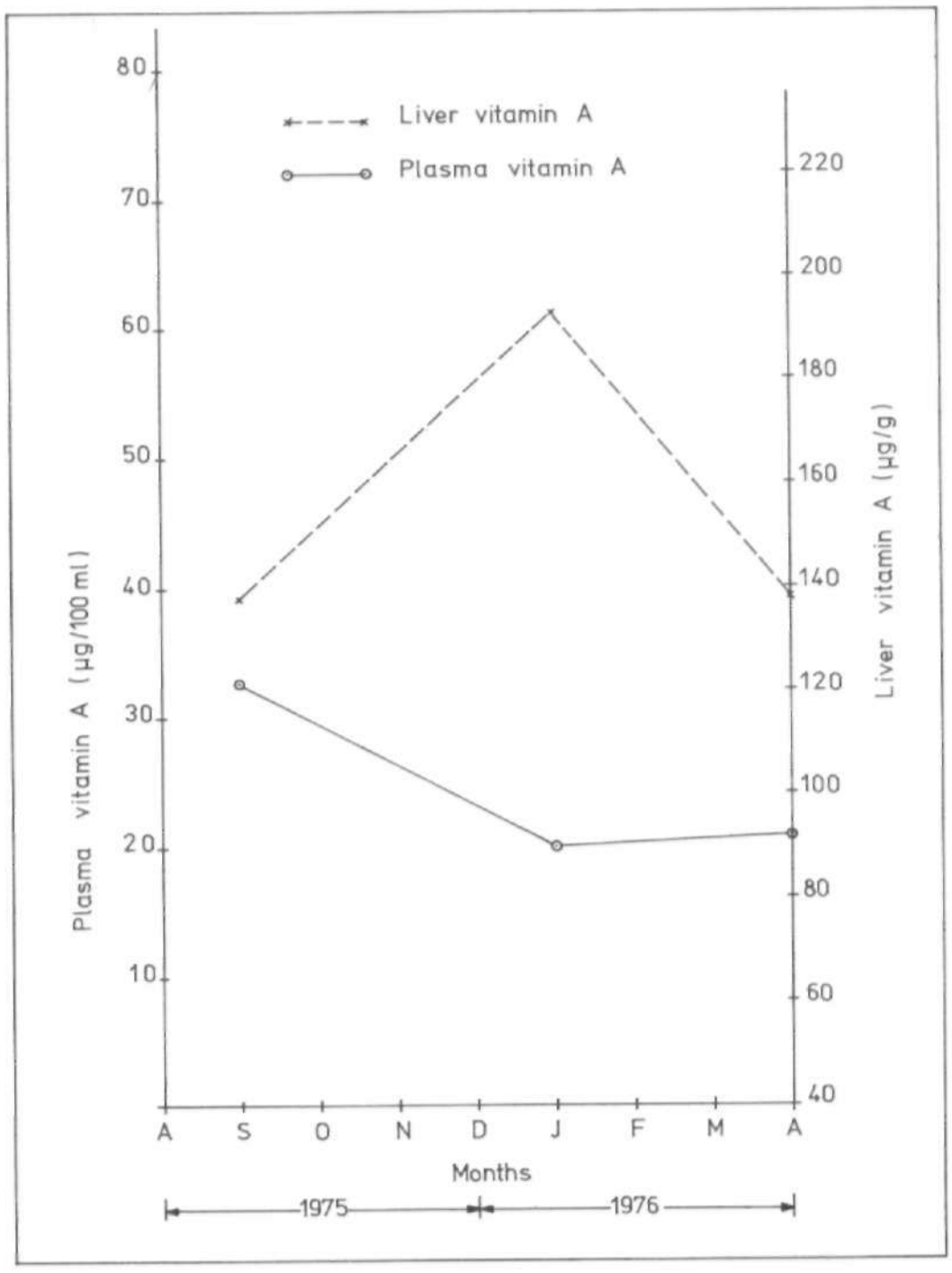

Liver vitamin A
Plasma vitamin A
Plasma vitamin A (µg/100 ml)
Liver vitamin A (µg/g)
80
70
60
50
40
30
20
10
220
200
180
160
140
120
100
80
60
40
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 5. Mean plasma levels of phosphorus, calcium and magnesium in cows from Kaduna abattoir.

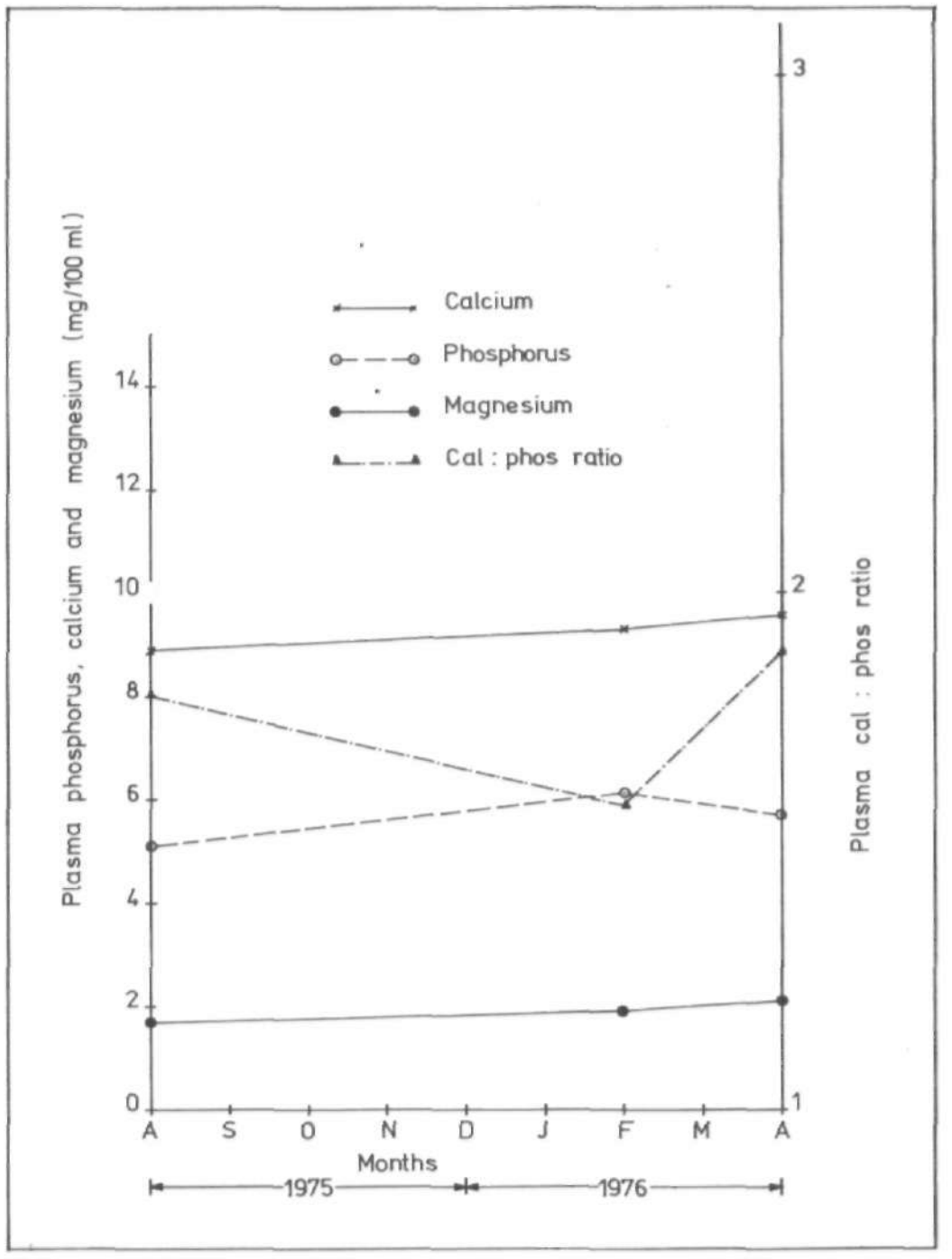

Calcium
Phosphorus
Magnesium
Cal : phos ratio
Plasma phosphorus, calcium and magnesium (mg/100 ml)
Plasma cal : phos ratio
0
2
4
6
8
10
12
14
1
2
3
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 6. Mean plasma and liver vitamin A values in cows from Kaduna abattoir.

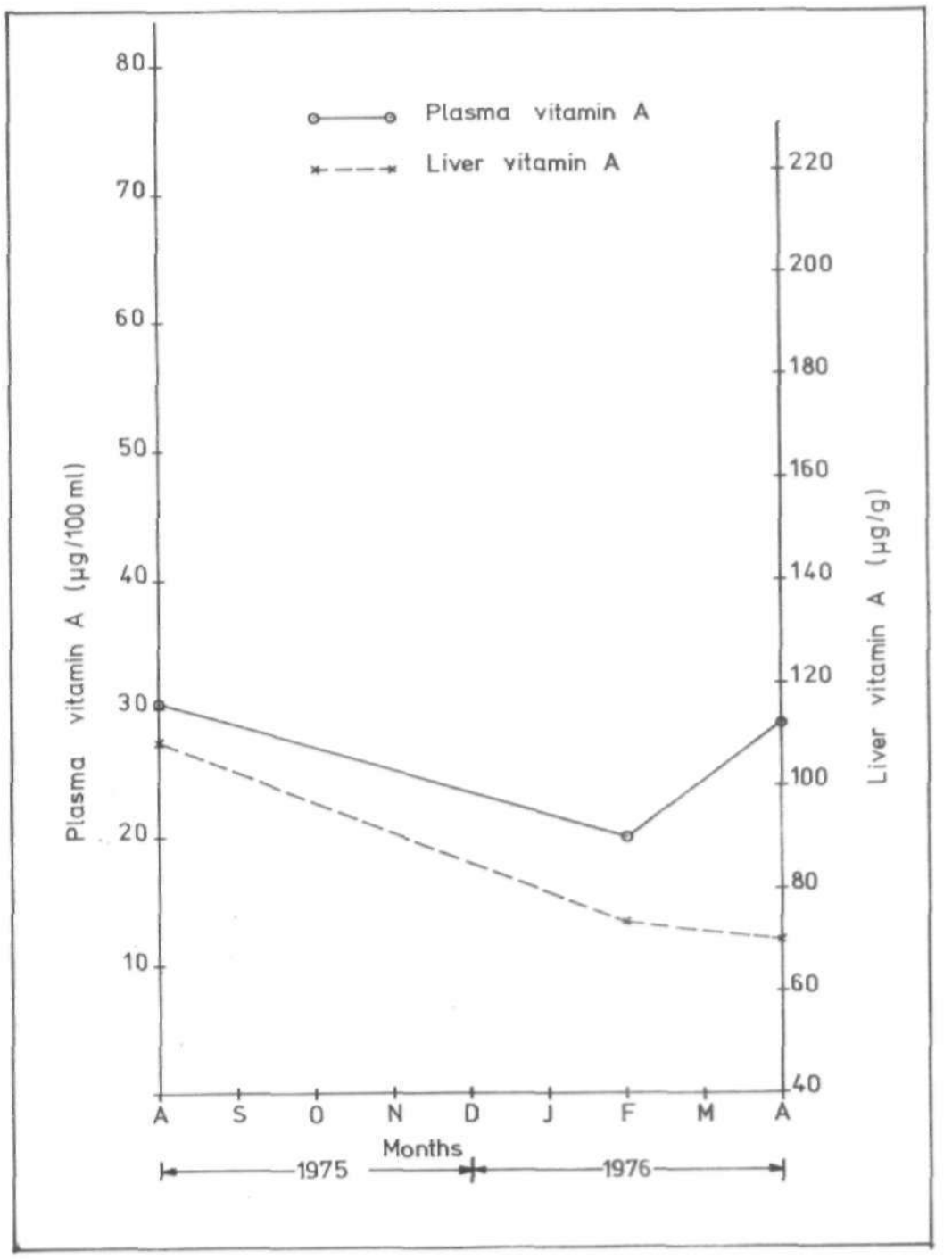

Plasma vitamin A
Liver vitamin A
Plasma vitamin A (µg/100 ml)
Liver vitamin A (µg/g)
80
70
60
50
40
30
20
10
220
200
180
160
140
120
100
80
60
40
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 7. Mean plasma levels of phosphorus, calcium and magnesium in does from Kaduna abattoir.

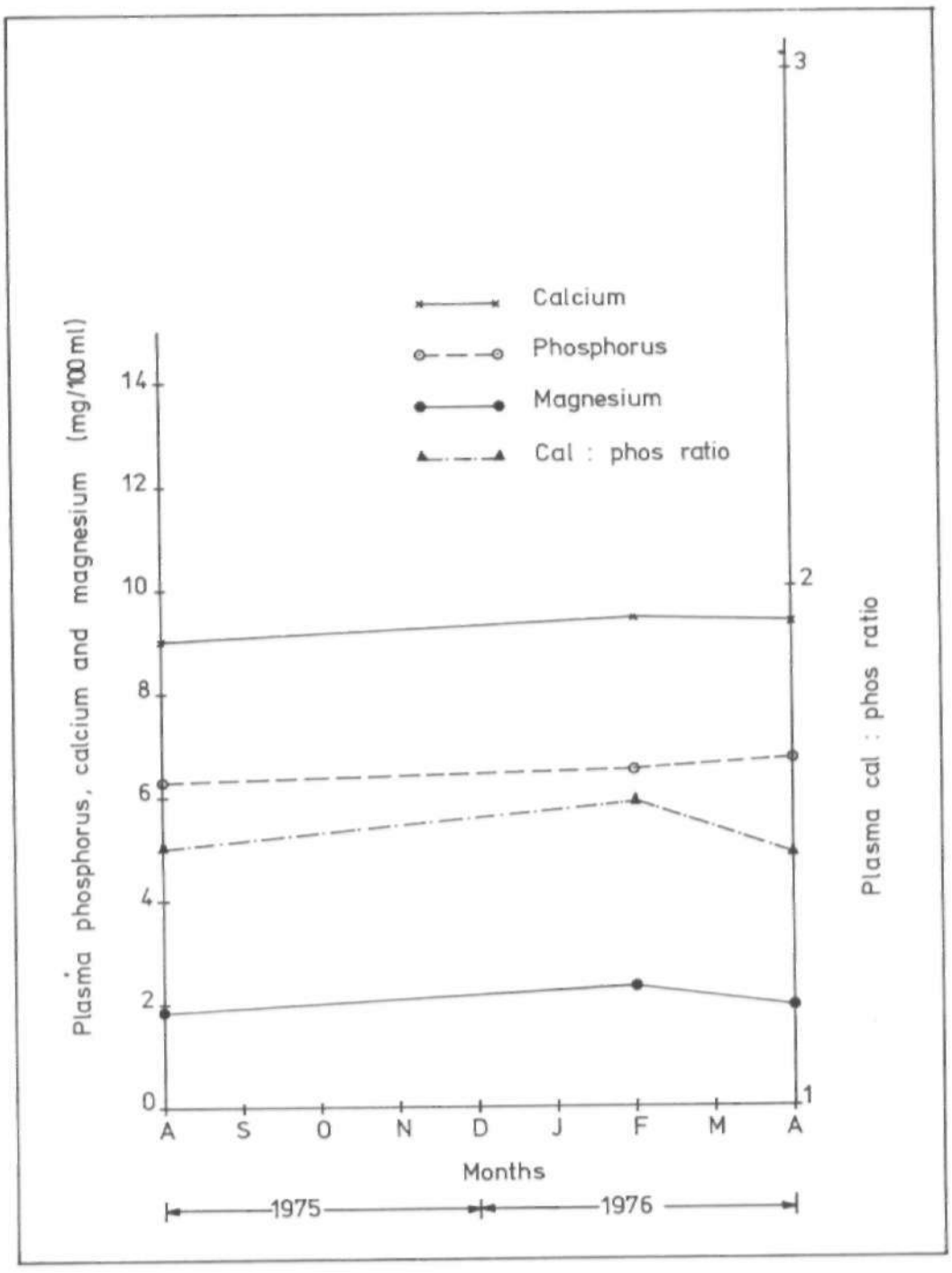

Calcium
Phosphorus
Magnesium
Cal : phos ratio
Plasma phosphorus, calcium and magnesium (mg/100 ml)
Plasma cal : phos ratio
0
2
4
6
8
10
12
14
1
2
3
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 8. Mean plasma and liver vitamin A values in does from Kaduna abattoir.

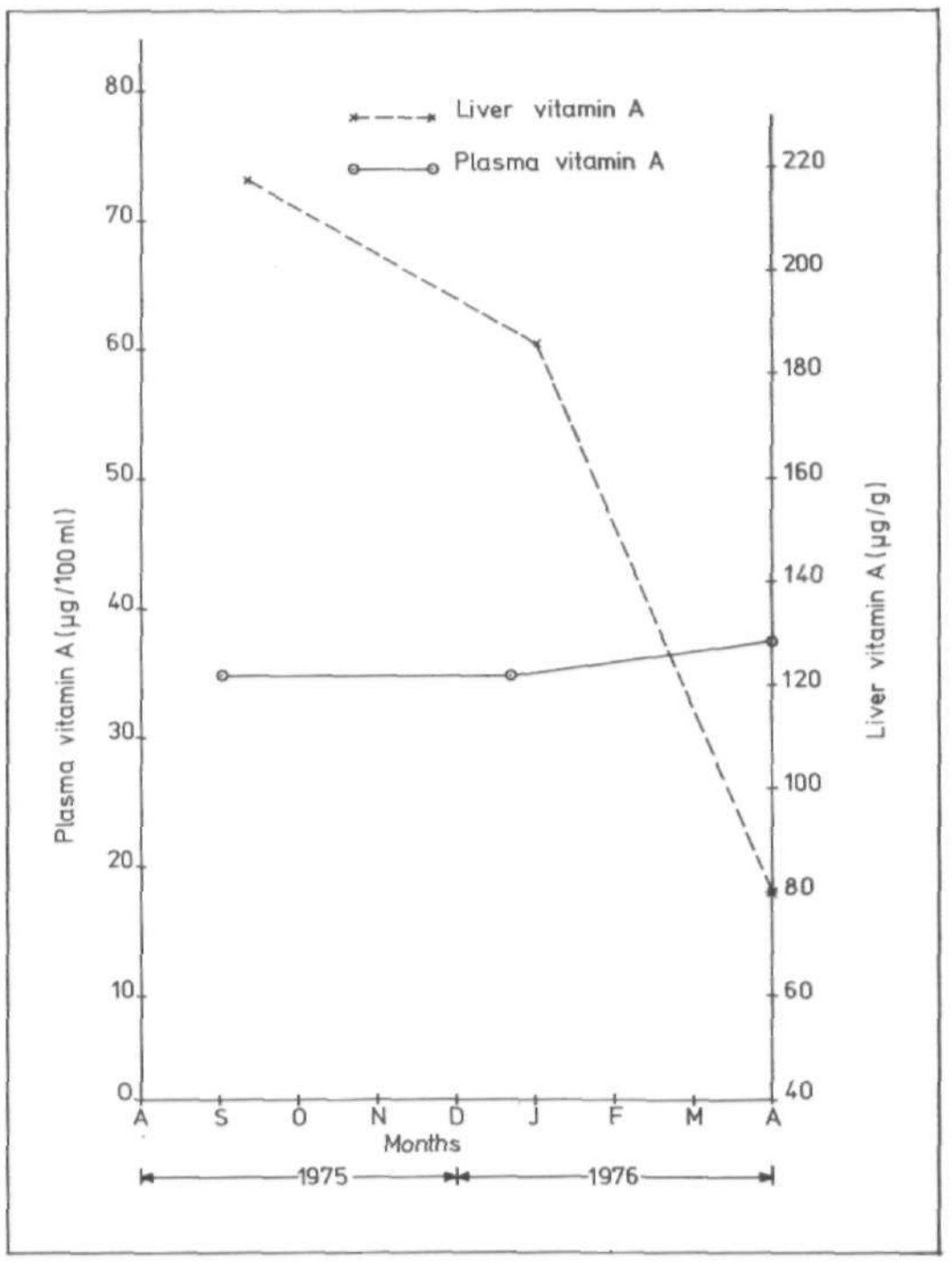

Liver vitamin A
Plasma vitamin A
Plasma vitamin A (µg/100 ml)
Liver vitamin A (µg/g)
80
70
60
50
40
30
20
10
0
220
200
180
160
140
120
100
80
60
40
A S O N D J F M A
Months
1975
1976

Fig. 9. Mean plasma levels of phosphorus, calcium and magnesium in does from Kano abattoir.

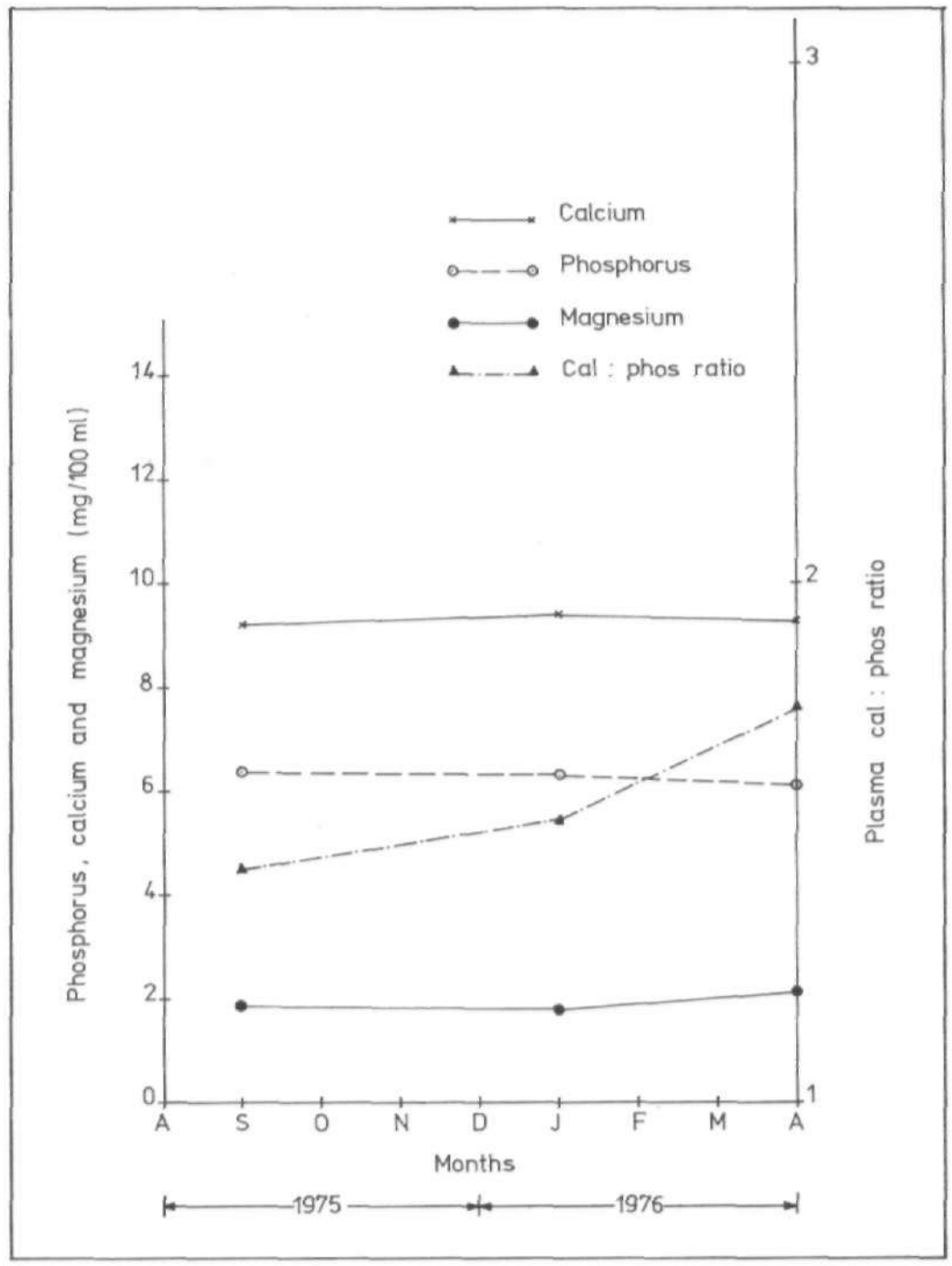

Calcium
Phosphorus
Magnesium
Cal : phos ratio
Phosphorus, calcium and magnesium (mg/100 ml)
Plasma cal : phos ratio
0
2
4
6
8
10
12
14
1
2
3
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 10. Mean plasma and liver vitamin A in does from Kano abattoir.

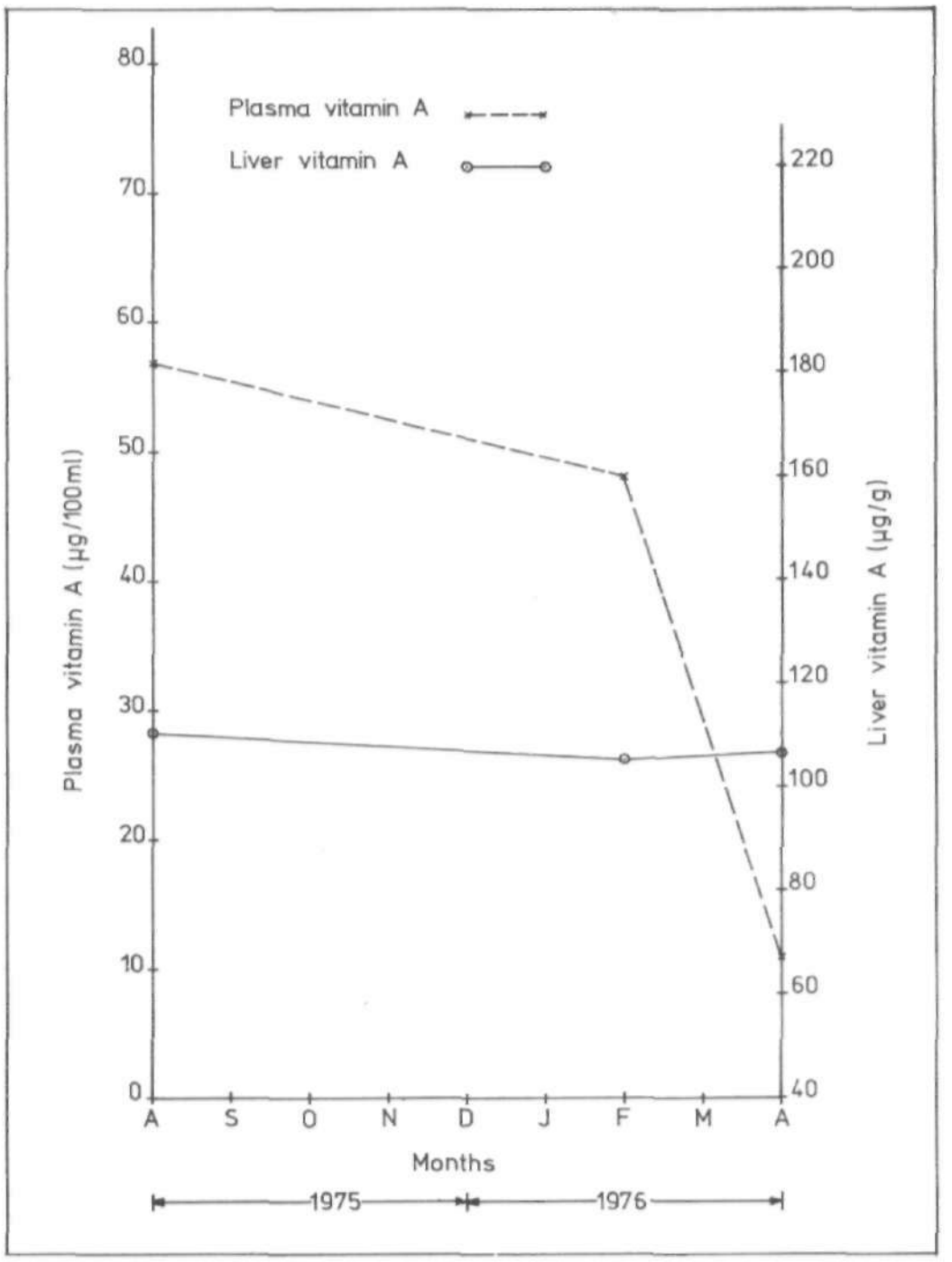
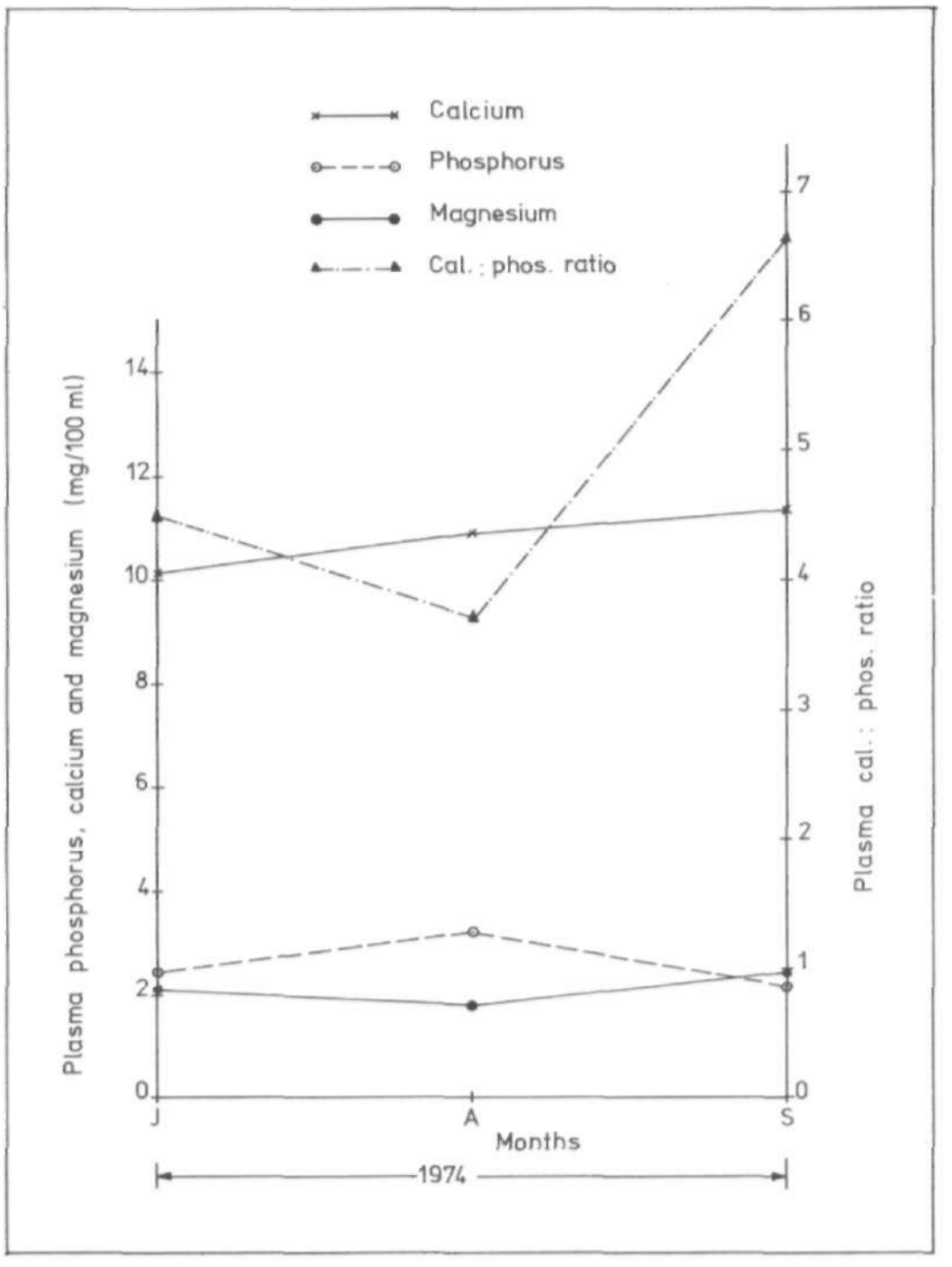

Plasma vitamin A
Liver vitamin A
Plasma vitamin A (µg/100ml)
Liver vitamin A (µg/g)
80
70
60
50
40
30
20
10
0
220
200
180
160
140
120
100
80
60
40
A
S
O
N
D
J
F
M
A
Months
1975
1976

Fig. 11. Mean plasma levels of phosphorus, calcium, and magnesium in the local nomadic herd in Yakase, Kaduna State.


Calcium
Phosphorus
Magnesium
Cal. : phos. ratio
Plasma phosphorus, calcium and magnesium (mg/100 ml)
Plasma cal. : phos. ratio
14
12
10
8
6
4
2
0
7
6
5
4
3
2
1
0
J
A
S
Months
1974

INTRODUCTION

Cattle in West Africa and Nigeria have a low reproductive efficiency compared with temperate zone breeds (Lansbury, 1962; Wheat and Broadhurst, 1968, 1972; Lamorde and Weinman, 1972; Zemjanis, 1974; Nuru, 1974). Lansbury (1962) emphasized the importance of the animal's nutritional environment in restricting productivity. Protein and phosphorus deficiencies in West African grasses have been confirmed by analytic and supplementation results. Lansbury (1962) recommended investigating urea and phosphates as economical means of supplying these nutrients.

Phosphorus has been found to be deficient in all types of forage investigated in the savanna grazing areas of Nigeria (Kapu, 1975). Phosphorus supplementation in one form or another has improved the reproductive efficiency of clinical or sub-clinical deficient cows and heifers (Theiler et al., 1928; Dunlop, 1947; Hignett and Hignett, 1951, 1952; Morrow, 1969; Little, 1975).

This study was carried out to determine the effect of bone-meal supplementation on pregnancy in Bunaji (White Fulani) cattle.

MATERIALS AND METHODS

Animals

Thirty-two Bunaji cows, aged 2 to 8 years, were selected from a herd of 72 at the University Farm, 5 km. north-west of Samaru (Appendix 1). The cows were carefully divided into two groups of 16 based on age and reproductive status.

The cows were maintained on grazing alone. Grazing consisted mainly of native grasses with Andropogon gayanus (Gamba grass), Pennisetum pedicellatum, Brachiaria jubata, and Hyperthelia dissoluta predominating. The cows had occasional access to a paddock containing cultivated Stylosanthes humilis. The herd from which the cows originated had access to a mineral lick containing 7.5% phosphorus in the night paddock.

Experimental Design

The cows were phosphorus-supplemented from February 1975 to April 1976. The experimental and control cows were identified by ear-tags and grazed together with the rest of the

herd of 72 during the day. At night, the two groups were placed in separate night paddocks. The experimental group was given bonemeal at the rate of 84 g/cow/day (equivalent to 12.6 g of phosphorus). The bonemeal was mixed with sodium chloride at a ratio of 4.2:1 and placed in half-drums.

Two mature bulls ran with the entire herd during the day and on alternate nights, one bull was placed in with the experimental or control group. Pregnancy status of each cow was determined monthly by rectal examination for the period of the study and for two months after.

Blood samples were taken monthly for analysis of plasma inorganic phosphorus, calcium and magnesium and handled as described in Part II. Blood samples were also taken for haematology in July and November 1975, and March 1976. Heparin was used as the anticoagulant.

Biochemical Procedures

Plasma inorganic phosphorus, calcium and magnesium were analyzed as described in Part II, and the Ca:P ratio calculated.

Haematological Examination

Haemoglobin (Hb) concentration was determined by the cyanmethaemoglobin method in a Coulter haemoglobinometer.[1]

Packed cell volume (PCV) was determined by the haematocrit method (Coles, 1974).

Red blood cell (RBC) and total white cell (WBC) counts were determined in a Coulter counter.[2]

The mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were calculated from the PCV, Hb and RBC values (Coles, 1974).

RESULTS

Monthly rainfall and mean plasma values of inorganic phosphorus, calcium and magnesium are presented in Table 1 and Figs. 1-3. The individual values are in Appendix 3 (Tables 13-18).

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[1] Coulter Electronics, Ltd; Harpenden, Herts., England.

[2] Coulter Electronics, Inc., Hialeah, Florida.

The monthly mean plasma levels of inorganic phosphorus for the bonemeal-supplemented cows ranged from 4.63 to 8.09 mg/100ml in contrast to 3.07 to 7.09 mg/100ml for the controls. The difference in the supplemented cows for May, July and August (wet season) was significant ($P< 0.01$) and also for November (early dry season) and March (late dry) ($P< 0.05$).

There was little difference between the ranges for the monthly mean plasma calcium and magnesium levels for both control and supplemented cows. There were, however, significant inter-month differences. For calcium, the control values over supplemented were significant for July, August, and November ($P< 0.01$), and the supplemented over controls for April and June ($P< 0.01$) and March and September ($P< 0.05$). For magnesium, the control values over supplemented were significant for July and November ($P< 0.01$), and supplemented over controls for June ($P< 0.01$) and March ($P< 0.05$).

The Ca:P ratios for the 13-month period are presented in Fig. 4.

Haemograms for July (wet season), November (early dry season), and March (late dry season) are given in Table 2.

The effect of bonemeal supplementation on pregnancy is summarized in Table 3. Pre- and post-supplementation calving

records and monthly rectal examination results are given in Appendix 3 (Tables 19-21). At the end of the test period 50% of the test cows had delivered calves in contrast to 25% of the controls. At the same time, 9 controls and 4 test cows were pregnant. Two months later, 8 of the 15 remaining test cows (53.3%) and 6 of the controls (37.5%) were pregnant. Of the 16 pregnancies in the supplemented group, 5 conceived in June, 4 in July, 2 in both April and May, and 1 each in December, February and March. Of the 14 pregnancies in the control group, 3 each conceived in December, February and June, 2 in September, and 1 each in July, August, and November (Appendix 3; Tables 20-21). During the period of peak plasma phosphorus levels, 9 of the 16 supplemented cows (56.3%) conceived compared to 4 (25%) of the controls.

The Ca:P ratios at the time of conception are summarized in Table 4. Twenty-two of the 30 conceptions (73.3%) occurred when the Ca:P ratio was 2.1 or less.

DISCUSSION

Low reproductive performance of indigenous nomadic cattle is a major constraint in the development of the Nigerian cattle industry. The primary factors involved in the low reproductive efficiency are considered to be nutritional and the traditional Fulani husbandry methods (Zemjanis, 1974; Osori, 1976). Nutritional factors are likely to be multiple and include deficiencies of phosphorus, vitamin A, protein, and protein-carbohydrate. The low fertility of nomadic cattle in the northern grazing areas of Nigeria (with a long dry season) suggests phosphorus deficiency as a major aetiological factor; calf every other year, oestrus failure, and heifers not exhibiting oestrus under two years of age (Roberts, 1971; Nuru, 1974). As all forage investigated in the northern savanna grazing areas are phosphorus-deficient (Kapu, 1975), phosphorus was selected as the first nutritional factor to be investigated. Bonemeal was selected as an economical and practical means of supplementing phosphorus which should be compatible with existing traditional Fulani methods of husbandry.

Seasonal values for plasma inorganic phosphorus, calcium and magnesium for both supplemented and control cows were similar to the values for healthy male and female Bunaji cattle at the Shika Research Station (Akerejola, 1976) except for higher wet season values at the University Farm. The range of the mean plasma levels for phosphorus for supplemented cows was within the normal range for cattle, 4 to 8 mg% (Simesen, 1963), while that of the control cows was lower (3 to 7 mg%).

Bonemeal supplementation resulted significantly in earlier conception and calving and appeared to hasten post-partum conception. The study was not continued long enough to confirm the latter. The supplemented cows had a significantly higher conception rate during the wet season with its peak plasma phosphorus levels than the controls. These findings suggest that supplemented phosphorus improved ovarian activity. This is in keeping with the increased seasonal ovarian activity during and immediately after the wet season when the plasma phosphorus levels are higher (Osori, 1976). This suggests that the lower conception rate in the controls was due to their lower plasma phosphate levels. This supports earlier findings that phosphorus supplements increase conception

at first insemination and reduce the incidence of anoestrus (Hignett and Hignett, 1952; Morrow, 1969).

The cows had adequate exposure to bulls day and night and the monthly rectal examinations revealed that they were cycling. Both the supplemented and control cows had access to a mineral lick in the original herd of 72 before their selection for this study and the farm records revealed reasonable fertility which was better in the control group. Withdrawal of access to the mineral lick lowered the fertility of the control cows. In constrast, the 16 supplemented cows had better access to the bonemeal in their night paddock than would be expected in the larger group of 72 in the original herd.

The findings indicate a relationship between the plasma Ca:P ratio and fertility as almost three-fourths of the cows conceived when the ratio was less than 2.1 This supports the earlier suggestion by Hignett and Hignett (1951) that the dietary Ca:P ratio influences bovine fertility; they recommended ratios between 1 and 2.1 as optimal.

It is concluded from this study that bonemeal supplementation is an economical and practical method for improving the fertility of Bunaji cattle in the savanna grazing areas of Northern Nigeria.

SUMMARY

The effect of bonemeal supplementation on pregnancy in 32 Bunaji (White Fulani) cattle was investigated for a period of 13 months. The monthly mean plasma levels of inorganic phosphorus for supplemented cows ranged from 4.63 to 8.09 mg/100ml in contrast to 3.07 to 7.09 for the controls. Differences for May, July and August (wet season) were significant ($P<0.01$) and also for November (early dry season) and March (late dry) ($P<0.05$). There was little difference between the ranges for the monthly mean plasma calcium and magnesium levels for both supplemented and control cows; some inter-months differences, however, were significant. The Ca:P ratios varied from 1.3 to 2.6 in the supplemented cows to 1.6 to 3.9 in the controls. Haemograms for July (wet season), November (early dry season), and March (late dry season) revealed little difference.

Fifty per cent of the test cows delivered calves by the end of the period of supplementation in contrast to 25% of the controls. During the period of peak plasma phosphorus level, 9 of the 16 supplemented cows (56.3%) conceived compared to 4 (25%) of the controls. Twenty-two of the 30 conceptions (73.3%)

occurred when the Ca:P ratio was 2.1 or less. It was concluded from the study that bonemeal was an economical and practical method for improving the fertility of Bunaji cattle in the grazing areas of Northern Nigeria.

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Table 1: Monthly rainfall and mean plasma levels of phosphorus, calcium, and magensium for control and bonemeal-supplemented cows at Samaru, Kaduna State, Nigeria.

Month	Rainfall	Supplemented			Controls		
	(mm)	Phosphorus	Calcium	Magnesium	Phosphorus	Calcium	Magnesium
Feb.'75	0.0	5.51±1.13	9.87±1.59	2.76±0.39	5.17±0.88	9.99±1.15	2.65±0.37
Mar.	0.3	6.64±0.96*	10.65±1.67*	3.07±0.36*	5.93±0.89	9.58±1.05	2.77±0.35
Apr.	85.8	4.63±0.52	11.80±1.32**	2.32±0.11	5.11±0.90	10.19±0.86	2.35±0.25
May	130.1	5.86±1.01**	12.11±0.88	2.36±0.24	3.07±1.08	10.78±1.04	2.35±0.23
June	135.5	6.46±1.04	11.92±0.79**	2.70±0.17**	5.95±1.14	10.28±0.53	2.44±0.29
July	343.1	6.60±1.13**	10.47±0.50	1.81±0.15	4.03±1.13	12.88±1.11**	2.77±0.31**
Aug.	113.4	8.09±1.06**	10.70±0.72	2.62±0.28	7.09±0.98	13.75±1.02**	2.66±0.32
Sept.	212.2	5.92±1.08	10.68±0.57*	2.82±0.23	5.71±1.33	10.15±0.84	2.82±0.18
Oct.	8.3	-	-	-	-	-	-
Nov.	0.0	5.290.95*	12.28±1.22	3.19±0.37	4.62±0.89	13.99±1.00**	3.40±0.20**
Dec.	0.0	5.72±1.36	13.36±1.28	3.50±0.48	5.38±1.23	13.58±0.66	3.30±0.32
Jan.'76	0.0	-	-	-	-	-	-
Feb.	0.0	-	-	-	-	-	-
Mar.	0.0	4.77±1.21**	10.27±0.46	2.75±0.46	3.66±0.96	9.95±1.04	2.81±0.31

* $P < 0.05$ ** $P < 0.01$

Table 2: Mean haematological values in bonemeal-supplemented and control cows during three seasons in Samaru, Kaduna State, Nigeria.

	Wet Season		Early Dry Season		Late Dry Season	
	Control	Supplemented	Control	Supplemented	Control	Supplemented
Hb g/100ml	12.34±1.57	12.17±1.62	12.63±1.63	13.63±1.61	12.29±1.27	13.08±1.39
PCV %	36.50±4.84	37.38±5.04	35.62±4.29	37.50±3.60	35.25±3.82	37.67±3.92
RBC cmm x 10^6	7.54±1.46	6.05±1.44	6.99±1.53	6.92±1.65	5.54±0.86	6.40±0.53
MCV μ^3	50.78±13.94	64.73±16.45	50.06±12.16	56.76±12.76	63.76±8.41	59.09±6.83
MCH $\mu\mu g$	17.11±4.61	21.05±5.52	18.89±4.72	20.52±4.40	22.33±2.22	20.52±2.25
MCHC %	33.82±0.59	32.49±1.45	34.95±1.69	36.11±2.0	34.97±2.12	34.78±1.90
WBC cmm x 10^3	7.9 ±2.3	7.8 ±1.8	8.7 ±1.2	8.1 ±1.6	7.9 ±2.2	8.5 ±1.6

Table 3: Summary of the effect of bonemeal supplementation on bovine pregnancy in Samaru, Kaduna State, Nigeria.

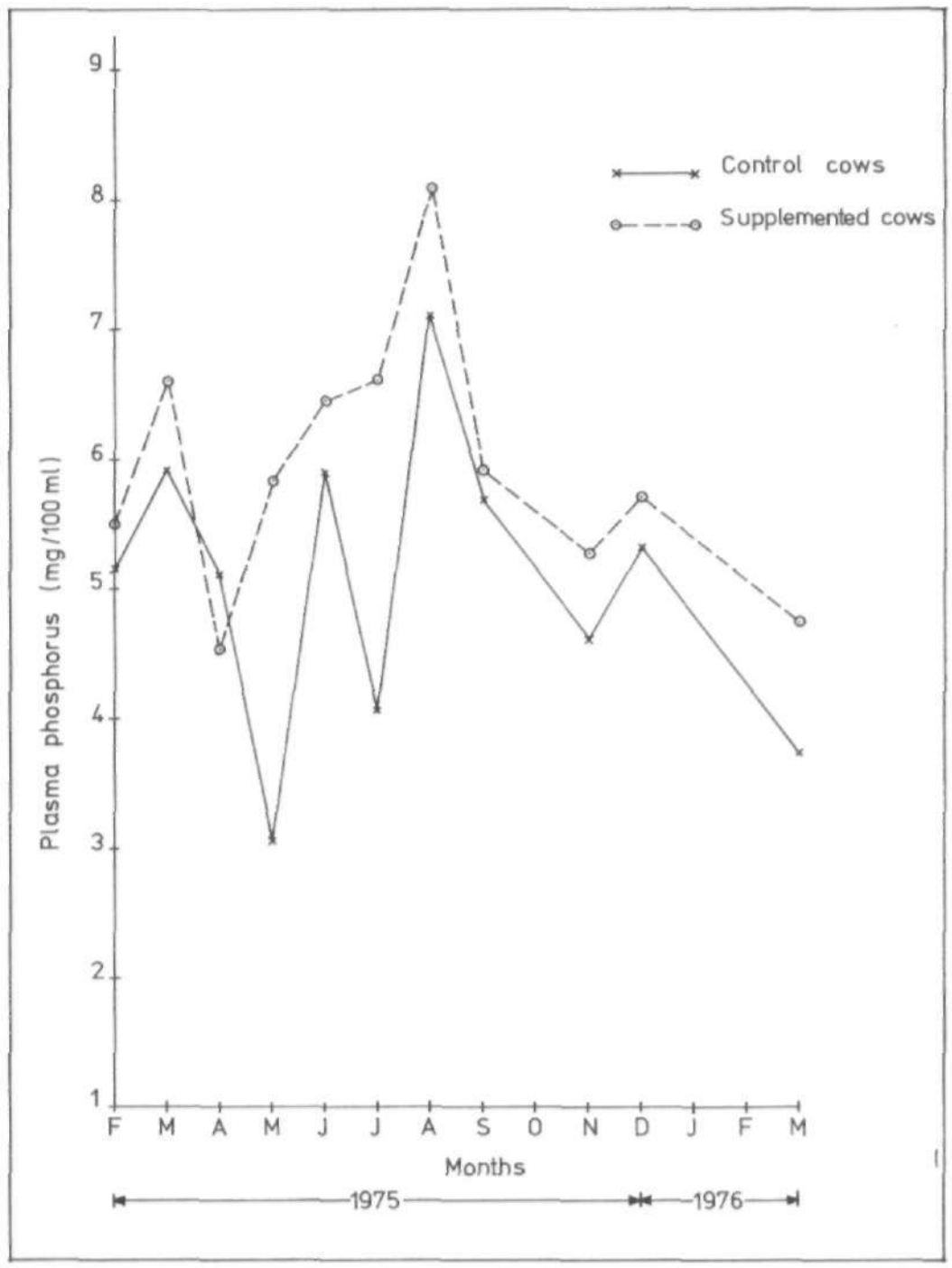
	Supplemented	Controls
No. cows	16	16
No. calving monthly*		
December, 1975	0	0
January, 1976	0	0
February "	1	0
March "	3	3
April "	4	1
Total	8	4
%	50.0	25.0
% cows pregnant 30/4/76	25.0	56.3
" " " 31/5/76	37.5	50.0
" " " 30/6/76	53.3**	37.5

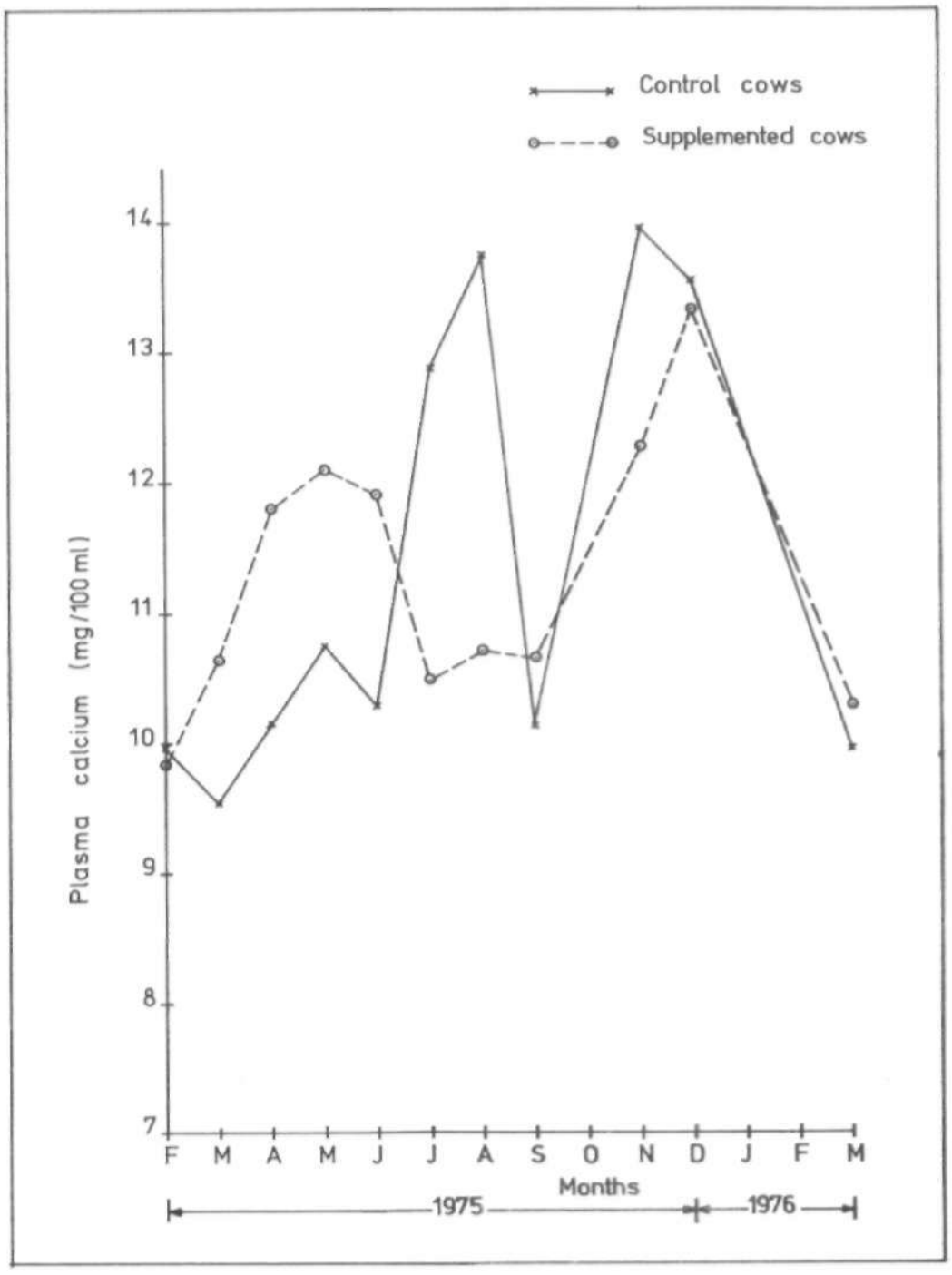
* Calving on or before November 1975 was attributed to conception before bonemeal supplementation (based on 280 day gestation).

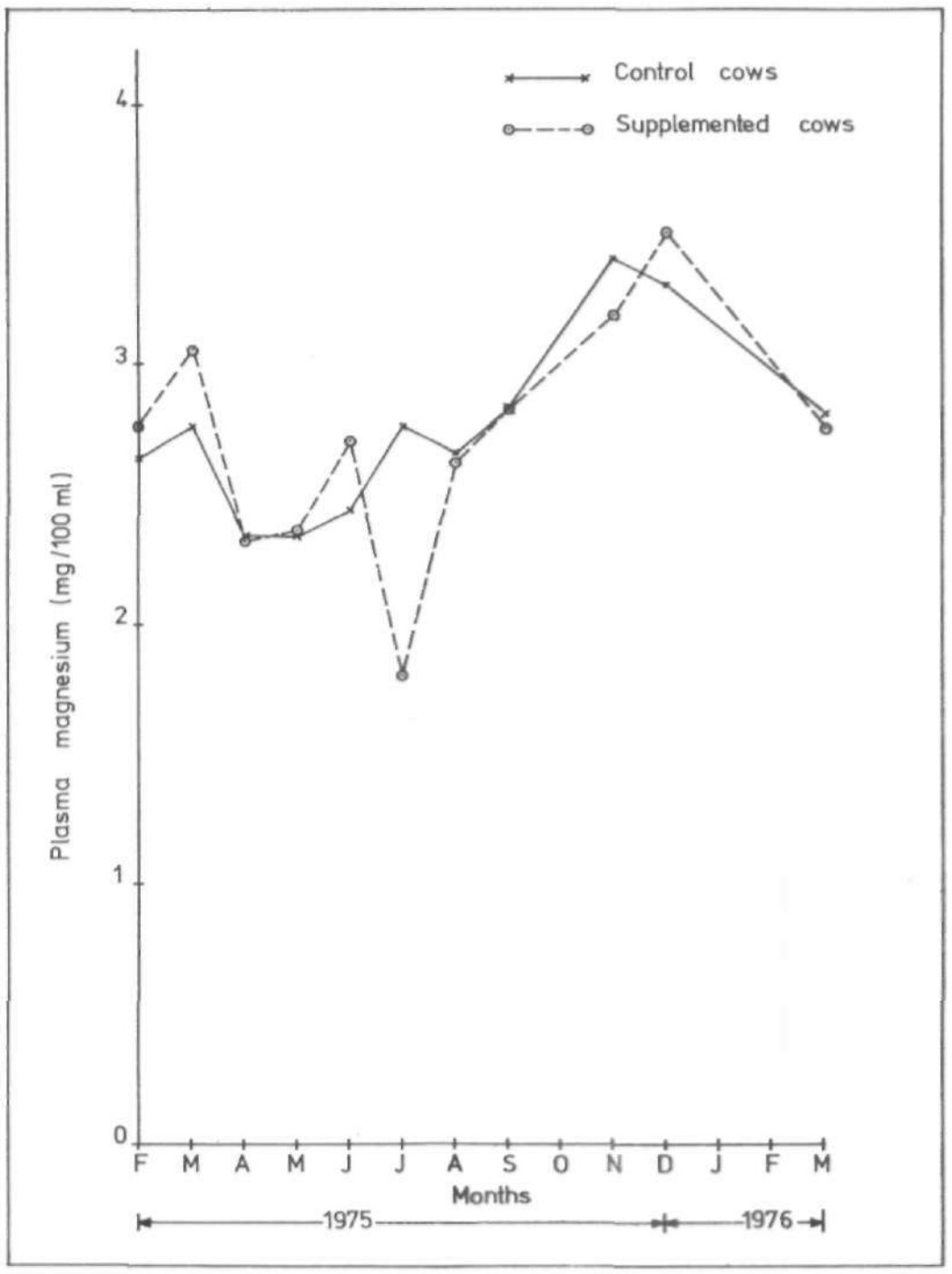
** 8 out of 15 (cow slaughtered, unmanageable).

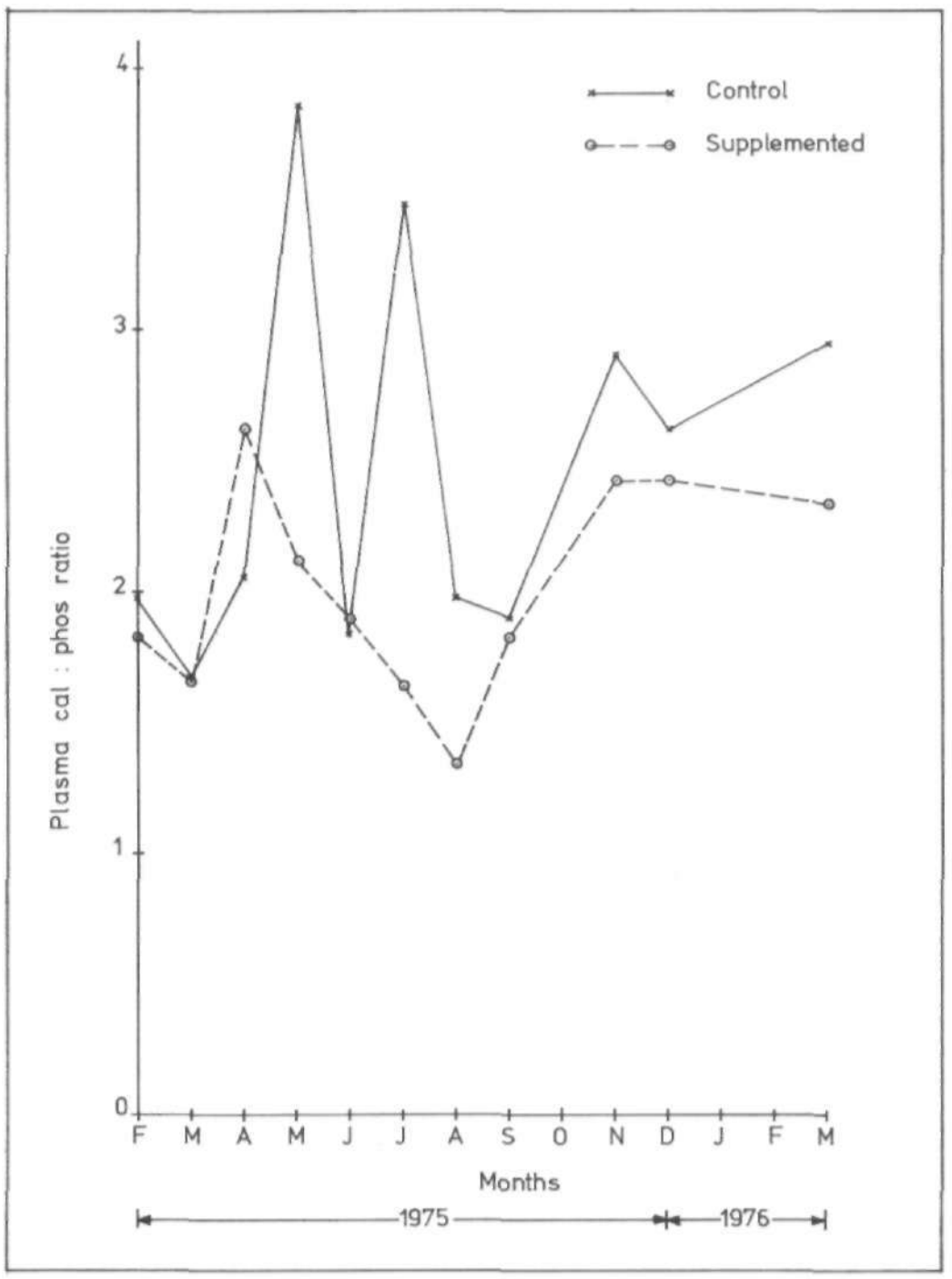
Table 4: Relationship of the Ca:P ratio to conception in cattle at the University Farm, Samaru, Nigeria.

Time	Supplemented		Controls	
	No. conceived	Ca:P	No. conceived	Ca:P
February	1	1.8	3	2.0
March	1	1.7	-	
April	2	2.6	-	
May	2	2.1	-	
June	5	1.9	3	1.9
July	4	1.6	1	3.5
August	-		1	2.0
September	-		2	1.9
November	-		1	2.9
December	1	2.4	3	2.6
Total	16		14	


Control cows
Supplemented cows
Plasma phosphorus (mg/100 ml)
9
8
7
6
5
4
3
2
1
F M A M J J A S O N D J F M
Months
1975
1976


Control cows
Supplemented cows
Plasma calcium (mg/100 ml)
14
13
12
11
10
9
8
7
F M A M J J A S O N D J F M
Months
1975
1976


Control cows
Supplemented cows
Plasma magnesium (mg/100 ml)
4
3
2
1
0
F M A M J J A S O N D J F M
Months
1975
1976


Control
Supplemented
Plasma cal : phos ratio
4
3
2
1
0
F M A M J J A S O N D J F M
Months
1975
1976

PART IV

EFFECT OF PHOSPHORUS SUPPLEMENTATION ON PREGNANCY IN KANO BROWN GOATS

INTRODUCTION

Infertility in goats has received little attention in tropical Africa. Goats have been largely neglected in Nigeria which is unfortunate as they are better adapted to the local climatic and ecological environments than sheep (Anon., 1966). Goats are more adaptable for survival in harsh environments than other domestic animals because of their higher digestive efficiency for cellulose, high fertility, and shorter generation interval (Devendra and Burns, 1970).

The nutritional requirements for goats in tropical regions have been largely neglected by scientists (Devendra and Burns, 1970). They commented that little has been reported on the significance of minerals and vitamins in caprine nutrition. These authors cautioned that studies on requirements for sheep and cattle, even in the tropics, may or may not be applicable to tropical breeds of goats. Because of uncertainty of the calcium and phosphorus requirements for goats they recommended further work in this area. Devendra and Burns commented that goats, by their wide browsing habits may avoid mineral deficiencies, which affect other ruminants. This is doubtful

for phosphorus in Nigeria as Lansbury (1962) indicated that combined grazing and browsing by ruminants in West Africa provides inadequate phosphorus intake; he considered phosphorus deficiency to be a limiting factor in ruminant nutrition.

In contrast to goats, nutritional deficiencies in sheep and their effect on fertility have been extensively studied (Roberts, 1971). The general nutritional deficiencies affecting cattle reproduction are considered to affect sheep and goats. Lowered productivity is the most important sign of phosphorus deficiency in goats (MacKenzie, 1970). Reproductive signs of phosphorus deficiency in sheep and goats are similar to those in cattle and are usually complicated by low protein and vitamin A levels (Roberts, 1971). The signs include delayed onset of puberty, irregular oestrous cycles, and tendency to lamb or kid every two years. Abortions are uncommon but weak or dead lambs or kids may be expelled at term.

This study was undertaken to determine the effect of phosphorus supplementation on pregnancy in Kano Brown goats.

MATERIALS AND METHODS

Experimental Animals

Forty-eight Kano Brown female goats, aged one-and-half years and over, average weight 15 kg, were purchased locally. The does were ear-tagged, and randomly divided into 4 groups. The does grazed during the day and at night were housed according to their groups. The grasses grazed included Hyparrhenia rufa, Eleusine indica, Sporobulus pyramidalis, and Brachiaria jubata. The does were kept in the study area for two months prior to use and were maintained solely by grazing. Pretreatment included faecal worm count and treatment with Ranide,[1] and spraying for ticks.[2] Throughout the experiment the does were monitored for both internal and external parasites and treated as required.

Experimental Design

The study extended from April 1975 to June 1976. Four

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[1] Rafoxanide. Merck, Sharp and Dohme, Hearlem, Netherlands.

[2] Pfizona, Pfizer Products Ltd., Ikeja, Nigeria.

groups of 12 does (PG, PPG, PV and CG) were given groundnut cake at night at the rate of 64 g per head per day.

PG group received 5.8 g of bonemeal per head per day. During the dry season, the combined grazing, groundnut cake and bonemeal was equivalent to a daily intake of 1.3 g phosphorus per head. The phosphorus intake for the PPG group was 2.6 g per head. The PV group received 1.3 g of phosphorus and 1,275 i.u. of vitamin A per head daily. The control group (CG) had a daily intake of 0.44 g per head from grazing and groundnut cake. Improved grazing during the wet season raised the phosphorus intake for the PG, PPG, PV and CG groups to 1.8, 3.1, 1.8, and 0.9 g, respectively.

Four adult bucks were rotated between the houses at night.

Blood samples were taken in March 1975 before supplementation started and again in May, June, July, August, and November, 1975 and in February and March, 1976 for blood mineral analyses and were handled as described in Part II. Blood samples were taken for haematology in July and October, 1975 and in March, 1976. Heparin was used as the anticoagulant.

Reproductive Performance

The does were closely observed and all births were recorded. Based on a 148-day gestation (Devendra and Burns, 1970) kidding before 20 September 1975 was not attributed to any effect of supplementation and was not recorded. At completion of the experiment all does that had kidded 3 months or longer (based on minimum 92-day postpartum service period), were slaughtered and their reproductive status determined.

Biochemical Analysis

Plasma inorganic phosphorus, calcium and magnesium were analyzed as described in Part II, and the Ca:P ratio calculated.

Haematological Examination

Blood values were determined as described in Part III.

RESULTS

The mean monthly plasma values for inorganic phosphorus,

calcium and magnesium are presented in Tables 1-3 and Figs. 1-3, and the individual values in Appendix 4 (Tables 22-33). The Ca:P ratios are given in Fig. 4. Individual monthly body weights are given in Appendix 4 (Tables 34-37).

Mean plasma phosphorus levels peaked during the wet season in all 4 groups but for only one month in the lower phosphorus-supplemented group (PG). The higher phosphorus-supplemented group (PPG) maintained a higher plasma level than the other groups and the differences over the control values were significant for June and February ($P<0.05$). The PG value over the controls was significant for June ($P<0.05$); the values in July, August and November were lower than those of the controls. The phosphorus-vitamin A (PV) values over the controls were not significant.

There were significant differences between the three levels of phosphorus supplementation. PPG values over PG were significant for July, August and for February ($P<0.05$). PPG values over PV were significant for June and February ($P<0.05$). PV values over PG were significant for August ($P<0.05$). PG value over PV was significant for June ($P<0.05$).

The mean monthly plasma calcium levels for the controls were significantly higher than the PG values for August and February ($P<0.05$). The PV calcium values were higher than that

of PG group for February ($P<0.05$).

There were significant differences in the mean monthly plasma magnesium levels. For June the control values were higher than PG ($P<0.05$). In July the PPG values were significantly lower than those of the other three groups and the CG values were significantly lower than PG ($P<0.05$). For November, the PG values were significantly higher than PV ($P<0.05$). For February, PPG values were higher than PV, and CG values higher than PV ($P<0.01$). The PPG were significantly higher than PV ($P<0.01$).

Haematological values for July (wet season), November (early dry season), and March (late dry season) for the PPG group revealed little difference from that of the controls (Table 4).

The effect of bonemeal supplementation on pregnancy is summarized in Table 5. The monthly kidding performances are given in Appendix 4 (Tables 38-41). Seven does were dropped from the study; 6 died (hearwater 5 and 1 undiagnosed) and 1 killed by a car. The PPG group had the best results (120%) and the PV group the worst (70%). One control and one PV doe aborted and the cause was undiagnosed. In the PV group, one presumably pregnant doe was lost (strayed or stolen) and one had mummified

twins *in situ* when slaughtered at the end of the experiment.

DISCUSSION

It is common for textbooks to discuss infertility in sheep and goats together and to leave the reader with the impression that the same conditions occur in the two species. Whether this is so or not is not known. Little is known about caprine infertility in the tropics.

Natural forages in the savanna grazing areas of Northern Nigeria are unable to supply adequate phosphorus to meet the needs of ruminants except during a few months of the wet season. This makes it difficult for indigenous goats, even with their better adaptability to harsh climates, to obtain adequate phosphorus intake for reproductive efficiency. Most deficiency diseases affecting reproduction in grazing ewes are multiple and involve mineral deficiency, especially phosphorus and cobalt, protein lack, and vitamin A deficiency (Roberts, 1971). The situation is probably similar in indigenous goats.

Impaired fertility is unlikely to occur in does receiving

protein supplements or phosphorus (Roberts, 1971). The findings in this study support this. Although the higher phosphorus supplemented group had the best fertility, it is hard to understand why the phosphorus-vitamin A supplemented group had the lowest, based on kidding. If the results are re-appraised on pregnancy, then there is little difference between the groups: 100% conception in the controls, 91% in the phosphorus-vitamin A group and 90% in the lower phosphorus-supplemented group. The high fertility in all groups including the controls probably resulted from the daily intake of 28 g of protein from the groundnut cake (Anon. 1968). Under this regime, the higher level of supplemented phosphorus gave higher fertility, earlier conception, and earlier postpartum conception. It is concluded from this study that a daily intake of 2.6 g phosphorus is beneficial to the fertility of Kano Brown does and that bonemeal is an economical source.

SUMMARY

The effect of phosphorus (bonemeal) supplementation on pregnancy was studied in Kano Brown goats. Four groups of 12

does (PG, PPG, PV, and CG) grazed during the day and at night were housed separately and were given 64 g groundnut cake per head. The three test groups received the following daily intake per head: PG 1.3 g phosphorus, PPG 2.6 g phosphorus and PV 1.3 g phosphorus and 1,275 i.u. vitamin A. Mean plasma phosphorus levels peaked during the wet season in all groups. The higher phosphorus-supplemented group (PPG) maintained higher plasma values than the other groups. The kidding performance was PPG 120%, PG 90%, PV 70%, and controls 91%. Evaluating the results on pregnancy, however, and allowing for 2 abortions, mummified twins, and one doe disappearing, the inter-group differences are less: PPG 120%, PG 90%, PV 90%, and controls 100%. It is concluded that a daily intake of 2.6 g supplemented phosphorus is beneficial to the fertility of Kano Brown does and that bonemeal is an economical source.

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Table 1: Mean monthly rainfall and plasma phosphorus (mg/100ml) of supplemented and control goats.

Month	Rainfal (mm)	PG	PPG	PV	CG
1975		-	-	-	-
Mar.	0.3	4.82±1.27	4.36±0.76	4.29±0.93	4.13±1.59
Post-supplementation					
Apr.	85.8	-	-	-	-
May	130.1	4.78±1.20	5.29±1.70	4.37±1.85	4.52±1.01
June	135.5	5.42±0.79*	5.66±1.62*	4.52±1.16	4.39±1.12
July	303.1	4.66±1.32	5.96±1.12	5.47±1.86	5.21±1.13
Aug.	113.4	4.43±0.80	5.82±0.88	5.83±1.09	5.28±1.50
Sept.	212.2	-	-	-	-
Oct.	8.3	-	-	-	-
Nov.	0.0	4.55±1.34	5.21±0.60	4.59±1.43	5.05±1.42
Dec.	0.0	-	-	-	-
Jan.'76	0.0	-	-	-	-
Feb.	0.0	4.57±0.81	5.55±0.92*	4.54±1.36	4.48±0.81
Mar.	0.0	5.45±1.28	5.17±0.78	4.85±0.86	4.70±0.88

* $P<0.05$

PG = Phosphorus supplemented, lower level

PPG = Phosphorus supplemented, higher level

PV = Phosphorus and vitamin A supplemented

CG = Controls

Table 3: Mean monthly rainfall and plasma magnesium (mg/100ml) of supplemented and control goats.

Month	Rainfall (mm)	PG	PPG	PV	CG
1975		-	-	-	
Mar.	0.3	2.20±0.45	2.26±0.37	2.20±0.25	2.31±0.29
Post-supplementation					
Apr.	85.8	-	-	-	-
May	130.1	2.72±0.31	2.32±0.40	2.33±0.38	2.60±0.25
June	135.5	2.25±0.32	2.56±0.14	2.55±0.45	2.77±0.38**
July	303.1	2.45±0.17	1.87±0.45	2.26±0.30	2.13±0.10
Aug.	113.4	2.12±0.23	2.23±0.30	2.18±0.33	2.18±0.18
Sept.	212.2	-	-	-	-
Oct.	8.3	-	-	-	-
Nov.	0.0	2.68±0.43*	2.48±0.28	2.36±0.20	2.53±0.31
Dec.	0.0	-	-	-	-
Jan.'76	0.0	-	-	-	-
Feb.	0.0	2.32±0.29	2.43±0.29*	2.07±0.36	2.14±0.20
Mar.	0.0	2.66±0.18	2.49±0.19	2.42±0.21	2.38±0.18

* $P < 0.05$

PG = Phosphorus supplemented, lower level

PPG = Phosphorus supplemented, higher level

PV = Phosphorus and vitamin A supplemented

CG = Controls

Table 4: Blood profile values for control and bonemeal-supplemented goats for three different seasons.

	WET SEASON (July)		EARLY DRY SEASON (Oct.)		LATE DRY SEASON (March)	
	Control	Supplemented	Control	Supplemented	Control	Supplemented
Haemoglobin g/100 ml	8.06±1.28	7.29±0.88	8.04±1.24	7.25±1.29	9.17±1.05	8.56±0.99
Packed Cell Volume %	23.54±3.57	22.25±2.82	23.67±3.87	21.11±4.14	22.55±3.24	24.78±2.77
Erythrocyte Count x 10^6/cm	8.68±1.86	7.07±0.68	8.59±1.93	8.76±1.58	11.62±3.04	7.63±0.90
Mean Corpuscular Volume μ^3	28.39±7.30	24.82±4.92	28.12±4.60	24.93±4.62	20.04±3.38	32.67±3.58
Mean Corpuscular Haemoglobin µµg	9.70±2.44	8.18±1.84	9.54±1.60	8.43±1.56	8.12±1.36	11.28±1.29
Mean Corpuscular Haemoglobin Concentration %	34.22±1.16	32.97±3.51	34.08±0.69	33.83±1.38	41.07±4.72	34.53±1.09
Total leukocyte Count x 10^3/cm	11.0 ±4.8	9.6 ±4.0	14.9 ±4.3	11.3 ±2.5	16.2 ±4.2	14.6 ±3.6

Table 5: Cumulative kidding incidence in supplemented and control goats.

Group	No. Does	1975 Sept.	Oct.	Nov.	Dec.	1976 Jan.	Feb.	March	Apr.	May	June	%
PG	10	2	2	2	3	6	6	6	9	9	9	90
PPG	10	3	3	3	3	7	7	9	9	10	12*	120
PV	10	0	0	0	2	4	4	4	5	5	7**	70
CG	11	0	0	0	2	3	3	6	8	10	10***	91

PG = Lower level of bonemeal

PPG = Higher level of bonemeal

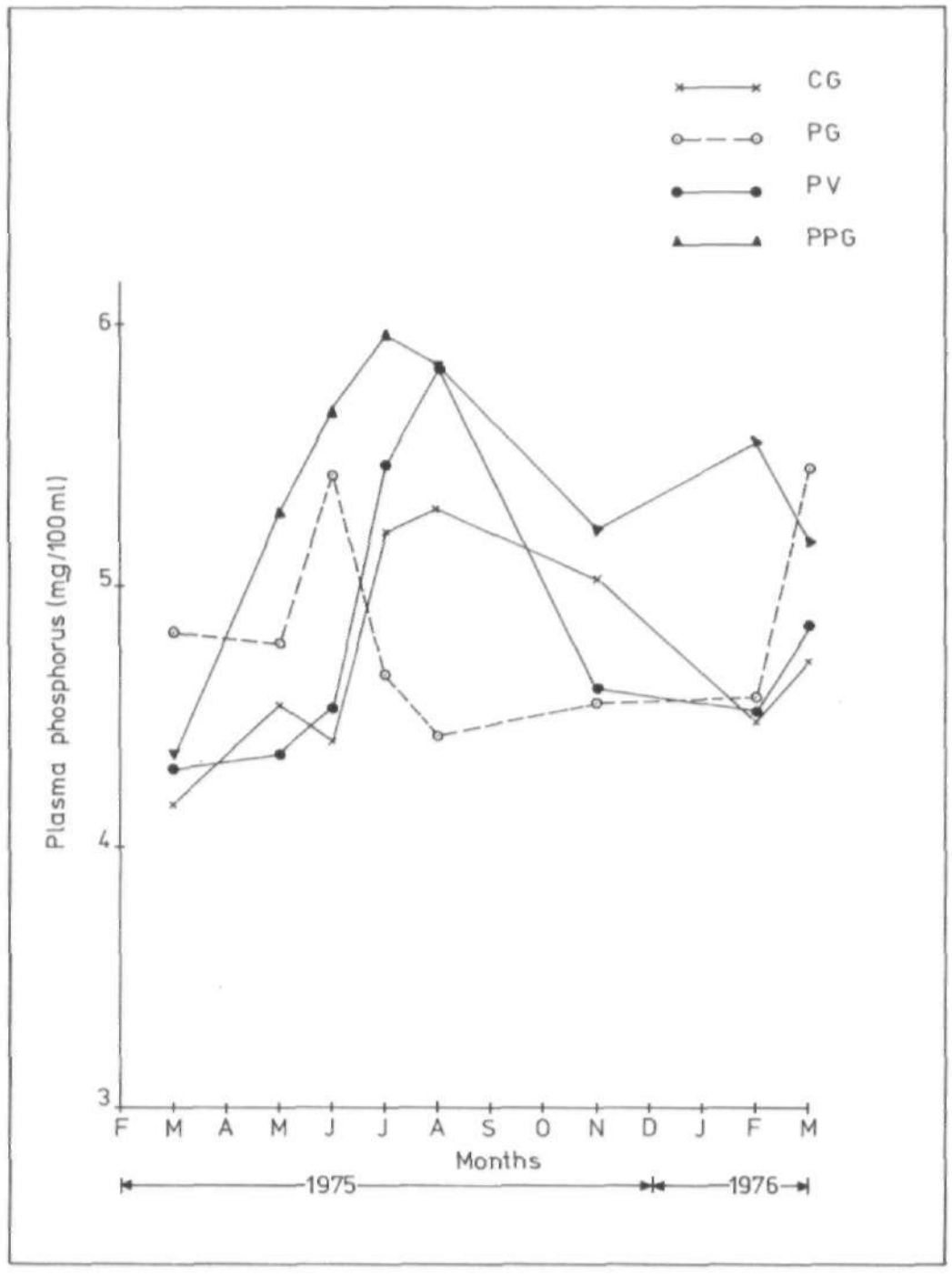
PV = Phosphorus + vitamin A

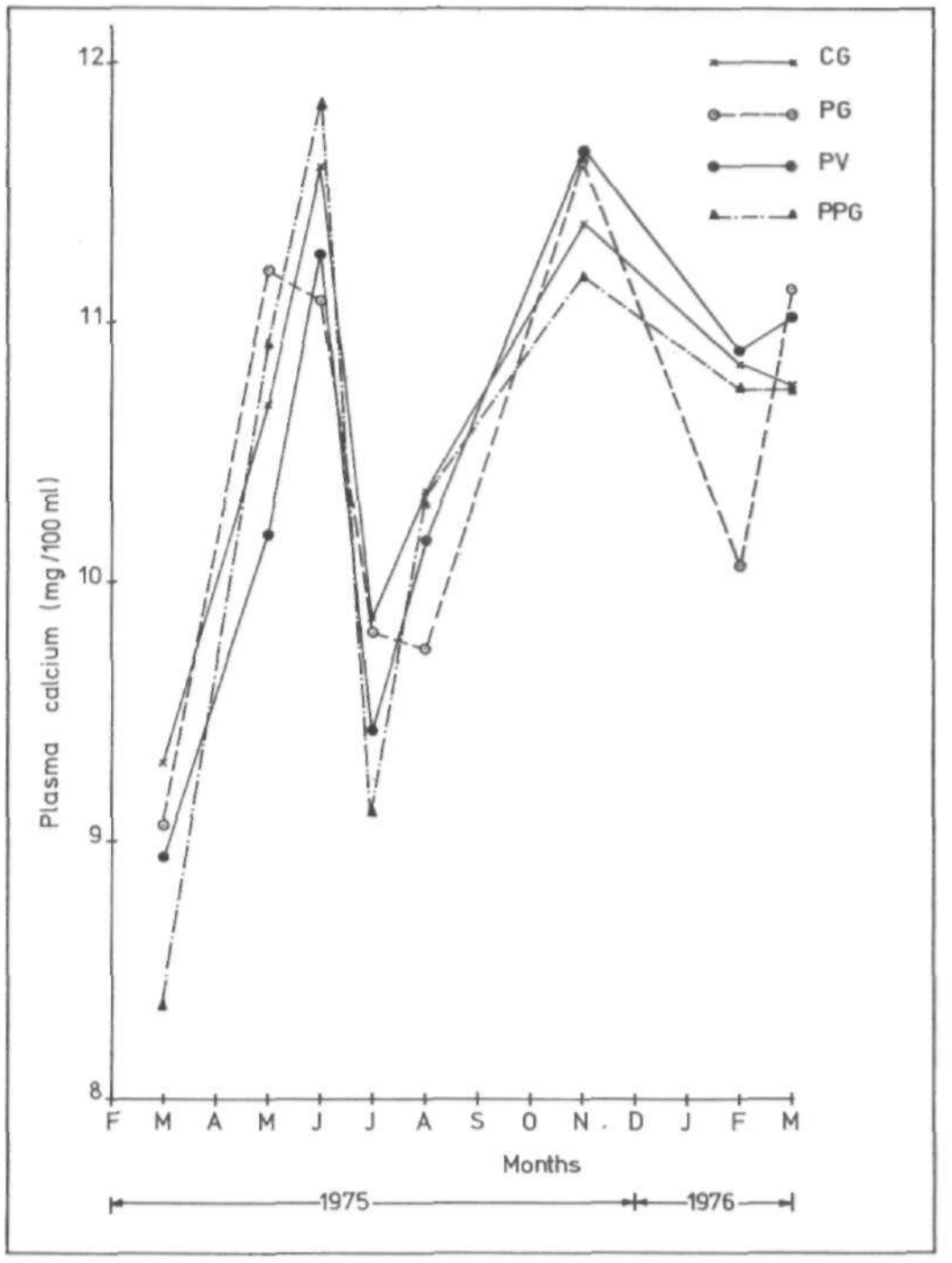
CG = Controls

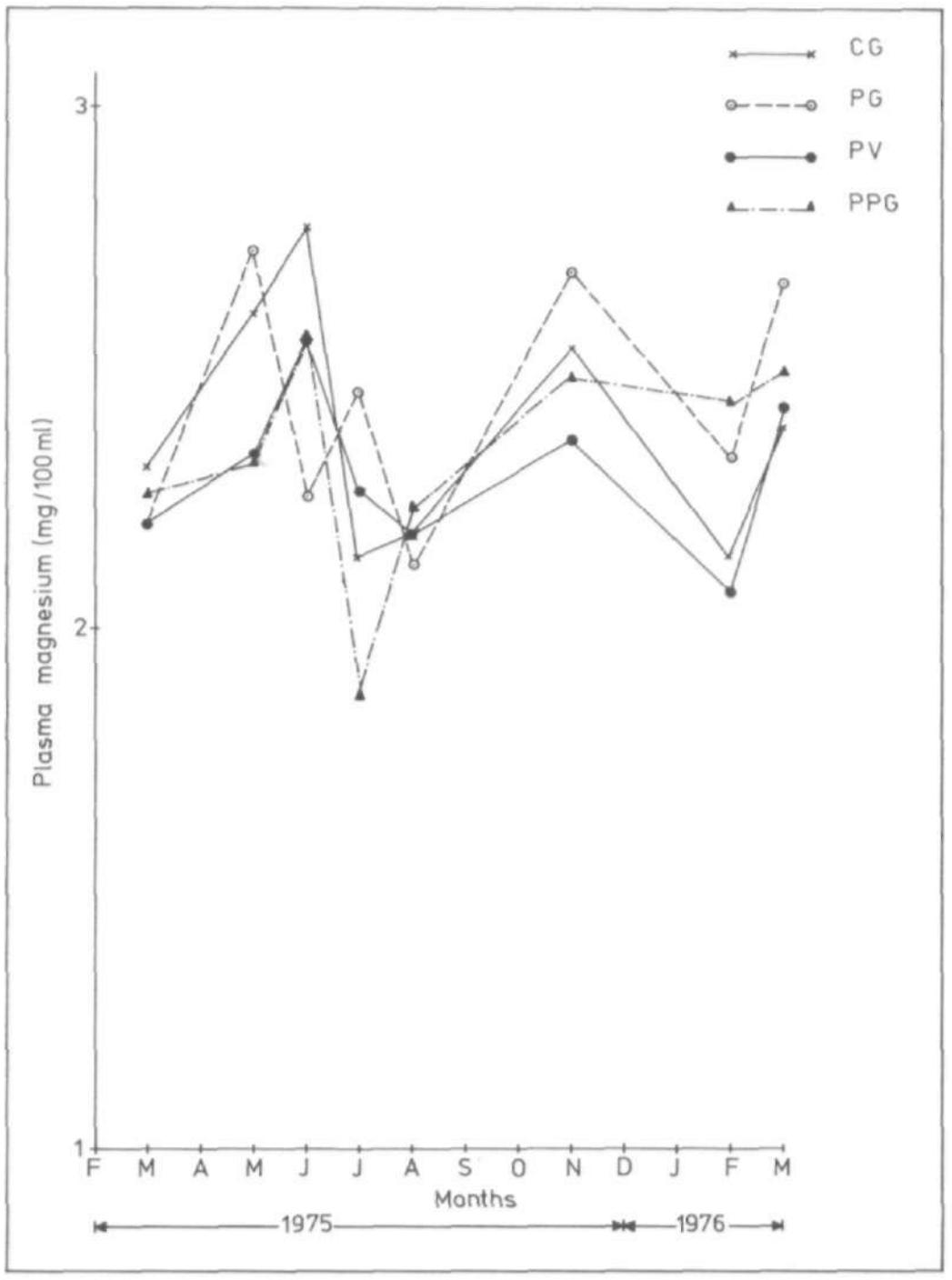
* = 2 does kidded twice during the study

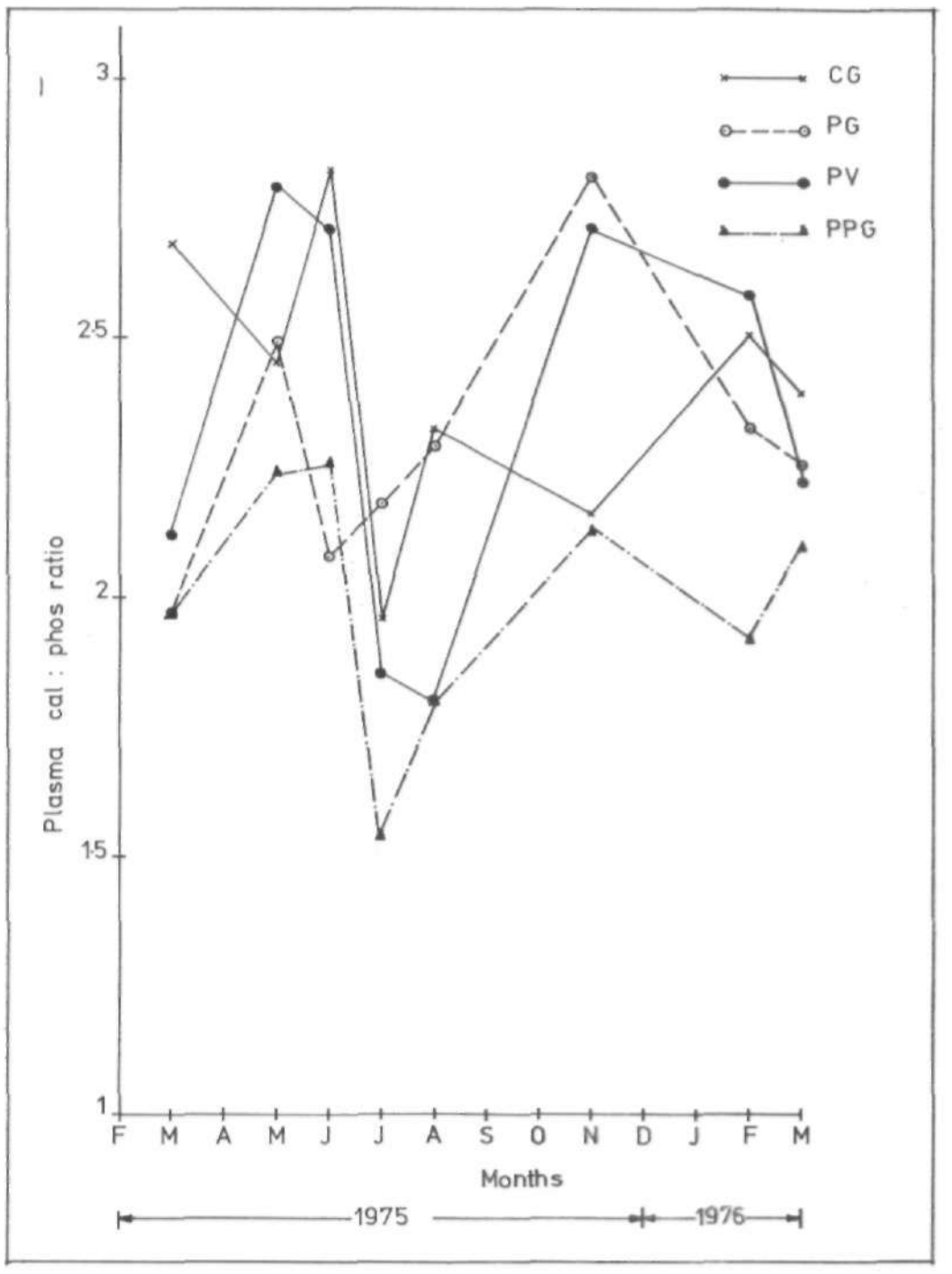
** = 1 doe kidded twice; 1 pregnant doe lost!; mummified twins in 1 doe, and 1 early abortion.

*** = 1 abortion.


CG
PG
PV
PPG
Plasma phosphorus (mg/100 ml)
6
5
4
3
F M A M J J A S O N D J F M
Months
1975
1976


CG
PG
PV
PPG
Plasma calcium (mg/100 ml)
12
11
10
9
8
F M A M J J A S O N D J F M
Months
1975
1976


CG
PG
PV
PPG
Plasma magnesium (mg/100 ml)
3
2
1
F M A M J J A S O N D J F M
Months
1975
1976


CG
PG
PV
PPG
Plasma cal : phos ratio
3
2·5
2
1·5
1
F M A M J J A S O N D J F M
Months
1975
1976

PART V

EFFECT OF VITAMIN A SUPPLEMENTATION ON PREGNANCY IN KANO BROWN GOATS

INTRODUCTION

Vitamin A deficiency adversely affects reproduction in cattle, sheep and goats by foetal death, abortion or birth of dead or weak neonates (Roberts, 1971). Infertility and early abortion in goats have been reported due to vitamin A deficiency (MacKenzie, 1970). The vitamin A requirements in goats for maintenance and reproduction is unknown.

Devendra and Burns (1970) stated that, in general, the majority of vitamins are available to goats in the tropics and that they are unlikely to be handicapped by seasonal availability. They admitted, however, that avitaminoses may exist in goats but that information is lacking. The caution that these authors made regarding nutritional requirements for sheep and cattle possibly not being applicable to tropical breeds of goats probably applies to vitamin A.

The purpose of this study was to investigate the effect of vitamin A supplementation on pregnancy in Kano Brown goats.

MATERIALS AND METHODS

Experimental Animals

Thirty-six adult Kano Brown does were used; 12 purchased locally and the PV and CG groups from Part IV. The does were housed, fed and were treated as described in Part IV.

Experimental Design

The study extended from April 1975 to June 1976. The three groups of 12 does (VG, PV and CG) were given groundnut cake at night (64 g per head daily).

VG and PV groups received 1,275 i.u. vitamin A per head daily; PV group had a daily intake of 1.3 g phosphorus per head during the dry season and about 1.8 g during the wet season, and the control group (CG) received groundnut cake only.

An adult buck was placed with each group at night and rotated on successive nights.

Blood samples were taken from each doe in May, August, November and March and analyzed for plasma vitamin A levels as previously described in Part II. Only samples from 10 animals

in each group were analyzed. Portion of the blood samples were examined haematologically as described in Part III. Heparin was used as anticoagulant.

Reproductive performance was observed and recorded as described in Part IV.

RESULTS

Mean monthly plasma levels of vitamin A are given in Table 1 and Fig. 1, and the individual values in Appendix 5 (Tables 42-44). The monthly body weights are in Appendix 4 (Tables 36-37) and Appendix 5 (Table 46).

The phosphorus-vitamin A supplemented group (PV) had higher monthly plasma means for vitamin A than the other groups except for November (early dry season). The PV values over VG and CG values were significant for May and August ($P<0.05$).

The haematological values were variable with the higher values tending to be in the controls (Table 2).

Four does were dropped from the study; 3 died and 1 disappeared.

Effect of vitamin A supplementation on kidding in Kano Brown does is summarized in Table 3. The kidding dates and reproductive status of each doe at the end of the study are in Appendix 4 and 5 (Tables 40-41, 45-46). The kidding performance of the two test groups was significantly lower than that of the controls ($P<0.05$). On the basis of conception and pregnancy, the differences were not significant; CG 100%, VG 81.8% and PV 91%.

DISCUSSION

Nutritional deficiencies involving caprine fertility in the savanna and sahelian grazing areas of Nigeria are unknown. These deficiencies are likely to be multiple and include protein, phosphorus and vitamin A. That these deficiencies have not been determined is not surprising when the nutritional requirements and feeding standards for goats in tropical regions are lacking (Devendra and Burns, 1970).

Vitamin A supplementation, alone or with phosphorus, did not improve conception or kidding in Kano Brown goats. The

amount of vitamin A used may have been inadequate. As vitamin A requirements of goats for maintenance and reproduction are unknown, the level used was that recommended for reproduction in sheep (Anon., 1968).

Fertility is unlikely to be impaired in does receiving protein or phosphorus supplements (Roberts, 1971). Groundnut cake provided 28 g protein daily for the does and this apparently helped fertility in all the groups. If this is so, then it is difficult to explain the lowered reproductive performance in the two supplemented groups. A possibility is interference with ovarian activity or conception which is not logical for either vitamin A or phosphorus.

SUMMARY

meal (1.3 g phosphorus) per head daily in addition to vitamin A, and the third group (CG) served as the controls.

The PV group had higher mean monthly plasma levels for vitamin A than the other two groups except for November; the values were significant for May and August ($P < 0.05$). The kidding performance of the two supplemented groups was significantly lower than that of the controls ($P < 0.05$). On the basis of conception and pregnancy, the differences were not significant.

Table 1: Mean monthly rainfall and plasma vitamin A (µg/100ml) of supplemented and control does.

Month	Rainfall (mm)	VG	PV	CG
1975		-	-	-
Mar.	0.3	21.54±7.43	26.15±0.00	27.69±4.87
Post-supplemention				
Apr.	85.8	-	-	-
May	130.1	33.84±10.88	44.61±12.14*	33.85±8.11
June	135.5	-	-	-
July	303.1	-	-	-
Aug.	113.4	26.15±7.69	31.28±15.38*	26.15±0.00
Sept.	212.2	-	-	-
Oct.	8.3	-	-	-
Nov.	0.0	29.23±9.73	26.15±7.25	27.69±4.87
Dec.	0.0	-	-	-
Jan.'76	0.0	-	-	-
Feb.	0.0	-	-	-
Mar.	0.0	32.31±7.95	35.38±10.76	30.77±7.43

* $P < 0.05$

VG Vitamin A supplement

PV Phosphorus and vitamin A supplement

CG Controls.

Table 2: Haematological values for vitamin A and phosphorus-vitamin A supplemented and controls goats for three seasons.

	Wet Season			Early Dry Season			Late Dry Season		
	PV	VG	CG	PV	VG	CG	PV	VG	CG
Hb g/100ml	6.99±0.6	7.15±1.2	8.06±1.3	7.65±1.3	7.30±1.7	8.04±1.2	8.50±1.2	8.71±1.1	9.17±1.1
PCV %	21.00±1.7	20.73±3.3	23.54±3.6	23.50±3.7	21.46±4.4	23.67±3.9	25.00±2.8	23.50±2.2	22.55±3.2
RBC cmm x 10^6	10.25±1.5	10.04±1.9	8.68±1.9	9.43±2.1	9.57±2.2	8.59±1.9	8.21±1.4	14.90±3.7	11.62±3.0
MCV μ^3	20.92±3.3	20.74±1.0	28.39±7.3	25.45±3.2	22.68±2.7	28.12±4.6	30.83±2.8	16.65±4.2	20.04±3.4
MCH µµg	6.94±1.1	7.15±0.5	9.70±2.4	8.24±0.9	7.71±1.0	9.54±1.6	10.43±0.8	6.24±2.0	8.12±1.4
MCHC %	33.28±0.3	34.53±2.7	34.22±1.2	32.47±1.4	34.00±1.3	34.08±0.7	33.9 ±1.2	36.01±4.6	41.07±4.7
WBC cmm x 10^3	13.5 ±5.5	-	11.00±4.5	14.02±2.7	13.74±2.9	14.9 ±4.3	17.27±3.2	20.51±7.9	16.2 ±4.2

PV = Phosphorus + vitamin A supplemented.

VG = Vitamin A supplemented.

CG = Controls.

Table 3: Cumulative kidding in vitamin A supplemented goats.

Group	No. Does	1975 Sept.	Oct.	Nov.	Dec.	1976 Jan.	Feb.	Mar.	Apr.	May	June	%
VG	11	0	0	0*	4	5	5	5	6	6	8	72.7
PV	10	0	0	0	2	4	4	4	5	5	7**	70
CG	11	0	0	0	2	3	3	6	8*	10	10	91

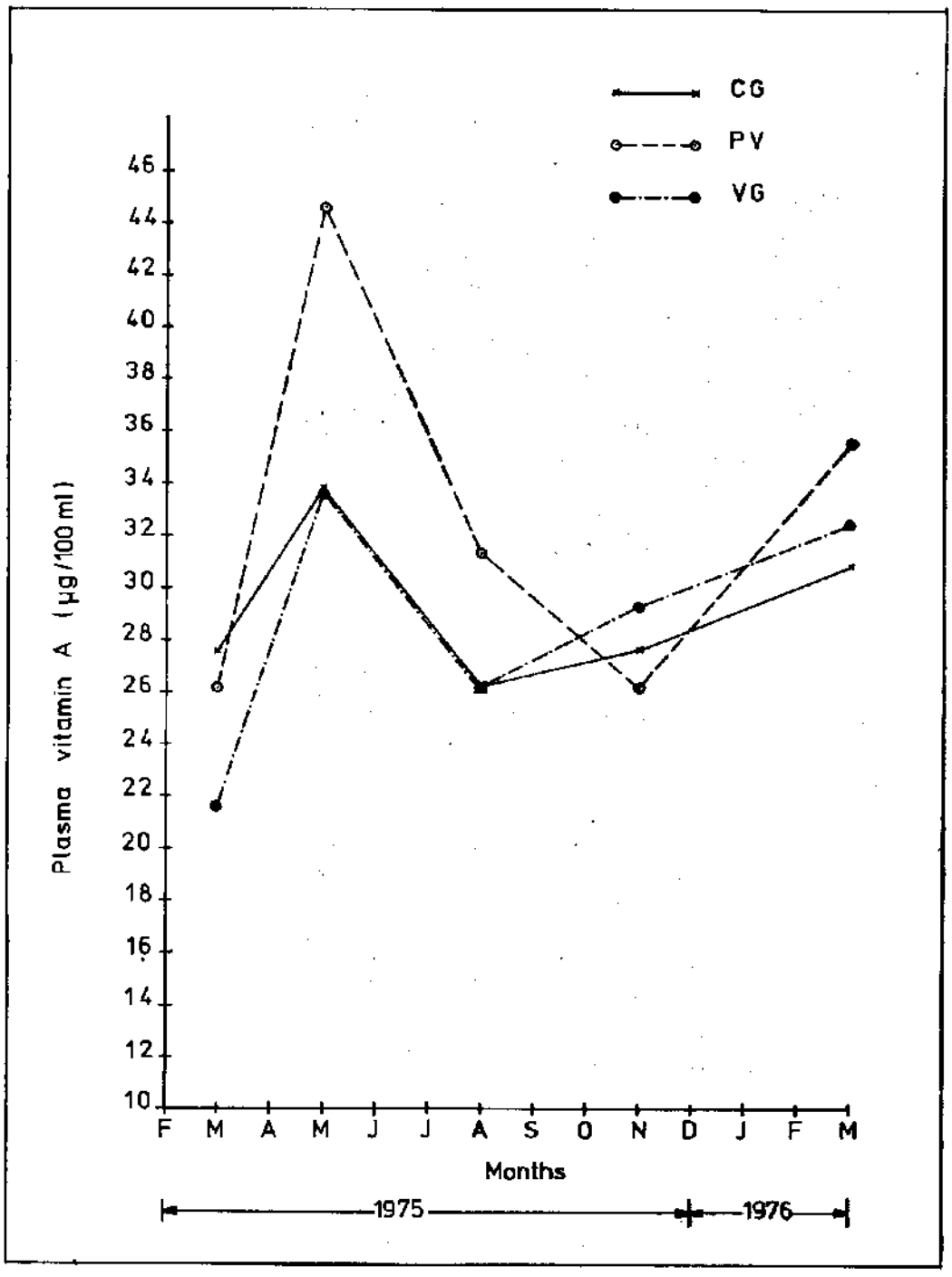
VG = Vitamin A supplemented.

PV = Phosphorus + vitamin A supplement.

CG = Control.

* = Aborted.

** = 1 doe kidded twice; 1 pregnant doe lost; mummified twins; and 1 early abortion.


CG
PV
VG
Plasma vitamin A (µg/100 ml)
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
F M A M J J A S O N D J F M
Months
1975
1976

PART VI

GENERAL DISCUSSION

GENERAL DISCUSSION

Livestock indigenous to West Africa have a lower rate of growth and reproduction compared to temperate zone breeds (Lansbury, 1962). Over 90% of the national cattle herd is located in the savanna and sahelian zones and is owned primarily by nomadic Fulanis. The reproductive efficiency of Fulani-owned cattle is low, being 35 to 40% of their genetic potential; surveys suggest that husbandry methods and nutrition are the major causes.

Conditions in the grazing areas of Northern Nigeria suggest aphosphorosis and avitaminosis A as causative factors in the poor growth and low reproductive efficiency of indigenous cattle under traditional nomadic methods of husbandry. The dry bleached pastures during the six to seven months dry season is virtually standing hay from which most, if not all, of the carotene and phosphorus has been lost. All natural forages investigated in the northern grazing areas were found to be phosphorus-deficient (Kapu, 1975).

The usual reproductive signs of phosphorus deficiency in cattle of delayed onset of puberty, anoestrus, and calving every other year are found in indigenous cattle grazing the

savanna and sahelian areas (Roberts, 1971). Vitamin A deficiency is not considered to cause bovine infertility but adversely affects reproduction during the second half of gestation. It is characterized by placental degeneration, foetal death, abortion, dystocia, retained placenta, birth of weak or dead calves, and septic metritis (Roberts, 1971). The role of vitamin A in bovine abortion, dystocia and neonatal mortality in Nigeria is unknown.

Vitamin A deficiency is described in cattle grazing dry, bleached pastures where protein, phosphorus and carbohydrate intake are also probably deficient - conditions typical of the savanna and sahelian grazing areas in Nigeria during the long dry season. It is concluded from the available literature and from this study that the nutritional causes for the low reproductive efficiency of indigenous cattle is not confined to phosphorus or vitamin A deficiencies but are multiple - the combined effects of deficiencies of protein, phosphorus, vitamin A and carbohydrate. It is impossible to separate these causative factors under the prevailing non-production-oriented nomadic husbandry. Lansbury (1960) suggested the primary deficiency during the dry season is protein.

It is recommended that the nutritional effects on the reproductive wastage in Nigerian cattle can be minimized by changing the nomadic husbandry to more conventional production-oriented methods and by improving nutrition by pasture improvement, cropping and by mineral supplements. With more and more land being converted to agricultural use, that available for grazing is being reduced each year which further aggravates the present low reproductive efficiency and low productivity of the Nigerian cattle industry. This is a complex rural sociological-animal production problem primarily involving land tenure, increasing agricultural utilization, Fulani nomadic husbandry practices, and tsetse flies. The only way this can be solved is by the Federal and State Governments making positive efforts to provide land for Fulanis to settle and by intensifying the tsetse fly (Glossina spp.) eradication programme to open up the better grazing areas towards the south.

As a result of this study, the following research projects are planned.

1. Effect of phosphorus and protein supplementation on bovine reproduction over a minimum period of three years starting with virgin two-year old heifers.

2. Re-examining the effect of phosphorus supplementation on reproduction in goats together with different levels of protein.

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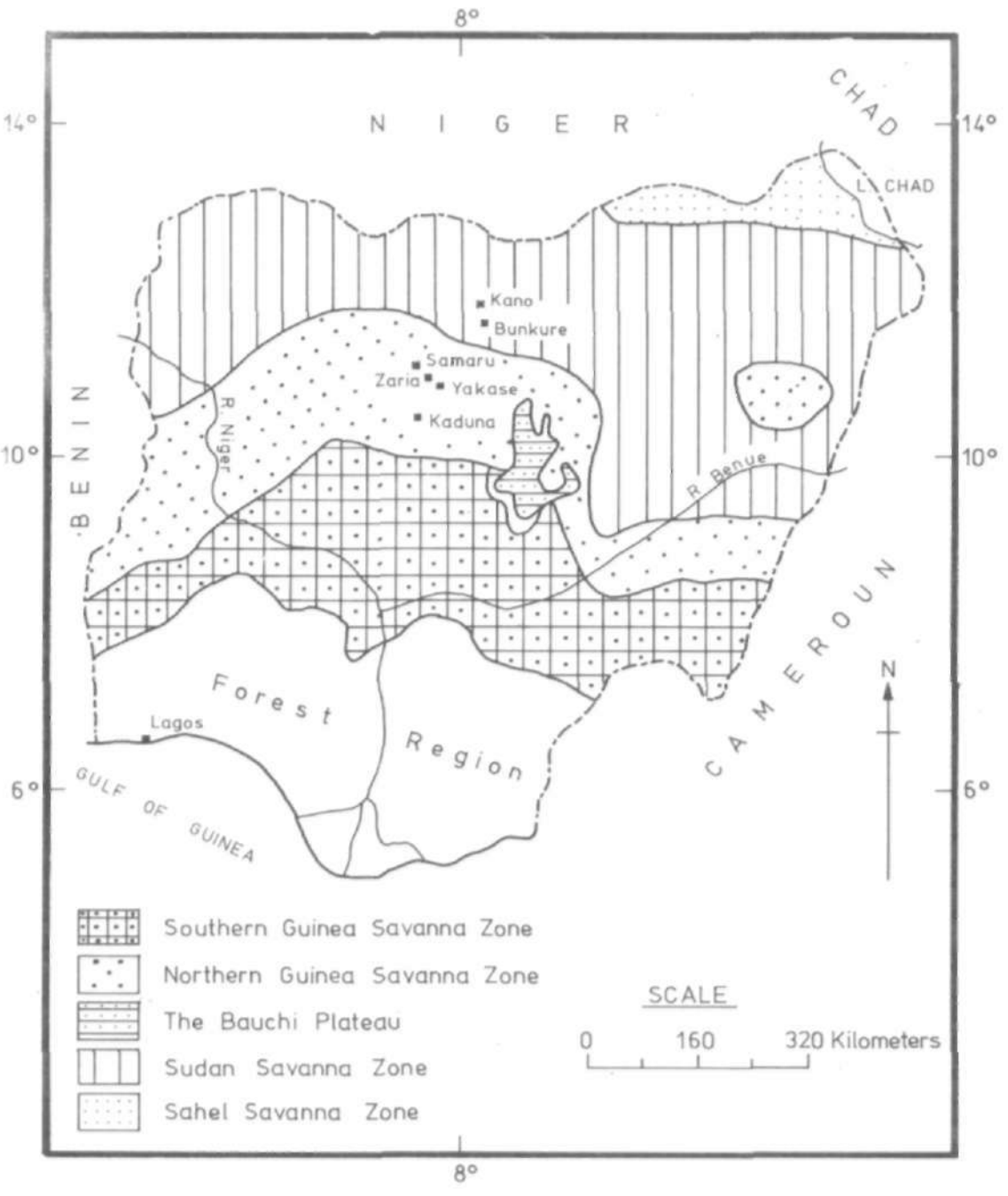
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APPENDIX 1

MAP OF NIGERIA


8°
14°
10°
6°
NIGER
CHAD
BENIN
CAMEROUN
L. CHAD
Kano
Bunkure
Samaru
Zaria
Yakase
Kaduna
R. Niger
R. Benue
Forest
Region
Lagos
GULF OF GUINEA
N
Southern Guinea Savanna Zone
Northern Guinea Savanna Zone
The Bauchi Plateau
Sudan Savanna Zone
Sahel Savanna Zone
SCALE
0 160 320 Kilometers

APPENDIX 2

SEASONAL CHANGES IN PLASMA MINERALS

AND PLASMA AND HEPATIC VITAMIN A VALUES

Tables 1 to 12

Table 1: Monthly total rainfall figures (mm) for Kaduna, Kano, Samaru and Zaria, 1973-76.

KADUNA

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1973	0.0	0.0	17.0	46.2	78.5	183.6	161.3	323.3	385.8	23.6	0.0	0.0
1974	0.0	0.0	24.9	23.1	123.1	183.5	280.0	327.8	444.4	36.8	0.0	0.0
1975	0.0	0.0	3.8	103.6	172.3	184.2	242.1	298.3	293.8	8.4	0.0	0.0
1976	0.0	0.0	0.0	103.1	189.8	148.3	194.5					

KANO

1973	0.0	0.0	0.0	0.0	3.1	39.0	164.4	171.8	35.8	0.0	0.0	0.0
1974	0.0	0.0	0.0	0.0	41.6	42.2	261.5	198.2	111.5	5.6	0.0	0.0
1975	0.0	0.0	0.0	18.3	39.6	127.5	125.2	224.0	180.4	0.0	0.0	0.0
1976	0.0	2.3	0.0	0.0	43.8	117.4	131.5					

SAMARU

1973	0.0	0.0	0.5	21.6	46.9	191.8	191.8	227.5	292.6	1.5	0.0	0.0
1974	0.0	0.0	11.2	30.0	38.8	144.2	253.0	328.7	246.9	67.6	0.0	0.0
1975	0.0	0.0	0.3	85.8	130.1	135.5	303.1	113.4	212.2	8.3	0.0	0.0
1976	0.0	0.0	0.0	86.2	135.5	240.2	226.4					

ZARIA

1973	0.0	0.0	0.8	5.7	34.3	168.2	255.9	226.8	217.7	0.0	0.0	0.0
1974	0.0	0.0	5.3	82.1	53.7	126.8	399.3	226.5	181.9	62.5	0.0	0.0
1975	0.0	0.0	0.0	89.3	129.1	97.4	240.2	179.4	202.2	11.4	0.0	0.0
1976	0.0	0.0	0.0	61.7								

Table 2: Plasma phosphorus, calcium and magnesium levels (mg/100ml) in cows, Bunkure cattle ranch.

	Phosphorus			Calcium			Magnesium		
	Aug. '75	Jan. '76	April '76	Aug. '75	Jan. '76	April '76	Aug. '75	Jan. '76	April '76
n =	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)	(16)
	5.76	4.78	3.21	5.30	10.15	12.35	1.10	2.05	3.35
	5.66	5.06	6.55	9.45	8.80	10.65	1.85	1.90	2.85
	4.02	5.63	5.07	11.20	8.05	10.75	1.70	1.40	2.80
	5.76	5.16	3.80	9.75	7.55	10.25	1.90	1.70	2.80
	6.53	4.40	5.76	10.20	9.10	13.80	1.75	1.90	4.75
	6.82	4.40	3.70	10.00	8.35	13.35	1.95	1.85	4.35
	5.42	7.24	5.76	9.40	9.90	11.15	1.90	1.75	2.80
	6.34	4.30	4.39	9.95	8.00	11.80	1.75	1.35	3.15
	4.41	6.49	4.43	10.10	9.45	14.50	1.85	1.55	3.50
	4.31	4.45	4.78	9.40	9.45	15.35	1.90	2.00	2.85
	7.69	3.54	4.29	8.75	9.15	10.30	1.50	2.25	2.80
	5.37	4.40	5.96	8.70	10.80	11.30	1.85	1.70	3.35
	5.18	4.97	3.99	10.05	10.25	11.10	1.40	2.10	2.95
	5.23	4.87	4.39	10.00	9.45	11.75	2.10	1.95	2.55
	8.46	5.35	5.07	7.65	10.20	12.10	1.60	2.30	2.70
	4.21	3.07	4.29	8.90	9.90	9.20	1.40	2.00	4.25
Mean	5.70	4.88	4.72	9.30	9.28	11.86	1.79	1.86	3.24
S.D.	±1.25	±1.01	±0.92	±1.34	±0.93	±1.67	±0.18	±0.28	±0.66

Table 3: Plasma vitamin A (ug/100ml) in cows, Bunkure cattle ranch.

	Aug. '75	Jan. '76	April '76
n =	(16)	(16)	(15)
	1.54	143.08	32.31
	13.85	26.15	60.00
	50.77	60.00	29.23
	23.08	50.77	38.46
	13.85	84.62	20.00
	7.69	16.92	16.92
	0.00	100.00	35.38
	0.00	81.54	50.77
	0.00	63.08	41.54
	0.00	87.69	53.85
	0.00	81.54	66.15
	0.00	72.31	103.08
	0.00	38.46	75.38
	0.00	100.00	38.46
	0.00	47.69	26.15
	0.00	87.69	-
Mean	6.92	71.36	45.85
S.D.	±13.63	±31.59	±23.05

Table 4: Plasma phosphorus, calcium and magnesium levels (mg/100ml).in cows, Kaduna abattoir.

	Phosphorus			Calcium			Magnesium		
	Aug. '75	Feb. '76	April '76	Aug. '75	Feb. '76	April '76	Aug. '75	Feb. '76	April '76
n =	(9)	(16)	(14)	(9)	(16)	(14)	(9)	(16)	(14)
	4.58	7.56	4.47	7.45	9.80	9.55	1.40	1.95	2.25
	5.33	7.37	2.90	9.20	8.70	9.15	2.00	2.60	2.00
	4.79	5.90	8.23	10.30	9.75	9.60	1.75	1.75	1.75
	5.04	5.23	8.84	10.35	8.95	10.85	1.85	1.70	2.50
	5.28	8.23	6.96	8.85	9.05	8.55	1.70	1.80	2.25
	7.02	4.80	6.37	8.95	10.10	8.75	1.50	2.05	1.40
	4.21	6.66	2.00	9.10	8.75	8.50	2.10	1.75	2.40
	4.60	5.61	5.52	8.55	8.90	9.45	1.80	2.00	2.45
	4.70	6.66	5.18	8.05	8.85	10.30	1.55	1.45	2.20
		5.75	5.71		9.40	9.20		2.10	2.00
		5.71	5.56		8.75	11.30		2.00	2.25
		4.28	6.80		9.45	9.75		1.90	1.95
		7.32	6.80		9.50	9.05		1.95	1.80
		6.94	5.56		10.05	9.15		2.20	2.05
		4.00			9.60			2.05	
		6.13			10.05			2.15	
Mean	5.06	6.13	5.78	8.98	9.35	9.51	1.74	1.96	2.09
S.D.	±0.82	±1.21	±1.84	±0.94	±0.51	±0.82	±0.23	±0.26	±0.30

Table 5: Plasma (µg/100ml) and hepatic (µg/g) vitamin A in cows, Kaduna abattoir.

	Plasma vitamin A			Hepatic vitamin A		
	Aug.'75	Feb.'76	April'76	Aug.'75	Feb.'76	April'76
n =	(9)	(14)	(14)	(10)	(10)	(7)
	26.15	32.31	56.92	153.19	25.53	59.58
	29.23	13.85	16.92	238.30	51.06	51.06
	26.15	35.38	26.15	68.08	102.13	119.15
	32.31	7.69	38.46	110.64	68.08	76.60
	29.23	10.77	13.85	59.58	76.60	59.58
	44.62	26.15	47.69	85.11	554.68	17.02
	32.31	26.15	53.85	187.23	85.11	102.13
	13.85	13.85	35.38	51.06	110.64	-
	38.46	10.77	18.85	68.08	127.67	-
	-	10.77	26.15	76.60	25.53	-
	-	20.00	16.92	-	-	-
	-	29.23	7.69	-	-	-
	-	32.31	35.38	-	-	-
	-	10.77	13.85	-	-	-
Mean	30.26	20.00	28.79	107.79	74.71	69.30
S.D.	±8.57	±9.88	±16.09	±62.85	±36.06	±33.84

Table 6: Plasma, phosphorus, calcium and magnesium levels (mg/100ml) in cows, Kano abattoir.

	Phosphorus			Calcium			Magnesium		
	Sept. '75	Jan. '76	April '76	Sept. '75	Jan. '76	April '76	Sept. '75	Jan. '76	April '76
n =	(12)	(9)	(16)	(12)	(9)	(16)	(12)	(9)	(16)
	8.12	5.53	4.84	8.95	8.35	8.05	1.35	1.65	1.65
	5.08	8.36	7.01	8.00	8.65	8.20	1.80	2.05	1.50
	8.12	4.74	5.44	8.70	9.25	9.20	1.60	1.65	1.90
	5.92	4.42	6.64	8.70	9.50	8.65	1.65	2.30	2.25
	6.08	7.38	5.52	10.35	9.95	8.65	2.10	1.40	2.10
	9.60	5.81	3.73	9.80	9.65	8.35	1.55	1.80	1.90
	7.76	6.64	2.94	7.55	9.35	9.05	0.85	1.95	1.75
	5.80	3.68	5.90	9.40	8.10	7.75	1.20	2.15	2.40
	10.84	4.88	8.96	8.90	9.75	11.85	1.30	2.25	1.90
	9.24		3.22	8.50		9.15	0.90		1.85
	5.36		5.62	7.85		10.00	1.70		2.65
	6.96		3.68	9.50		8.40	1.10		1.85
			2.92			8.40			1.95
			4.14			8.75			2.15
			4.05			8.55			1.85
			6.50			8.80			1.45
$\bar{x}$	7.45	5.72	5.07	8.85	9.17	8.86	1.43	1.91	1.94
S.D.	±1.93	±1.51	±1.69	±0.82	±0.65	±0.96	±0.38	±0.31	±0.31

Table 7: Plasma (µg/100ml) and hepatic (µg/g) vitamin A in cows, Kano abattoir.

	Plasma vitamin A			Hepatic vitamin A		
	Sept.'75	Jan.'76	April'76	Aug.'75	Jan.'76	March'76
n =	(10)	(8)	(15)	(10)	(5)	(7)
	44.62	26.15	13.85	153.19	246.81	25.53
	10.77	10.77	32.31	85.11	68.08	216.17
	32.31	29.23	7.69	127.67	238.30	136.17
	29.23	13.85	10.77	136.17	187.23	289.36
	50.77	16.92	38.46	187.23	221.28	110.64
	26.15	26.15	10.77	85.11	-	110.64
	29.23	10.77	26.15	178.72	-	76.60
	38.46	26.15	26.15	119.15	-	-
	44.62		16.92	153.19	-	-
	26.15		29.23	153.19	-	-
			7.69			
			13.85			
			29.23			
			13.85			
			41.54			
$\bar{x}$	33.23	20.00	21.23	137.87	192.34	137.87
S.D.	±11.70	±7.71	±11.29	±34.70	±73.12	±88.45

Table 8: Plasma, phosphorus and magnesium levels (mg/100ml) in local nomadic cows, Yakase, Kaduna State.

	Phosphorus			Calcium			Magnesium		
	July '74	Aug. '74	Sept. '74	July '74	Aug. '74	Sept. '74	July '74	Aug. '74	Sept. '74
n =	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)	(15)
	1.96	2.44	2.52	10.55	11.40	11.45	2.00	2.35	2.65
	3.28	4.28	3.08	9.45	10.45	11.55	1.95	1.90	2.30
	2.52	2.32	1.96	10.65	10.80	10.25	2.40	2.05	2.60
	1.28	2.36	1.40	9.55	10.30	11.70	1.80	1.75	2.35
	2.60	3.72	1.96	10.45	10.85	12.60	-	1.30	2.55
	3.80	3.88	3.00	9.85	10.50	11.70	2.10	2.35	2.45
	2.52	4.36	2.76	10.05	11.20	11.40	2.20	1.20	2.05
	1.96	2.80	2.48	10.20	11.85	10.55	1.95	2.35	2.30
	1.84	3.60	1.76	8.95	10.60	10.10	1.60	2.40	2.40
	1.88	1.88	1.12	10.05	11.55	13.55	2.70	2.30	2.90
	2.24	2.60	1.56	11.00	8.60	11.15	2.35	1.50	2.60
	3.16	4.00	1.96	11.15	11.55	12.10	2.10	1.65	2.60
	1.60	1.72	0.56	9.70	11.25	10.50	1.85	1.35	2.30
	3.00	5.48	4.08	10.15	12.05	10.20	2.10	1.45	2.40
	3.52	3.28	1.84	10.70	10.75	11.45	2.15	1.95	2.60
$\bar{x}$	2.48	3.25	2.14	10.16	10.91	11.35	2.09	1.86	2.47
S.D.	±0.75	±1.06	±0.88	±0.61	±0.83	±0.96	±0.27	±0.43	±0.20

Table 9: Plasma phosphorus, calcium and magnesium levels (mg/100ml) in goats, Kaduna abattoir.

	Phosphorus			Calcium			Magnesium		
	Aug.'75	Feb.'76	April'76	Aug.'75	Feb.'76	April'76	Aug.'75	Feb.'76	April'76
n =	(14)	(5)	(15)	(14)	(5)	(14)	(14)	(5)	(14)
	6.30	6.09	6.30	8.50	9.45	9.90	1.75	1.75	2.05
	6.34	7.29	7.75	8.00	5.80	8.65	1.85	1.65	2.10
	4.30	4.79	5.33	8.90	11.70	8.60	1.90	2.80	2.05
	4.21	9.05	5.76	9.05	10.60	9.95	2.05	2.90	1.60
	5.58	4.74	9.64	8.70	9.50	9.70	2.10	2.35	2.55
	9.52		6.15	9.85		9.95	1.95		1.45
	7.53		8.67	8.90		9.50	2.00		1.85
	7.20		7.02	9.45		8.60	2.10		1.85
	6.20		6.72	9.70		10.45	1.95		2.40
	5.54		7.56	8.70		9.35	2.15		1.90
	4.54		6.93	8.45		9.75	1.95		2.00
	7.91		6.97	10.15		7.40	1.75		1.75
	4.59		7.02	7.95		9.00	1.70		2.05
	8.95		3.63	10.15		9.35	1.75		2.10
			4.41						
$\bar{x}$	6.34	6.39	6.66	9.03	9.41	9.30	1.93	2.29	1.98
S.D.	±1.70	±1.82	±1.53	±0.73	±2.22	±0.79	±0.15	±0.58	±0.29

Table 10: Plasma (µg/100ml) and hepatic (µg/g) vitamin A in goats, Kaduna abattoir.

	Plasma vitamin A			Hepatic vitamin A		
	Aug.'75	Feb.'76	April'76	Aug.'75	Feb.'76	April'76
n =	(14)	(5)	(14)	(10)	(9)	(10)
	26.15	26.15	26.15	153.19	187.23	34.04
	26.15	26.15	26.15	204.26	110.64	34.04
	26.15	26.15	26.15	68.08	357.45	25.53
	26.15	26.15	41.54	68.08	170.21	42.55
	26.15	26.15	13.85	374.47	170.21	161.70
	26.15		13.85	187.23	76.60	93.62
	41.54		26.15	136.17	68.08	102.13
	26.15		26.15	374.47	238.30	34.04
	26.15		26.15	204.26	51.06	25.53
	26.15		26.15	68.08		119.15
	26.15		41.54			
	26.15		29.23			
	26.15		26.15			
	41.54		26.15			
$\bar{x}$	28.35	26.15	26.81	183.83	158.86	67.23
S.D.	±5.59	±0.00	±7.74	±113.99	±97.32	±48.22

Table 11: Plasma, phosphorus, calcium and magnesium levels (mg/100ml) in goats, Kano abattoir.

	Phosphorus			Calcium			Magnesium		
	Sept.'75	Jan.'76	April'76	Sept.'75	Jan.'76	April'76	Sept.'75	Jan.'76	April'76
n =	(15)	(13)	(15)	(15)	(13)	(16)	(15)	(13)	(16)
	6.67	5.13	5.24	8.75	10.45	9.30	2.15	1.85	1.85
	4.33	8.48	3.62	9.55	10.75	10.25	2.15	2.20	1.90
	7.14	8.48	4.95	8.60	9.10	10.05	1.80	1.55	1.90
	5.90	4.99	5.52	8.60	9.20	9.95	1.60	2.05	1.75
	5.00	5.42	6.38	10.05	9.60	9.75	2.00	2.10	2.65
	4.67	5.91	6.95	9.00	9.50	10.00	1.85	1.50	2.05
	7.05	5.52	6.95	9.85	9.15	10.95	1.90	1.40	1.75
	7.14	5.14	9.05	9.15	9.10	9.30	1.70	1.65	2.40
	5.90	7.52	8.58	9.40	9.75	9.20	1.65	1.60	2.05
	9.05	6.95	5.33	9.65	10.40	9.55	2.25	2.15	1.70
	4.81	5.90	5.43	8.90	7.25	8.55	2.00	1.85	2.20
	7.90	7.43	3.10	9.45	9.55	11.10	2.45	1.95	1.55
	7.24	4.76	6.86	9.45	8.10	10.80	1.65	1.55	2.95
	7.24		6.05	9.20		9.55	1.85		1.55
	5.33		7.24	9.00		8.05	1.70		1.95
						9.10			2.05
Mean	6.36	6.28	6.08	9.24	9.38	9.72	1.91	1.80	2.02
S.D.	±1.35	±1.33	±1.62	±0.44	±0.95	±0.83	±0.43	±0.27	±0.38

Table 12: Plasma (µg/100ml) and hepatic (µg/g) vitamin A in goats, Kano abattoir.

	Plasma vitamin A			Hepatic vitamin A		
	Sept.'75	Jan.'76	April'76	Aug.'75	Jan.'76	April'76
n =	(15)	(15)	(15)	(10)	(10)	(10)
	26.15	26.15	26.15	314.89	153.19	51.06
	87.69	56.92	26.15	272.34	195.74	68.08
	26.15	41.54	26.15	119.15	255.32	76.60
	26.15	41.54	41.54	229.78	153.19	153.19
	10.77	41.54	26.15	85.11	127.67	59.58
	26.15	26.15	41.54	119.15	374.47	93.62
	26.15	26.15	56.92	238.30	136.17	59.58
	26.15	26.15	41.54	255.32	51.06	68.08
	26.15	26.15	41.54	221.28	238.30	25.53
	26.15	26.15	41.54	323.40	170.21	144.58
	41.54	56.92	56.92			
	56.92	41.54	26.15			
	41.54	26.15	41.54			
	26.15	56.92	41.54			
	41.54	41.54	26.15			
$\bar{x}$	34.36	34.36	37.43	217.87	185.53	79.99
S.D.	±18.27	±18.27	±10.83	±83.40	±87.97	±40.34

APPENDIX 3

BONEMEAL SUPPLEMENTATION IN BUNAJI COWS

Tables 13 to 21

Table 13: Plasma phosphorus levels (mg/100ml) in bonemeal-supplemented cows

Cow No.	1975										1976
	Feb	March	April	May	June	July	Aug	Sept	Nov	Dec	March
n =	15	16	12	16	16	12	16	16	16	16	16
1	4.20	6.80	4.60	5.50	7.10	8.14	7.87	6.83	5.68	5.00	2.93
2	4.90	6.30	4.90	6.00	7.20	5.43	7.38	5.90	5.05	5.16	4.17
3	6.45	8.00	-	5.70	6.40	6.57	7.87	6.24	6.07	9.56	6.11
4	6.75	6.30	4.10	4.70	6.60	7.04	8.84	6.24	5.68	7.36	6.39
5	-	8.20	3.50	4.50	7.60	6.29	9.52	4.39	5.13	5.55	2.97
6	4.40	5.00	4.40	6.70	5.90	7.33	8.06	5.56	4.97	4.14	2.60
7	5.70	7.00	-	7.30	6.50	-	7.48	4.54	4.89	5.55	4.45
8	4.65	6.60	4.70	4.80	5.00	-	8.16	5.41	5.05	5.79	5.37
9	3.55	6.60	5.40	6.40	5.10	6.57	8.21	5.46	4.34	5.31	4.91
10	4.45	8.40	5.20	5.80	6.70	7.23	8.21	4.78	5.44	6.02	5.09
11	6.10	7.00	4.90	8.00	7.30	6.48	9.38	7.41	4.81	6.42	4.72
12	6.75	6.30	5.00	6.50	8.30	8.23	8.94	5.85	7.65	6.57	6.94
13	5.25	5.20	-	4.30	6.90	-	7.28	5.04	4.57	5.24	4.88
14	6.90	6.70	4.40	5.40	6.10	5.72	7.62	8.01	6.15	4.14	4.88
15	7.10	5.70	4.40	6.10	6.40	-	9.43	7.58	5.91	5.63	5.32
16	5.50	6.10	-	6.10	4.20	4.20	5.24	5.43	3.31	4.06	4.53
$\bar{x}$	5.51	6.64	4.63	5.86	6.46	6.60	8.09	5.92	5.29	5.72	4.77
SD	±1.13	±0.96	±0.52	±1.01	±1.04	±1.13	±1.06	±1.08	±0.95	±1.36	±1.21

Table 14: Plasma phosphorus levels (mg/100ml) in control cows

Cow No.	1975										1976
	Feb	March	April	May	June	July	Aug	Sept	Nov	Dec	March
n =	16	14	15	16	16	16	16	16	16	16	16
1	4.35	4.50	4.30	3.10	7.50	4.56	9.10	5.56	3.90	4.86	3.71
2	4.35	5.90	6.00	5.60	7.00	6.12	7.06	7.41	5.08	6.50	4.82
3	5.10	5.25	-	2.20	5.30	5.56	6.28	5.32	4.21	4.46	3.34
4	6.30	6.70	4.50	2.20	7.70	3.12	7.69	6.92	3.66	4.86	2.60
5	6.15	5.10	4.30	2.30	4.20	2.48	5.97	3.27	2.96	5.01	3.34
6	5.45	5.75	5.70	4.30	6.00	5.08	7.69	6.83	4.53	3.99	4.08
7	5.95	-	4.40	3.60	6.60	2.12	6.12	7.07	5.71	7.68	3.34
8	6.90	7.60	6.40	2.00	6.60	4.24	6.28	3.80	3.90	6.03	2.04
9	5.05	5.65	6.20	4.20	6.40	4.72	8.78	5.71	5.60	4.86	2.41
10	4.30	7.50	4.10	-	5.90	4.28	7.61	7.13	6.62	8.39	4.08
11	4.70	5.55	4.00	1.90	4.00	2.88	5.81	3.42	3.94	4.62	3.98
12	4.40	5.90	4.20	4.20	5.70	4.64	7.37	4.58	4.89	5.25	4.45
13	4.50	5.30	5.50	2.30	4.90	4.50	6.98	5.92	4.57	4.15	5.66
14	4.35	-	5.50	2.70	4.70	3.70	7.37	6.41	4.37	4.78	3.40
15	6.25	6.65	5.40	2.70	5.50	3.30	5.97	5.72	5.05	5.72	4.58
16	4.55	5.60	5.10	2.70	7.20	3.10	7.37	6.21	4.50	4.86	2.72
$\bar{x}$	5.17	5.93	5.11	3.07	5.95	4.03	7.09	5.71	4.62	5.38	3.66
SD	±0.88	±0.89	±0.90	±1.08	±1.14	±1.13	±0.98	±1.33	±0.89	±1.23	±0.96

Table 15: Plasma calcium levels (mg/100ml) in bonemeal-supplemented cows

Cow No.	1975										1976
	Feb	March	April	May	June	July	Aug	Sept	Nov	Dec	March
n =	15	16	12	16	16	12	16	16	16	16	16
1	8.35	10.35	12.30	12.20	11.65	10.20	10.25	11.15	12.45	13.55	9.40
2	7.90	8.15	11.80	11.65	11.65	10.25	9.65	10.60	13.65	12.45	10.30
3	9.30	8.45	-	10.20	11.45	9.15	9.85	9.75	12.25	13.80	10.15
4	10.65	9.95	11.60	11.55	12.15	10.45	9.30	10.85	12.30	14.05	11.30
5	-	10.05	11.40	12.90	11.80	10.95	10.90	10.75	12.40	14.10	10.75
6	10.60	10.65	12.05	12.85	10.25	10.75	10.90	11.75	11.80	12.55	11.25
7	10.25	10.35	-	12.85	11.10	-	10.45	10.85	12.80	13.90	11.35
8	8.80	9.60	11.60	11.35	11.55	-	11.10	10.85	11.60	13.50	9.95
9	11.40	10.20	12.15	12.70	11.85	11.15	11.95	10.30	13.70	10.10	10.60
10	9.35	9.65	8.65	11.50	11.80	10.50	10.55	10.85	11.15	11.95	9.25
11	9.05	9.25	10.95	11.90	13.05	10.75	10.35	11.35	12.05	13.05	10.05
12	11.80	13.15	11.85	13.65	13.40	10.50	11.80	10.40	12.10	15.05	8.85
13	6.65	11.35	-	11.40	12.95	-	10.80	10.15	10.75	13.90	9.80
14	11.80	13.00	14.40	12.55	11.90	10.45	10.70	9.90	12.50	13.95	10.05
15	12.15	13.65	12.90	11.45	11.50	-	10.95	11.40	9.85	15.45	10.75
16	9.95	12.65	-	13.10	12.65	10.50	10.75	10.05	15.05	12.35	10.55
$\bar{x}$	9.87	10.65	11.80	12.11	11.92	10.47	10.70	10.68	12.28	13.36	10.27
SD	±1.59	±1.67	±1.32	±0.88	±0.79	±0.50	±0.72	±0.57	±1.22	±1.28	±0.73

Table 16: Plasma calcium levels (mg/100ml) in control cows

Cow No.	1975										1976
	Feb	March	April	May	June	July	Aug	Sept	Nov	Dec	March
n =	16	14	15	15	16	16	16	16	8	16	16
1	11.10	10.65	10.55	12.65	11.05	12.70	12.40	10.45	-	12.50	8.50
2	10.70	9.65	9.85	10.00	10.05	12.45	14.30	9.55	-	14.80	9.85
3	9.85	10.40	-	10.70	10.15	11.60	13.65	10.20	-	13.60	10.60
4	9.70	10.40	9.95	9.50	10.00	12.50	12.55	9.10	-	11.95	11.50
5	9.35	9.30	10.55	9.70	9.80	11.60	11.85	9.50	-	13.35	9.65
6	11.00	7.80	10.00	10.80	10.20	12.50	14.15	10.15	-	13.40	9.90
7	12.25	-	9.85	10.65	10.65	13.65	15.05	10.80	-	13.50	10.45
8	11.95	10.00	10.45	9.75	9.70	14.40	15.25	10.65	-	13.95	11.05
9	10.00	10.80	10.55	9.50	10.70	13.30	14.20	8.65	15.30	14.30	8.70
10	9.15	9.10	10.25	-	10.35	12.60	14.30	9.25	13.10	13.50	9.65
11	9.85	8.90	10.25	10.65	10.45	10.75	12.95	10.90	13.45	13.90	8.20
12	9.30	11.00	10.35	11.40	9.50	13.00	15.25	11.90	13.55	14.05	10.15
13	8.80	8.40	10.10	10.90	9.45	12.05	13.00	9.85	12.60	13.45	8.40
14	9.70	-	12.15	12.95	11.30	14.55	13.75	10.75	14.55	13.90	11.15
15	7.90	7.90	10.20	11.40	10.55	13.90	14.05	9.80	14.05	13.35	10.85
16	9.25	9.75	7.80	11.15	10.65	14.50	13.35	10.95	15.35	13.70	10.55
$\bar{x}$	9.99	9.58	10.19	10.78	10.28	12.88	13.75	10.15	13.99	13.58	9.95
SD	±1.15	±1.05	±0.86	±1.04	±0.53	±1.11	±1.02	±0.84	±1.00	±0.66	±1.04

Table 17: Plasma magnesium levels (mg/100ml) **in bonemeal-supplemented cows**

Cow No.	1975										1976
	Feb	March	April	May	June	July	Aug	Sept	Nov	Dec	March
n =	15	16	12	16	16	12	16	16	16	16	16
1	2.80	2.95	2.45	2.35	2.75	1.60	2.45	2.85	3.30	3.80	2.75
2	2.35	2.45	2.35	2.45	2.65	1.80	2.65	2.85	3.50	3.60	2.70
3	2.85	3.10	-	2.65	2.95	1.80	2.75	2.85	3.35	3.35	2.45
4	2.80	3.15	2.20	2.60	2.80	1.65	2.45	3.10	3.25	3.40	2.80
5	-	2.75	2.10	2.30	2.80	2.00	2.60	2.55	3.10	3.30	2.85
6	2.75	3.90	2.35	2.50	2.75	1.75	2.70	3.00	3.45	2.95	3.20
7	3.40	3.75	-	2.55	2.60	-	2.80	3.20	3.80	4.25	3.70
8	2.45	3.10	2.45	1.70	2.70	-	2.05	2.55	2.50	3.25	3.15
9	2.65	2.95	2.45	2.20	2.65	2.00	2.95	2.65	3.85	2.80	2.90
10	2.50	2.80	2.35	2.40	2.80	2.05	2.75	3.00	2.70	3.10	2.40
11	2.85	3.05	2.35	2.00	2.40	1.75	2.50	2.70	3.25	3.85	3.05
12	2.65	3.15	2.20	2.45	2.55	1.90	3.05	2.90	2.85	3.40	1.70
13	2.05	3.00	-	2.50	2.50	-	2.65	2.60	2.95	3.45	2.20
14	3.35	2.65	2.35	2.50	2.70	1.85	2.70	2.65	3.35	3.95	2.50
15	3.45	3.25	2.25	2.35	3.05	-	2.85	3.15	2.95	4.55	3.10
16	2.55	3.15	-	2.30	2.55	1.60	2.05	2.50	2.95	3.05	2.50
$\bar{x}$	2.76	3.07	2.32	2.36	2.70	1.81	2.62	2.82	3.19	3.50	2.75
SD	±0.39	±0.36	±0.11	±0.24	±0.17	±0.15	±0.28	±0.23	±0.37	±0.48	±0.46

Table 18: Plasma magnesium levels (mg/100ml) in control cows

Cow No.	1975										1976
	Feb	March	April	May	June	July	Aug	Sept	Nov	Dec	March
n =	16	14	15	15	16	16	16	16	8	16	16
1	3.50	2.80	2.50	2.70	2.80	3.00	2.40	3.20	-	4.20	3.10
2	2.25	2.35	2.25	2.35	2.35	2.40	2.80	2.60	-	2.90	2.45
3	2.55	2.95	-	2.45	2.95	2.60	2.85	2.85	-	3.40	2.80
4	2.70	2.80	2.70	2.65	2.75	3.10	2.50	2.95	-	3.20	2.95
5	2.50	2.35	2.45	2.40	2.15	2.75	2.20	2.90	-	3.50	2.75
6	2.60	2.90	2.55	2.20	2.20	2.90	2.60	2.60	-	3.50	2.70
7	3.40	-	2.50	2.20	2.40	3.25	3.00	2.70	-	3.45	3.00
8	2.80	2.85	2.55	2.05	2.25	3.15	3.10	2.75	-	3.45	3.25
9	2.40	2.55	2.25	1.95	2.45	2.40	3.00	2.65	3.55	3.20	2.50
10	2.40	3.50	2.25	-	2.15	2.55	2.80	2.55	3.50	3.40	2.45
11	2.60	3.10	2.45	2.35	2.65	2.15	2.45	3.15	3.40	3.45	2.70
12	2.50	2.60	2.40	2.35	2.05	2.65	3.00	2.85	3.20	3.00	2.80
13	2.15	2.30	1.95	2.30	2.00	2.65	2.80	2.85	3.25	2.95	2.50
14	2.95	-	2.50	2.80	2.55	3.00	2.15	2.75	3.15	3.00	3.10
15	2.65	2.50	2.20	2.35	2.65	2.95	2.80	2.80	3.40	3.15	2.90
16	2.45	3.20	1.75	2.20	2.65	2.85	2.10	2.90	3.75	3.10	3.05
$\bar{x}$	2.65	2.77	2.35	2.35	2.44	2.77	2.66	2.82	3.40	3.30	2.81
SD	±0.37	±0.35	±0.25	±0.23	±0.29	±0.31	±0.32	±0.18	±0.20	±0.32	±0.31

Table 19: Reproductive performance of bonemeal-supplemented and control cows.

No.	Pre-supplement calving				Feb. 1975		Post-suppl. Calving		
	1972	1973	1974	1975	Age (yrs)	Preg. Status	1975	1976	Preg. Status 30/6/76
Supplemented Group									
1	23/8	-	21/5	-	6	Open		19/3	Preg.
2					3	Open			Preg.
3		12/12	-	17/4	5	Preg.			Preg.
4	15/6	-	-	10/1	5	Open		27/4	Open
5		2/12	-	25/2	4	Preg.		1/3	Preg.
6				30/3	5	Preg.		15/4	Killed*
7		15/12	-	17/4	5	Preg.			Open
8	8/6	-	18/2	-	6	Open		22/3	Open
9			20/3	-	4	Open		10/2	Open
10			3/5	-	3	Open		26/4	Open
11			22/3	-	3	Preg.		16/4	Open
12					2	Open			Preg.
13			25/3	23/4	3	Preg.			Preg.
14			2/9**	29/7	2½	Open			Open
15			15/4	-	3	Open			Preg.
16		3/3	18/3	14/4	6	Preg.			Preg.**

* Slaughtered, unmanageable

** Aborted, cause unknown

Table 19: Continued

No.	Pre-supplement Calving				Feb. 1975		Post-suppl. Calving		
	1972	1973	1974	1975	Age (yrs)	Preg. Status	1975	1976	Preg. Status 30/6/76
Control Group									
1	19/1	20/2	16/3	26/11	6	Preg.			Open
2					3	Open		17/3	Open
3			12/4	3/5	5	Preg.			Preg.
4	27/5	5/12	17/11	-	6	Open			Preg.
5	14/7	18/6	10/6	-	8	Open			Open
6	6/1	11/2	30/3	-	7	Open		1/3	Open
7		21/1	-	16/3	4	Preg.			Preg.
8		17/2	-		7	Open		15/3	Open
9		28/3	-		3	Open		10/4	Open
10		1/7	-		3	Open			Preg.
11		24/2	26/2		3	Preg.			Preg.
12					2	Open			Open
13		29/3	10/5		3	Preg.			Preg.
14		28/4	-		3	Open			Preg.
15					3	Open			Preg.
16		1/5	-		7	Open			Preg.

Table 20: Pregnancy status in bonemeal supplemented cows determined by monthly rectal examination.

No.	1/2/75		1975					1976					
	Age (yrs)	Preg. Status	7/8	15/9	17/10	14/11	16/12	13/1	13/2	31/3	30/4	31/5	30/6
1	6	Open	P	P	P	P	P	P	P	C19/3	-	-	P
2	3	Open	-	-	-	-	-	-	-	-	P	P	P
3	5	Preg.	-	-	-	-	-	-	?	P	P	P	P
4	5	Open	P	P	P	P	P	P	P	P	C27/4	-	-
5	4	Preg.	P	P	P	P	P	P	P	C1/3	-	P	P
6	5	Preg.	?	?	P	P	P	P	P	P	C15/4	*	*
7	5	Preg.	-	-	-	-	-	-	-	-	-	-	-
8	6	Open	P	P	P	P	P	P	P	C22/3	-	-	-
9	4	Open	P	P	P	P	P	P	C10/2	-	-	-	-
10	3	Open	?	P	P	P	P	P	P	P	C26/4	-	-
11	3	Preg.	P	P	P	P	P	P	P	P	C16/4	-	-
12	2	Open	-	-	-	-	-	-	-	-	?	P	P
13	3	Preg.	-	-	-	-	-	-	-	-	-	-	P
14	2½	Open	C29/7	-	-	-	-	-	-	-	-	-	-
15	3	Open	-	-	-	-	-	-	-	?	P	P	P
16	6	Preg.	-	-	-	-	?	P	P	P	P	P	P
No. Preg.		7	5	7	8	8	8	9	8	6	4	6	8

* Slaughtered, unmanageable

P = pregnant ? = suspect pregnant C = calved.

Table 21: Pregnancy status of control cows determined by rectal examination.

No.	1/2/75		1975					1976					
	Age (yrs)	Preg. Status	7/8	15/9	17/10	14/11	16/12	13/1	13/2	31/3	30/4	31/5	30/6
1	6	Preg.	P	P	P	C26/11	-	-	-	-	-	-	-
2	3	Open	P	P	P	P	P	P	P	C17/3	-	-	-
3	5	Preg.	-	-	-	?	P	P	P	P	P	P	P
4	6	Open	-	P	P	P	P	P	P	P	P	C21/5	-
5	8	Open	-	-	-	-	-	-	-	-	-	-	?
6	7	Open	P	P	P	P	P	P	P	C1/3	-	-	-
7	4	Preg.	-	-	-	-	P	P	P	P	P	P	P
8	7	Open	P	P	P	P	P	P	P	C15/3	-	-	-
9	3	Open	-	P	P	P	P	P	P	P	C10/4	-	-
10	3	Open	-	-	-	-	-	-	P	P	P	P	P
11	3	Preg.	-	-	-	-	P	P	P	P	P	P	P
12	2	Open	-	-	-	-	-	-	-	-	-	-	-*
13	3	Preg.	-	-	-	-	-	-	P	P	P	P	P
14	3	Open	-	-	P	P	P	P	P	P	P	P	C12/6
15	3	Open	-	-	-	-	?	P	P	P	P	P	P
16	7	Open	-	P	P	P	P	P	P	P	P	P	C5/6
No. Preg.		5	4	7	8	7	10	11	13	10	9	8	6

* Juvenile tract

P = pregnant ? = suspect pregnant C = calved

APPENDIX 4

BONEMEAL SUPPLEMENTATION IN KANO BROWN GOATS

Tables 22 to 41

Table 23: Plasma phosphorus levels (mg/100ml) in bonemeal and vitamin A supplemented goats (PV)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	12	12	11	11	9	10	10	10
1	5.35	4.20	4.90	3.62	4.39	4.35	4.12	4.08
2	3.83	2.80	4.00	4.29	4.48	2.92	3.34	4.64
3	3.60	1.70	5.70	7.73	6.30	7.20	7.11	4.80
4	5.82	6.50	3.80	4.58	6.35	4.27	5.22	5.52
5	5.91	6.10	3.50	4.67	5.92	4.11	4.65	3.55
6	3.74	7.40	6.00	8.02	6.01	4.19	4.50	4.85
7	4.34	2.80	5.60	5.68	5.63	5.85	1.80	4.12
8	5.57	4.80	2.10	8.26	5.34	5.85	4.98	5.95
9	2.68	3.20	5.40	4.58	-	2.37	5.13	4.85
10	4.52	3.30	4.20	4.29	8.02	4.74	4.50	6.53
11	4.71	5.80	4.50	4.40	-	-	-	-
12	3.65	3.93	-	-	-	-	-	-
$\bar{x}$	4.29	4.37	4.52	5.47	5.83	4.59	4.54	4.85
SD	±0.93	±1.85	±1.16	±1.86	±1.09	±1.43	±1.36	±0.86

Table 24: Plasma phosphorus levels (mg/100ml) in high level bonemeal supplemented goats (PPG).

Goat No.	March '75	May '75	June '75	July '75	Aug. '75	Nov. '75	Feb. '76	March '76
n =	(11)	(12)	(8)	(9)	(10)	(10)	(10)	(10)
1	5.08	8.20	4.80	4.76	5.08	4.19	4.16	4.45
2	3.02	5.80	7.50	7.14	5.80	5.18	6.87	3.97
3	4.54	3.70	7.10	6.12	5.11	5.35	5.82	6.47
4	5.53	7.00	7.70	7.47	6.74	5.35	5.11	4.83
5	4.72	3.60	4.40	-	5.70	5.85	4.63	5.12
6	4.01	5.20	6.00	6.63	6.03	6.12	6.87	5.02
7	3.38	6.70	4.20	5.90	6.06	6.18	5.82	6.18
8	4.46	4.10	3.60	4.47	5.00	4.42	5.49	5.12
9	4.10	3.30	-	4.98	7.37	5.56	5.21	5.36
10	4.77	5.30	-	6.13	5.19	4.90	5.80	5.00
11	-	6.80	-	-	-	-	-	-
12	4.40	3.20	-	-	-	-	-	-
$\bar{x}$	4.36	5.29	5.66	5.96	5.82	5.21	5.55	5.17
S.D.	±0.76	±1.70	±1.62	±1.12	±0.88	±0.60	±0.92	±0.78

Table 25: Plasma phosphorus levels (mg/100ml) in control goats (CG)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	12	12	12	12	12	11	11	11
1	5.62	4.10	5.96	5.46	6.07	5.62	4.54	5.98
2	3.11	4.20	3.00	4.01	1.32	4.46	3.30	2.81
3	4.81	5.85	4.56	4.88	4.61	3.63	4.06	5.79
4	3.74	3.35	2.86	5.31	4.07	3.88	3.43	4.25
5	4.54	2.95	3.80	6.28	5.34	5.62	4.63	4.75
6	4.41	3.90	5.26	4.69	6.26	4.13	5.54	4.21
7	2.04	4.85	4.54	6.13	6.21	3.63	4.25	4.75
8	2.93	5.70	3.66	8.05	5.00	4.05	3.78	4.54
9	2.22	4.30	4.28	5.41	6.94	6.78	5.68	5.13
10	3.83	5.35	6.80	3.82	5.48	8.27	4.87	5.31
11	6.83	5.10	4.60	4.30	6.45	5.70	5.21	4.18
12	4.68	5.05	4.14	4.65	6.55	-	-	-
$\bar{x}$	4.13	4.52	4.39	5.21	5.28	5.05	4.48	4.70
SD	±1.59	±1.01	±1.12	±1.13	±1.50	±1.42	±0.81	±0.88

Table 26: Plasma calcium levels (mg/100ml) in **low-level** bonemeal supplemented goats (PG)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	11	11	11	11	10	7	9	10
1	10.35	10.15	12.35	10.40	10.60	10.95	10.50	11.10
2	9.15	10.15	10.50	9.85	8.95	11.25	10.40	10.60
3	10.55	11.35	9.15	8.80	9.10	11.45	9.85	10.80
4	9.95	10.55	11.15	9.05	9.35	10.55	10.40	9.80
5	8.75	10.05	11.95	9.85	9.80	12.35	10.00	13.10
6	8.95	12.65	11.25	10.00	9.35	12.25	9.15	11.25
7	9.25	11.70	11.10	9.75	9.75	12.45	9.90	11.20
8	10.00	12.05	11.25	9.45	10.75	-	10.15	11.10
9	8.20	11.15	10.05	10.10	9.15	-	10.20	15.25
10	-	11.65	11.65	10.15	9.90	-	-	10.95
11	5.40	11.10	11.45	10.35	-	-	-	-
12	9.00	-	-	-	-	-	-	-
$\bar{x}$	9.06	11.20	11.08	9.80	9.74	11.61	10.06	11.12
SD	±1.49	±0.84	±0.90	±0.70	±0.59	±0.75	±0.41	±0.82

Table 27: Plasma calcium levels (mg/100ml) in bonemeal and vitamin A supplemented goats (PV)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	12	12	11	10	9	8	10	10
1	9.75	11.75	10.50	10.65	10.85	11.00	10.70	11.25
2	9.95	9.75	10.90	8.80	9.90	11.60	10.50	10.95
3	7.80	10.65	10.45	9.75	9.25	12.50	9.55	10.45
4	9.15	11.50	11.35	9.85	11.45	11.80	11.20	11.00
5	10.50	10.20	11.45	9.80	9.50	11.66	11.15	11.30
6	7.85	11.55	11.25	9.65	10.60	11.55	10.30	10.50
7	9.75	10.45	11.30	9.80	10.05	12.60	11.35	10.90
8	8.45	8.80	11.40	10.35	10.10	-	11.40	10.70
9	8.45	7.70	13.85	10.75	-	-	12.20	11.30
10	9.20	10.30	10.95	6.82	9.65	10.55	10.55	11.75
11	8.75	8.80	10.50	8.00	-	-	-	-
12	8.15	10.55	-	-	-	-	-	-
$\bar{x}$	8.94	10.17	11.25	9.42	10.15	11.66	10.89	11.01
SD	±1.30	±1.26	±0.94	±1.49	±0.70	±0.74	±0.73	±0.40

Table 28: Plasma calcium levels (mg/100ml) in high-level bonemeal supplemented goats (PPG)

Goat No.	March '75	May '75	June '75	July '75	Aug. '75	Nov. '75	Feb. '76	March '76
n =	(11)	(12)	(8)	(10)	(10)	(8)	(10)	(10)
1	6.55	11.55	11.90	8.95	9.35	10.95	10.05	9.00
2	8.05	10.60	11.20	9.60	11.15	10.40	10.90	10.10
3	9.00	11.50	12.05	10.00	10.70	10.95	9.20	11.55
4	9.25	12.15	12.25	10.10	10.15	11.70	10.30	10.75
5	7.85	10.40	12.65	5.05	10.60	11.05	10.45	10.60
6	7.60	12.00	11.30	9.25	11.45	11.65	9.65	10.85
7	7.65	8.30	11.00	9.35	9.90	11.50	10.30	11.60
8	8.65	10.00	12.40	10.75	9.10	-	11.80	10.50
9	9.90	9.80	-	8.25	10.00	11.45	10.75	11.70
10	9.00	11.10	-	10.05	10.60	-	10.95	10.75
11	-	12.45	-	-	-	-	-	-
12	8.90	10.00	-	-	-	-	-	-
$\bar{x}$	8.35	10.90	11.84	9.13	10.30	11.17	10.38	10.74
S.D.	±0.99	±1.23	±0.61	±1.74	±0.83	±0.47	±0.75	±0.85

Table 29: Plasma calcium levels (mg/100ml) in control goats (CG)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	12	12	12	12	12	9	11	11
1	9.00	11.60	11.60	10.05	9.65	12.90	10.85	10.40
2	9.95	11.65	14.25	10.30	9.50	10.00	11.90	11.80
3	8.25	11.45	11.90	9.50	9.95	13.00	11.10	12.40
4	9.25	10.40	11.65	10.10	10.40	9.50	10.40	10.00
5	9.30	10.10	11.00	9.95	10.50	11.60	11.60	10.40
6	9.75	10.65	10.65	9.10	10.70	12.40	10.20	10.45
7	10.00	10.65	11.65	9.65	10.45	10.65	10.30	10.85
8	7.35	10.40	10.05	10.25	10.45	10.80	10.45	10.25
9	7.80	10.35	11.55	9.80	10.20	11.70	9.80	10.15
10	9.15	9.90	11.70	9.00	10.45	-	11.25	10.35
11	10.65	10.25	11.80	9.95	10.85	-	11.25	11.30
12	10.35	9.95	11.30	10.45	10.75	-	-	-
$\bar{x}$	9.30	10.68	11.60	9.85	10.35	11.39	10.83	10.76
SD	±0.95	±0.63	±0.95	±0.44	±0.42	±1.25	±0.65	±0.76

Table 30: Plasma magnesium levels (mg/100ml) in low-level bonemeal supplemented goats (PG)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	11	11	11	11	10	7	9	10
1	2.60	2.10	2.15	2.35	1.90	2.50	2.15	2.45
2	2.20	2.50	2.10	2.50	1.95	2.50	1.95	2.55
3	1.10	2.90	1.90	2.45	1.90	2.80	2.20	2.70
4	2.50	2.95	2.20	2.25	1.80	2.45	2.60	2.55
5	2.60	2.75	2.60	2.50	2.40	2.15	2.05	3.05
6	2.20	2.90	2.20	2.45	2.30	2.87	2.20	2.45
7	2.20	2.60	2.30	2.25	2.20	3.50	2.35	2.75
8	1.95	2.55	1.85	2.20	2.25	-	2.80	2.60
9	2.25	2.35	2.05	2.65	2.00	-	2.60	2.75
10	2.10	3.55	2.55	2.70	2.45	-	-	2.70
11	2.50	2.85	2.90	2.65	-	-	-	-
12	2.10	-	-	-	-	-	-	-
$\bar{x}$	2.20	2.72	2.25	2.45	2.12	2.68	2.32	2.66
SD	±0.45	±0.31	±0.32	±0.17	±0.23	±0.43	±0.29	±0.18

Table 31: Plasma magnesium levels (mg/100ml) in bonemeal and vitamin A supplemented goats (PV)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	12	12	11	10	9	8	10	10
1	1.95	2.55	2.25	2.60	2.30	2.20	1.85	2.45
2	2.65	2.35	2.50	2.35	2.25	2.25	2.20	2.40
3	1.90	2.30	2.50	2.70	2.40	2.40	1.55	2.35
4	2.20	2.30	2.25	1.95	2.50	2.50	1.80	2.15
5	2.50	2.45	2.10	2.45	2.05	2.10	1.95	2.80
6	2.05	2.60	2.65	2.05	2.05	2.70	1.95	2.20
7	2.20	2.70	2.35	2.10	2.25	2.40	2.90	2.60
8	2.45	1.95	3.20	2.05	2.45	-	2.10	2.20
9	2.35	1.39	3.55	2.45	-	-	2.15	2.35
10	2.10	2.10	2.60	1.90	1.40	2.32	2.20	2.65
11	2.50	2.90	2.15	2.20	-	-	-	-
12	2.15	2.25	-	-	-	-	-	-
$\bar{x}$	2.20	2.33	2.55	2.26	2.18	2.36	2.07	2.42
SD	±0.25	±0.38	±0.45	±0.30	±0.33	±0.20	±0.36	±0.21

Table 32: Plasma magnesium levels (mg/100ml) in high level bonemeal supplemented goats (PPG)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	11	12	9	10	10	8	10	10
1	2.35	2.30	2.55	1.85	2.40	2.05	2.65	2.80
2	2.90	2.95	2.75	2.25	2.65	2.85	2.50	2.45
3	2.30	2.95	2.65	2.35	1.90	2.65	2.20	2.85
4	2.55	2.40	2.35	1.90	2.00	2.30	1.90	2.35
5	1.75	2.35	2.65	0.85	2.00	2.35	2.40	2.35
6	1.80	2.25	2.35	1.95	2.60	2.40	2.95	2.40
7	2.15	2.20	2.60	1.85	2.30	2.75	2.40	2.45
8	2.20	1.70	2.55	1.95	1.95	-	2.40	2.40
9	2.65	1.75	2.65	2.30	2.10	2.35	2.60	2.35
10	1.95	2.10	-	2.00	1.95	-	2.30	2.25
11	-	2.55	-	-	-	-	-	-
12	2.30	2.20	-	-	-	-	-	-
$\bar{x}$	2.26	2.32	2.56	1.87	2.23	2.48	2.43	2.49
SD	±0.37	±0.40	±0.45	±0.45	±0.30	±0.28	±0.29	±0.19

Table 33: Plasma magnesium levels (mg/100ml) in control goats (CG)

Goat No.	1975						1976	
	March	May	June	July	Aug	Nov	Feb	March
n =	12	12	12	12	12	9	11	11
1	2.05	2.95	2.30	2.30	1.95	3.15	2.20	2.35
2	3.00	2.35	3.80	2.15	2.15	2.60	2.35	2.05
3	2.10	2.75	3.05	2.10	2.30	2.60	2.00	2.40
4	2.30	2.60	2.85	2.10	2.35	2.60	2.05	2.15
5	2.40	2.45	2.90	2.00	2.00	2.35	2.35	2.75
6	2.00	2.75	2.70	2.00	2.20	2.55	2.15	2.45
7	2.20	2.65	2.90	2.25	2.35	2.25	1.80	2.30
8	2.20	2.40	2.55	2.20	2.25	2.05	2.10	2.45
9	1.95	2.80	2.75	2.25	1.80	2.60	2.30	2.50
10	2.30	2.55	2.70	2.00	2.25	-	1.80	2.30
11	2.55	2.05	2.40	2.15	2.05	-	2.40	2.45
12	2.75	2.95	2.35	2.10	2.35	-	-	-
$\bar{x}$	2.31	2.60	2.77	2.13	2.18	2.53	2.14	2.38
SD	±0.29	±0.25	±0.38	±0.10	±0.18	±0.31	±0.20	±0.18

Table 34: Monthly body weight (kg) of does in the lower phosphorus-supplemented group.

No.	1975								1976				Final Wt. 15-21/6/76
	April	May	June	July	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April/May	
PG 1	13.6	12.0	13.6	14.4	15.4	16.2	17.4	19.4	23.2	26.2	27.0		34.6
2	17.2	16.4	18.4	17.2	16.8	18.8	20.6	22.6	30.2	34.4	39.0	13/4*	23.0
3	19.8	17.6	17.0	18.8	14.4	20.6	21.4	24.4	29.0	31.8	33.0	10/4*, Died 10/5	
4	16.6	15.2	18.0	16.2	17.1	18.1	20.4	21.4	26.4	30.4	34.0	23/5*	
5	11.4	10.6	11.8	12.8	13.4	15.6	-	20.4	20.2*	21.6	22.0		24.0
6	16.8	16.0	18.4	19.0	21.2*	-	19.2	20.2	25.2	28.4	25.0		34.2
7	15.4	13.8	15.8	16.4	17.8	20.6	24.0	22.3*	23.4	23.0	22.0		29.2
8	20.8	19.2	22.5	24.2	25.8*	-	23.4	25.0	26.4	26.2	27.0		40.6
9	14.0	13.0	16.0	16.6	18.2	19.8	22.6	24.9	23.4*	24.4	26.0		28.0
10	13.2	11.8	12.4	13.0	12.8	14.0	16.0	17.6	17.2*	18.4	19.0		22.6
11	19.8	18.2	21.4	21.8	20.5	22.2	24.6	Died 6/12/75**	-	-			-
12	15.0	Died 5/5/75**	-	-	-	-	-	-	-	-	-		-

* Kidded within the month.

** Heartwater.

Table 35: Monthly body weight (kg) of does in the higher phosphorus-supplemented group.

No.	1975								1976				Final Wt. 15-21/7/76
	April	May	June	July	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April/May	
PPG 1	17.8	16.8	20.4	24.0	25.6*	-	18.6	20.4	23.2	24.4	24.0		32.4
2	11.8	11.6	12.0	12.6	12.8	12.20	14.2	16.6	20.2	23.4	21.0*		26.2
3	15.6	13.2	18.8	19.2	20.0*	-	15.8	17.0	18.2	21.2	24.0		-
4	16.8	15.8	20.8	21.2	24.0*	15.0	23.8	26.6	29.2	30.6	31.0		39.6
5	18.6	17.4	17.8	17.0	17.6	19.2	21.0	25.0	23.2*	23.6	23.0		29.2
6	13.2	11.2	13.4	13.2	14.0	14.2	18.4	16.8	17.0*	17.2	18.0		22.2
7	17.2	15.2	15.2	14.2	14.8	16.8	17.0	18.9	23.0	24.8	22.0*	Died 3/4	-
8	16.4	14.8	18.2	18.0	18.4	20.4	23.4	26.8	27.2*	29.0	31.0		32.2
9	-	-	-	-	-	10.8	11.4	18.6	16.4	-	12.0		19.6
10	-	-	-	-	-	-	14.8	14.8	17.2	20.6	22.0	18/5*	20.8
11	15.8	14.6	Died**	-	-	-	-	-	-	-	-		-
12	14.8	13.4	Died	-	-	-	-	-	-	-	-		-

* Kidded.

** Heartwater.

Table 36: Monthly body weight (kg) in phosphorus and vitamin A supplemented does.

No.	1975								1976				Final Wt. 15-21/6/76
	April	May	June	July	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April/May	
PV 1	12.4	10.4	12.0	11.0	11.2	13.0	14.0	15.5	18.2	21.2	22.0		*
2	17.2	15.2	15.8	15.6	15.0	15.8	17.0	20.8	26.0	23.6	23.0		30.0***
3	11.4	10.0	10.6**	10.4	10.2	10.2	10.8	12.7	14.0	14.8	15.0		20.8
4	14.0	12.4	12.4	13.6	14.5	17.0	20.4	19.2*	22.2	24.2	24.0		25.6
5	18.2	16.2	19.2	19.6	21.2	24.0	29.0	34.4	34.2*	35.4	33.0		35.4
6	16.6	15.6	-	17.4	18.6	21.4	23.4	24.0*	28.0	29.4	30.0		35.4
7	18.2	16.2	18.2	19.6	20.0	21.0	24.0	26.6	24.4*	23.6	22.0		28.8
8	14.2	12.6	14.6	14.8	14.0	15.6	18.0	19.2	25.4	28.4	28.0	12/4*	-
9	10.4	-	-	-	-	10.8	11.2	12.8	15.2	18.2	18.0	Missing 2/4	-
10	17.2	-	-	-	-	11.6	12.6	14.8	15.2	17.4	17.0	-	25.0
11	11.0	9.8	13.0	13.2	Killed by a car 12/8/75				-	-	-	-	-
12	16.4	14.2	Died 18/6/75****		-	-	-	-	-	-	-	-	-

* Kidded

** Aborted

*** Mummified twins in situ

**** Heartwater

Table 37: Monthly body weight (kg) of the control does.

No.	1975								1976				Final Wt. 15-21/6/76
	April	May	June	July	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April/May	
CG 1	12.4	10.2	12.8	13.4	13.3	14.1	14.4	16.8	20.0	21.4	22.0	**	24.5
2	19.6	17.2	17.6	19.0	19.0	21.4	25.0	29.6	31.2*	31.0	30.0		32.0
3	13.0	11.4	13.8	15.2	15.0	17.3	19.0	22.2	28.2	31.4	26.4*		25.4
4	13.0	11.4	12.2	13.4	12.4	12.8	14.0	16.0	26.0	28.2	30.0	22/4*	-
5	17.2	16.0	16.8	17.0	17.0	18.8	19.6	21.0	26.2	29.0	24.0*		21.8
6	14.2	13.0	13.4	14.4	15.4	16.8	19.6	19.0*	20.2	21.0	20.0		25.6
7	14.6	12.4	14.6	14.8	14.8	15.4	16.8	18.8	25.2	28.8	23.0*		-
8	11.4	9.0	11.6	13.4	13.4	15.2	18.0	19.2	20.2	22.6	23.0	15/4*	-
9	14.4	13.6	14.8	15.2	16.0	16.4	17.6	20.0	22.2	24.8	27.0	19/5*	-
10	15.4	14.2	15.4	15.4	16.0	17.6	20.0	21.1	24.2	28.4	30.0	22/5*	-
11	20.6	17.8	18.4	19.2	20.4	23.1	27.8	24.6*	29.2	32.0	33.0		40.0
12	13.2	12.6	15.0	14.6	15.0	16.6	Died 26/10/75***						

* Kidded

** Aborted 2/4/76

*** Heartwater

Table 38: Reproductive performance of goats receiving the lower level of bonemeal.

Doe No.	1975				1976						Reproductive Status at Slaughter*		
	Sept.*	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June*	Pregnancy	R. Ovary	L. Ovary
PG 1											Twins, 4mth.	2CL	Static
2								13/4			Not slaughtered**		
3								10/4			"	"	
4								23/5			"	"	
5					15/1						Twins, 2mth.	CL	CL
6	27/9										Twins, 4mth.	CL	CL
7			13/12								Single, 4mth.	CL	Static
8	25/9										Twin, 4mth.	Static	2CL
9					20/1						Twin, 3mth.	CL	CL
10					16/1						Single, 2mth.	CL	Static

* From 20/9/75, up to 14/6/76, and 15-21/6/76, respectively

Supplementation commenced 25/4/75, any kidding before 20/9/75 not recorded (based on 146 day gestation

** Based on minimum postpartum oestrus of 92 days, any doe kidding on or after 15/3/76 were not slaughtered.

Table 39: Reproductive performance of goats receiving the higher level of bonemeal.

Doe No.	1975				1976						Reproductive Status at Slaughter*		
	Sept.*	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June*	Pregnancy	R. Ovary	L. Ovary
PPG 1	23/9										Twins, 1mth.	Static	2CL
2							17/3				Not slaughtered		
3	25/9									2/6	Not slaughtered		
4	29/9										Twins, 4½mth.	2CL	Static
5			16/1								Twins, 3mth	CL	CL
6			10/1								Twins, 2½mth.	2CL	Static
7					10/3						Died 4/4	Static	Static
8			4/1							14/6	Not slaughtered		
9			13/1								Single, 2mth.	Static	CL
10									18/5		Not slaughtered		

* From 20/9/75, up to 14/6/76, and 15-21/6/76, respectively.

Table 40: Reproductive performance of goats receiving phosphorus and vitamin A supplementation.

Doe No.	1975				1976						Reproductive Status at Slaughter*		
	Sept.*	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June*	Pregnancy	R. Ovary	L. Ovary
PV 1										9/6	Not slaughtered		
2											Mummified twins	CL	CL
3**											Single, 2½mth.	CL	Static
4		6/12								1/6	Not slaughtered		
5			13/1								Single, 3mth.	Static	2CL
6		22/12									Pyometra	2CL	Static
7			10/1								Twins, 3½mth.	Static	2CL
8								12/4			Not slaughtered		
9					***						-	-	-
10											Twins, 3½mth.	CL	CL

* From 20/9/75, up to 14/6/76, and 15-21/6/76, respectively.

** Aborted 7/6/75, estimated foetal age 2 months.

*** Pregnant, based on weight gain; doe lost or stolen.

Table 41: Reproductive performance of the control goats.

Doe No.	1975				1976						Reproductive Status at Slaughter*		
	Sept.*	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June*	Pregnancy	R. Ovary	L. Ovary
CG 1								2/4**			Single, 1½mth.	CL	CL
2					17/1						Triplets, 3mth.	2CL	CL
3							10/3				Twins, 2½mth.	Active	2CL
4								22/4			Not slaughtered		
5							12/3				Twins, 1mth.	CL	CL
6			14/12								Twins, 2½mth.	2CL	CL
7							18/3				Not slaughtered		
8								15/4			Not slaughtered		
9									19/5		Not slaughtered		
10									22/5		Not slaughtered		
11			12/12								Single, 4mth.	CL	CL

* From 20/9/75, up to 14/6/76, and 15-21/6/76 respectively.

** Aborted, approximately 3½ months.

APPENDIX 5

VITAMIN A SUPPLEMENTATION IN KANO BROWN GOATS

Tables 42 to 46

Table 42: Plasma vitamin A levels (ug/100ml) in vitamin A supplemented goats (VG)

Goat No.	1975 March	1975 May	1975 Aug	1975 Nov	1976 March
n =	10	10	9	10	10
1	10.77	41.54	-	10.77	41.54
2	26.15	26.15	26.15	26.15	26.15
3	26.15	56.92	26.15	41.54	41.54
4	26.15	26.15	26.15	41.54	41.54
5	26.15	26.15	26.15	26.15	26.15
6	26.15	26.15	41.54	26.15	26.15
7	10.77	41.54	10.77	26.15	26.15
8	26.15	41.54	26.15	26.54	26.15
9	26.15	26.15	26.15	26.15	26.15
10	10.77	26.15	26.15	41.54	41.54
$\bar{x}$	21.54	33.84	26.15	29.23	32.31
SD	±7.43	±10.88	±7.69	±9.73	±7.95

Table 43: Plasma vitamin A levels (µg/100ml) in vitamin A and bonemeal supplemented goats (PV)

Goat No.	1975 March	May	Aug	Nov	1976 March
n =	10	10	9	10	10
1	26.15	41.54	26.15	26.15	41.54
2	26.15	56.92	41.54	26.15	26.15
3	26.15	56.92	26.15	26.15	41.54
4	26.15	56.92	-	26.15	41.54
5	26.15	26.15	56.92	41.54	56.92
6	26.15	56.92	41.54	26.15	41.54
7	26.15	26.15	41.54	26.15	26.15
8	26.15	41.54	26.15	26.15	26.15
9	26.15	41.54	10.77	10.77	26.15
10	26.15	41.54	10.77	26.15	26.15
$\bar{x}$	26.15	44.61	31.28	26.15	35.38
SD	0.00	±12.14	±15.38	±7.25	±10.76

Table 44: Plasma vitamin A levels (µg/100ml) in control goats

Goat No.	1975 March	1975 May	1975 Aug	1975 Nov	1976 March
n =	10	10	10	10	10
1	26.15	26.15	26.15	26.15	26.15
2	26.15	41.54	26.15	26.15	41.54
3	26.15	26.15	26.15	26.15	41.54
4	26.15	26.15	26.15	26.15	26.15
5	26.15	26.15	26.15	26.15	41.54
6	26.15	41.54	26.15	26.15	26.15
7	26.15	41.54	26.15	41.54	26.15
8	26.15	26.15	26.15	26.15	26.15
9	26.15	41.54	26.15	26.15	26.15
10	41.54	41.54	26.15	26.15	26.15
$\bar{x}$	27.69	33.85	26.15	27.69	30.77
SD	±4.87	±8.11	±0.0	±4.87	±7.43

Table 45: Kidding performance of vitamin A supplemented does.

No.	1975				1976						Reproductive Status at Slaughter*		
	Sept.*	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June*	Pregnancy	R. Ovary	L.Ovary
VG 1				13/12							Single,2mth.	Static	CL
2				9/12							Twins,2mth.	2CL	Static
3				6/12							Twins,3½mth.	CL	CL
4								24/4			Not slaughtered		
5											Twins,4mth.	CL	CL
6						17/1					Died 15/5/76		
7				19/12							Twins,3mth.	2CL	CL
8											Non-preg.	CL	CL
9									1/6		Not slaughtered		
10									10/6		Not slaughtered		
11				Aborted 6/11**							Single,2⅔mth.	CL	Static

* From 20/9/76, up to 14/6/76, and 15-21/6/76, respectively.

** Approximately 4 months.

Table 46: Monthly body weight (kg) of the vitamin A supplemented does.

No.	1975								1976				Final Wt. 15-21/6/76
	April	May	June	July	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April/May	
VG 1	21.2	19.4	21.8	22.8	23.7	26.0	28.0	26.4*	27.2	26.0	25.0	-	28.4
2	18.6	16.2	19.4	20.4	22.0	25.4	26.8	22.0*	23.0	23.8	23.0	-	30.4
3	16.4	14.4	16.0	18.6	20.0	22.2	23.2	23.1*	25.0	26.0	23.0	-	30.2
4	11.8	10.6	10.4	10.6	11.2	11.4	13.0	15.0	19.2	22.8	25.0	24/4*	-
5	15.4	13.2	13.2	13.2	13.2	-	16.0	17.2	21.0	22.2	23.0	-	35.0
6	20.6	18.0	20.4	20.6	21.4	22.4	25.0	28.6	27.0*	24.6	27.0	Died 15/5***	-
7	16.2	15.8	17.0	17.2	18.2	21.2	25.0	21.8*	-	27.6	32.0	-	33.2
8	15.0	12.8	13.6	13.8	13.4	14.2	15.8	16.5	18.4	18.0	17.0	-	22.8
9	15.8	-	-	-	-	10.4	11.2	11.5	12.4	14.4	14.0	- 1/6*	-
10	18.6	-	-	-	-	10.4	12.0	12.6	15.2	18.2	20.0	10*	-
11	16.0	14.6	14.8	15.0	16.8	19.2	19.0**	19.0	-	-	-	-	21.2
12	18.8	16.6	19.4	20.8	20.7	22.0	Died 4/11***		-	-	-	-	-

* Kidded

** Aborted 6/11/76, 4 mths.

*** Heartwater

EFFECT OF PHOSPHORUS AND VITAMIN A ON BOVINE AND CAPRINE REPRODUCTION IN THE SAVANNA ZONE OF NIGERIA

By

ELIEZER C.I. MOLOKWU

BSc. Tuskegee Institute, USA., 1968

DVM. Tuskegee Institute, USA., 1969

MSc. Iowa State University, USA., 1972

AN ABSTRACT OF A THESIS

Submitted to

Ahmadu Bello University, Nigeria

for the degree

DOCTOR OF PHILOSOPHY

Department of Veterinary Physiology and Pharmacology

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With the increasing demand for more animal protein in Nigeria, this investigation was undertaken to determine the effect of phosphorus and vitamin A supplementation on the reproductive efficiency of Bunaji (White Fulani) cattle and Kano Brown goats.

A survey was carried out in Kaduna and Kano States of Nigeria to determine the plasma levels of phosphorus, calcium and magnesium, and plasma and hepatic vitamin A levels of Bunaji (White Fulani) cows and Kano Brown does. A distinct seasonal variation was observed in the bovine plasma phosphorus values from Kano but not Kaduna State; the peak occurred with pasture growth during the rainy season ($P < 0.01$). The mean phosphorus values for August-September, January-February, and April for Bunkure and Kano, Kano State, were 5.7 ± 1.25, 4.88 ± 1.25 and 4.72 ± 0.92 and 7.45 ± 1.93, 5.72 ± 1.51, and 5.07 ± 1.69, respectively. Calcium levels increased significantly from the rainy to the dry season in Bunkure ($P < 0.01$) but not Kano and Kaduna. Plasma magnesium levels increased significantly in cows from the rainy to dry season for Bunkure ($P < 0.01$) and Kano ($P < 0.05$) but not for Kaduna. There was no significant seasonal variation in the caprine phosphorus, calcium and magnesium levels.

Except for Bunkure, the highest plasma values for vitamin A in the cows occurred during the rainy season. The decrease from September to January for Kano and from August to February for Kaduna was significant ($P<0.05$). Dry season changes were variable; it decreased significantly from January to April for Bunkure ($P<0.05$), and rose between February and April for Kaduna. There was little difference between August and April values for Kaduna. The caprine plasma vitamin A level varied slightly between seasons. The bovine hepatic vitamin A levels fell significantly from August to February for Kaduna ($P< 0.01$), and less so from February to April. For Kano, the fall occurred only within the dry season from January to April ($P< 0.05$). The hepatic vitamin A levels in goats decreased significantly from the rainy to the dry season ($P< 0.001$).

The effect of bonemeal supplementation on pregnancy in 32 Bunaji cattle was carried out for a period of 13 months. The monthly mean plasma levels of inorganic phosphorus for supplemented cows ranged from 4.63 to 8.09 mg/100ml in contrast to 3.07 to 7.09 for the controls. Differences for the wet season were significant ($P<0.01$) and also for the early dry season and late dry ($P<0.05$). There was little difference between the ranges for the monthly mean plasma calcium and magnesium levels for both supplemented and control cows; some inter-months differences, however, were significant.

The Ca:P ratios varied from 1.3 to 2.6 in the supplemented cows to 1.6 to 3.9 in the controls. Haemograms for the wet season, early dry season, and late dry season revealed little difference.

Fifty per cent of the test cows delivered calves by the end of the period of supplementation in contrast to 25% of the controls. During the period of peak plasma phosphorus level, 9 of the 16 supplemented cows (56.3%) conceived compared to 4 (25%) of the controls. Twenty-two of the 30 conceptions (73.3%) occurred when the Ca:P ratio was 2.1 or less. It was concluded from the study that bonemeal was an economical and practical method of supplying phosphorus for improving the fertility of Bunaji cattle in the grazing areas of Northern Nigeria.

The effect of phosphorus supplementation on pregnancy was studied in Kano Brown goats. Four groups of 12 does grazed during the day and at night were housed separately and were given 64 g groundnut cake per head. The three test groups received the following daily total intake per head: PG 1.3 g phosphorus, PPG 2.6 g phosphorus and PV 1.3 g phosphorus and 1,275 i.u. vitamin A. Mean plasma phosphorus levels peaked during the wet season in all groups. The higher phosphorus-supplemented group (PPG) maintained higher plasma values than the other groups. The kidding performance was: PPG 120%, PG 90%, PV 70%, and controls 91%. Evaluating the results

on pregnancy the inter-group differences were less: PPG 120%, PG 90%, PV 90%, and controls 100%. It is concluded that a daily intake of 2.6 g phosphorus is beneficial to the fertility of Kano Brown does and that bonemeal is an economical source.

The effect of vitamin A supplementation on pregnancy was studied in 36 Kano Brown goats. The does were divided into 3 equal groups, grazed during the day, housed separately at night and supplemented with 64 g groundnut cake per head daily. One group (VG) received 1,275 i.u. vitamin A per head daily, second group (PV) received 5.8 g bonemeal (1.3 g phosphorus) per head daily in addition to 1,275 i.u. vitamin A, and the third group (CG) served as the controls. In general, the PV group had higher mean monthly plasma levels for vitamin A than the other two groups; the values were significant for May and August ($P<0.05$). The kidding performance of the two supplemented groups was significantly lower than that of the controls ($P<0.05$). On the basis of conception and pregnancy, the differences were not significant.

It is concluded from the available literature and from this study that the nutritional causes associated with the low reproductive efficiency of indigenous cattle is not confined to phosphorus or vitamin A deficiencies but are multiple - the combined effects of

deficiencies of protein, phosphorus, vitamin A and carbohydrate. It is impossible to separate these causative factors under the prevailing non-production-oriented method of nomadic husbandry.