UNIVERSITI PUTRA MALAYSIA

STUDIES ON MINERAL SUPPLEMENTATION IN THE SWAMP BUFFALO

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STUDIES ON MINERAL SUPPLEMENTATION IN THE SWAMP BUFFALO

By

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A Thesis Submitted in Partial Fulfilment of the Requirement for the Degree of Master of Science in the Universiti Pertanian Malaysia, Serdang, Selangor.

1983

Dedicated to my wife and parents

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This thesis attached hereto, entitled "Studies on mineral supplementation in the swamp buffalo" prepared and submitted by Rachjan Gunasah Pratas in partial fulfilment of the requirements of the degree of Master of Science, is hereby accepted.

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ACKNOWLEDGEMENTS

I am sincerely grateful to Dr. T.A. Bongso and Dr. P. Vijchulata for their advice, continued guidance, encouragement and supervision of this thesis. I am also thankful to Dr. M.I. Djafar for the planning of experiments and initial supervision of this thesis.

I am indebted to the Scholarship Section of Education Ministry, Malaysia for financial support and to the Dean of the Faculty of Veterinary Medicine and Animal Science of Universiti Pertanian Malaysia (UPM) for his encouragement in my research. The Dean of the Faculty of Animal Husbandry of Institut Pertanian Bogor (IPB), Indonesia is also gratefully acknowledged. Special appreciation is expressed to Prof. Dr. Harsya Bachtiar of the Interdiciplinary Consortium, Department of Education and Culture, Republic of Indonesia and Mr. Andrew A. Tuen (UPM) for their kindness and support.

Thanks are extended to Mr. Ibrahim bin Shamsudin and Mr. Ibrahim Muchsin for their technical assistance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Two experiments were conducted to study (a) the effect of mineral supplements on weight gain and on blood plasma calcium, inorganic phosphorus, magnesium, iron and copper in male and female swamp buffalo calves up to 10 months of age and (b) the effects of mineral and energy supplementation on the utilization of Guinea grass by swamp buffaloes.

In the first experiment, 20 swamp buffalo calves (10 males, 10 females) were distributed into mineral supplemented and unsupplemented groups and rotationaly grazed through several paddocks and pasture species. Pastures comprised of Guinea (*Panicum maximum*), Signal (*Brachiaria decumbens*), Setaria (*Setaria ancep*) and Star (*Cynodon plectostachyus*).

Mineral supplementation with Phos-Rich, Rockies (Tithebarn, Ltd., England) had no significant effect on average daily gain from birth to weaning (6 months of age) and from birth to 10 months of age. However, mineral supplements had a significant ($P<0.01$) effect on average daily gain from weaning to 10 months of age. This experiment also demonstrated that there was a tendency for plasma inorganic phosphorus levels to be higher in supplemented animals as compared to unsupplemented animals. The concentration of plasma calcium had a tendency to be lower in the supplemented calves. Plasma inorganic phosphorus was negatively correlated ($P<0.01$) with age in both males and females. Plasma calcium levels in supplemented calves were positively correlated ($P<0.01$) with age at 6 to 10 months of age but not significant at 2 to 6 months of age. In unsupplemented calves there were positive correlations ($P<0.01$) with age (2 to 6 months) which were however not significant at 6 to 10 months of age.

Average daily gain from birth to weaning (6 months of age) ranged from 0.468-0.615 kg. Further, average daily gain from weaning to 10 months of age ranged from 0.527-0.537 kg for supplemented calves and 0.350-0.370 kg for unsupplemented calves. Plasma inorganic phosphorus levels ranged from 8.26-9.19 mg per 100 ml (2 months), 4.68-7.90 mg per 100 ml (6 months) and 3.84-4.43 mg per 100 ml at 10 months of age. Plasma calcium levels ranged from 5.04-6.69 mg per 100 ml (2 months), 7.21-8.29 mg per 100 ml (6 months) and 10.02 to 11.08 mg per 100 ml at 10 months of age. Plasma magnesium levels of swamp buffalo calves ranged from 1.03-3.85 mg per 100 ml while plasma iron and copper levels ranged from 1.33-1.76 μg per ml and from 0.43-1.19 μg per ml respectively.

In the second experiment, three male and three female swamp buffaloes aged 16 months with body weights ranging from 210 to 240 kg were distributed at random into six individual stalls. Three experimental rations were provided in a double 3 x 3 Latin square experiment based on sex. Ration A was forage only, ration B was forage and corn (energy) supplement and ration C was forage and corn (energy) + mineral supplement. Guinea grass (*Panicum maximum*) was used as forage.

Dry matter, nitrogen, calcium, iron and copper intakes from Guinea grass, were higher in swamp buffaloes receiving a combination of Guinea grass, corn (energy) + mineral supplement as compared to those fed Guinea grass only and those receiving a combination of Guinea grass and corn (energy), under stall fed conditions. The apparent digestibility of dry matter in Guinea grass, a combination of Guinea grass and corn, and a combination of Guinea grass, corn (energy) + mineral were 51.3 , 52.5 and 55.5 percent respectively.

It is concluded that mineral supplementation increases daily weight gain from weaning to 10 months of age and maintains plasma inorganic phosphorus levels at normal levels in swamp buffalo calves. Further, a combination of corn (energy) and mineral supplementation increases voluntary intake of forage.

INTRODUCTION

The water buffalo (Bubalus bubalis) is an important animal in the agricultural economy of many Asian countries. It has been classified into river and swamp types, based on habitat (Cockrill, 1974). The river type used mainly for milk, wallows in fresh water, while the swamp type used for meat and draft prefers muddy water.

Since the distribution of swamp buffaloes is greatest in Asia, tremendous interest has gathered in this region in increasing the productivity of this species, so as to exploit its many uses. In Malaysia, 50% of the beef supply comes from the swamp buffalo (Syed Ali Bakar, 1979).

Many factors have been known to influence the productivity of the buffalo, the most important being inadequate nutrition and reduced reproductive efficiency. It is well known that these two factors play an interrelated role in increasing buffalo productivity. A poor plan of nutrition, particularly mineral deficiencies is known to affect reproductive performance. A mean calving interval of 550 days has been reported for the swamp buffalo of Malaysia (Jainudeen, 1977). The length of the calving interval has been incriminated as the most important economic factor affecting the productivity of buffaloes in Indonesia (Robinson, 1977).

Swamp buffaloes in Southeast Asia are usually managed in small holdings and their diet is usually comprised of low quality roughage. Inferior pasture forms the main bulk of the diet, obtained through grazing or a 'cut and carry' system. It is therefore clear that numerous mineral deficiencies may affect growth rate, carcass composition and eventually reproductive efficiency.

Phosphorus has been shown to be deficient in cattle feeds in most countries (McDowell, 1976). Phosphorus deficiency in blood of buffaloes in Malaysia was reported by Hill and Rajagopal (1962). Eighty percent of buffaloes and cattle in Malaysia were also known to be copper deficient (Hill *et al.*, 1962).

Buffalo production is dependent almost entirely on pastures. Thus adequate protein, digestible energy and minerals from the grass are the major limiting factors in buffalo productivity. Although the total requirement of minerals is not high for animals, minerals have a significant effect on the efficiency of feed utilization, since they play a role in regulation of tissue metabolism.

Information on the effects of minerals on growth rate and reproduction of buffaloes is very limited. Thus, two experiments were designed to study (a) the effects of mineral supplement on weight gain and on blood plasma calcium, inorganic phosphorus, magnesium, iron and copper levels in male and female swamp buffalo calves up to 10 months of age and (b) the effects of mineral and energy supplementation on the utilization of Guinea grass by swamp buffaloes.

REVIEW OF LITERATURE

The Swamp Buffalo

The water buffalo (*Bubalus bubalis*, Linnaeus) has been classified into two types based on habitat and uses. The river type found in India, Pakistan, Egypt and in The Mediteranian region, wallows in fresh water and is used for milk. The swamp type which prefers muddy water and used for meat and draft is found in Southeast Asia, extending northward as far as the Yantse valley in China, Burma, Laos, The Khmer Republic, Vietnam, Malaysia, Indonesia and Philippines (Pant and Roy, 1972, Mason, 1974, Fahimuddin, 1975).

Water buffaloes have also been recently classified on cytogenetic status. The river type possesses a 2n = 50 chromosome complement while the swamp type of most Asian countries have 2n = 48 (Bongso *et al*., 1982). It has been suggested that the two groups may represent new "taxas" of this species and the name "*Bubalus bubalis kerbau*" has been suggested for the Malaysian swamp buffalo (Bongso and Hilmi, 1982, Bongso *et al*., 1983).

In Malaysia, there has been a drastic decline in the buffalo population from 255,000 head in 1976 to approximately 200,000 in 1980 (Syed Ali Bakar, 1979). Fifty percent of Malaysia's beef supply comes from the water buffalo. Buffaloes are also used to pull carts carrying oil palm bunches in estates where the thick foliage prevents the use of machinery. In spite of increased mechanisation in rice fields, the water buffalo is still being used to pull the plough in certain states of Malaysia.

The swamp buffalo appears to have evolved separately from the wild buffalo which was once abundant in the Southeast Asian region.

Reasons have been attributed to comparatively more humid conditions and characteristic husbandry practices in the region. They were mainly distributed in areas where the rainfall was 60 to 80 inches and in hot humid areas. The typical habitat of the swamp buffalo is marshy land where it wallows in mud and feeds on weeds and coarse grasses (Fahimuddin, 1975). The swamp buffalo has a small body conformation, light grey in colour, with laterally placed long horns. The tail reaches to just below the hocks in adult animals and the calves have a thick hair coat (Cockrill, 1976).

The swamp buffalo of Thailand is heavier than in most other Asian countries. They attain maximum weights of 450 kg compared with maximum weights of 350 kg for Malaysian buffaloes (Cockrill, 1967). Adult live weights of swamp buffaloes in Malaysia approximate 500 kg and 400 kg for males and females respectively (Fahimuddin, 1975 Hilmi, 1978).

Weight gains in young buffaloes ranged from 0.28 to 0.44 kg per day. The best weight gain was obtained before the animal reached 3.5 years of age (Camoens, 1976). The average daily gain was reported to be 0.3-0.6 kg to 2.5 years of age and 0.005 kg per day at about 5.5 years for Malaysian swamp buffaloes (Hilmi, 1978).

Swamp buffaloes are happiest when immersed up to their neck in mud wallows, grazing in the morning and evening and ruminating in the night on hillsides. Mud wallows usually accomodate one or a few animals only. Buffaloes are rarely found in areas where there is no ready access to water. The plastering of mud which swamp buffaloes acquire in the wallows gives some protection against biting flies and also against the sun (Mason, 1974). The swamp buffalo consumes up to 10-45 litres of water per day, intake being 2-3 times daily.

Tropical Forages

The vegetation in the tropics has been classified as rain forest, dry forest, savannah, dry bush, desert steppe and high mountains. Rice, bananas, plantain and maize are the major crops in South-east Asia (Payne, 1966).

The nutritive value and the production of the tropical forages depend on the interaction of a number of factors including soils, plant species, maturity, yield, pasture management and climate. Rainfall plays an important role.

The available wet tropic herbage is fibrous and high in water content. The crude fibre content of humid tropical forages is not only inversely related to the amount of rainfall but appears to be consequently higher than that of temperate forages at the same stage of growth. The coefficient of digestibility of tropical forages is lower than temperate herbage (McDonald et al., 1973).

Seasonal fluctuations in the nutritive value of tropical grasses result in a consistent pattern of weight changes in cattle. Cattle gain rapidly in the early rainy season and then lose weight in the dry season (Stobbs, 1975). McDowell (1976) reported that tropical forages contained less minerals during the dry season. It is logical to assume that cattle would most likely suffer mineral inadequacies during this time.

The mineral content of semi arid tropical forages particularly phosphorus is low and this may be another limiting factor in the nutrition of the ruminant. Blue and Tergas (1969) reported that during the dry season the nitrogen, phosphorus and potassium content of grasses dropped. After two weeks of effective rain, plant uptake of nitrogen and phosphorus was rapid which was later followed by a sharp surge of dry matter production due to a rapid expansion of leaf area (Norman, 1963). Nitrogen and phosphorus yield per unit area continued to increase up to 8-14 weeks, whereas the percentage of dry matter decreased, the ratio between nitrogen and phosphorus being maintained constant. However, Beeson and Gomez (1970) postulated that an increase of phosphorus content of grasses in the dry season must be accompanied by decreases in copper content.

There was a variation in mineral content of different plant species growing on the same soil (Thompson, 1957, Underwood, 1966, Gomide et al., 1969a). It was reported that total soil phosphorus declined with increasing intensity of weathering and thus in highly weathered acid soils, phosphorus deficiency could be expected (Olson and Engelstad, 1972).

Plant maturity is also an important factor in affecting the chemical composition as well as the overall nutritive value of forages. Gomide (1978) reported that the level of nitrogen, phosphorus and potassium decreased with advancing age of the plant. Translocation of nitrogen, phosphorus and potassium from the older tissue to newer areas is high within the plant, whereas calcium, magnesium, zinc and iron are relatively immobile, being most concentrated in the stem.

Dry matter content increased with age, while the crude protein, in vitro cellulose digestibility, phosphorus, potassium and iron content of grasses started to decline within 4 to 8 weeks after cutting (Gomide, et al., 1969b).

Cattle grazing pressure influenced the species of forage predominating in a grazing area, thereby affecting mineral composition. Good perenial grasses are grazed to the ground late in the dry season resulting in disastrous effects on their power of regeneration and replacement with tougher species of inferior quality. Burning grassland usually improved herbage quality. After burning or cutting, the crude protein content decreased with the age of regrowth (Paladines, 1974).

The phosphorus level was higher in burnt pastures than either unburnt or mowed pastures (Kirk *et al*., 1974). Fox *et al*., (1964) demonstrated that liming a soil to pH 6.1 increased plant uptake of phosphorus and at pH 7.1 caused a marked decrease in phosphorus uptake.

Minerals and Ruminant Nutrition

At least, fifteen minerals are required for farm animals. They are calcium (Ca), phosphorus (P), magnesium (Mg), sulphur (S), potassium (K), sodium (Na), chlorine (Cl), iron (Fe), zinc (Zn), copper (Cu), maganese (Mn), molybdenum (Mo), cobalt (Co), iodine (I) and selenium (Se). (Underwood, 1966; McDonald *et al*., 1973; McDowell, 1976).

Many factors affect mineral requirements. These include the level of production, age, chemical form of mineral, interrelationships with other nutrients and mineral intake, breed and adaptation (National Research Council, 1976). It is difficult to pinpoint the exact needs of specific mineral requirements for an animal, because this is dependent on mineral interrelationships, amount of dietary mineral supplied and biological availability (Ammerman and Miller, 1972; Peeler, 1972).

Deficiency and toxicity states in animals are usually ameliorated by the extent to which other components are present or absent from whole rations. The diagnosis of mineral disorders include clinical signs, pathological changes and chemical analysis of soil, animal tissues and feedstuffs (McDowell, 1976).

Mineral deficiencies may vary from severe deficiencies, with more or less characteristic disorders, to slight deficiencies, with non-specific signs, such as slow development, low fertility, low body weight at slaughter and low milk yield. Tokarnia et al., (1978) reported that experiments with mineral supplementation may seem to be the easiest method of diagnosis for mineral deficiency. However, it is often difficult to conduct well performed experiments in cattle under range conditions, because of many natural limitations in deficient areas.

Mineral supplements containing calcium, phosphorus, magnesium, potassium, sodium and copper increased calf liveweight gains from weaning to 32 weeks, but corn supplements were ineffective in increasing gain (Kaizer, 1975).

Little (1975) demonstrated that twenty five percent of unsupplemented animals and ten percent of phosphorus supplemented animals in Queensland failed to exhibit oestrus before weaning of calves.

Phosphorus

Extensive phosphorus deficient areas occur throughout the world and deficiency of this element is the most widespread and economically important factor of all the mineral deficiencies affecting grazing livestock (Underwood, 1966; McDowell, 1976; Thompson, 1978).

Thompson (1978), concluded that problems associated with phosphorus deficiency in range cattle include: (i) lower conception rates and smaller calf crops, (ii) difficult calvings, (iii) lower milk supply and a consequent lower weaning weight of calves, (iv) reduced growth and size at a given age and (v) poor appearance. Other disorders related to phosphorus deficiency include, loss of body fluids, poor feed efficiency, low resistance to infectious diseases and rickets. Thus, phosphorus is one the most limiting of the mineral nutrients for ruminants. The first evidnece of phosphorus deficiency is a drop in plasma inorganic phosphorus below normal levels. The utilization of phosphorus for various species of animals from various sources is influenced by the type of ration fed, chemical form of the element, the calcium-phosphorus ratio, age of animal, sex, fat and energy levels, interaction with other minerals and nutrients, chelating agents, feed processing and the physical nature of phosphorus sources and other feedstuffs in the diet (Peeler, 1972).

Lofgreen (1960) utilized a radioisotope dilution technique in which endogenous phosphate supplement interference was eliminated in order to determine the true digestibility of several inorganic phosphate supplements and dicalcium phytate. The data showed that biological availability of dicalcium phosphate was 100%, bone meal 92%, calcium phytate 66% and soft phosphate 28%. Tremendous variation in biological availability of various phosphate sources was observed in beef cattle, when different assay systems were used (Table 1).

The effects of phosphorus supplements on growth rates in beef cattle have been very variable. Norman and Arndt (1959)

TABLE 1. BIOLOGICAL AVAILABILITY OF VARIOUS PHOSPHATE SOURCES FOR BEEF CATTLE

Assay system	Dicalcium phosphate	Deflourinated phosphate	Soft Phosphate
Growth response[1]	100	-	17
Net retention isotope technique[2]	100	71	68
True absorption-depletion-repletion[3]	100	95	88
True digestibility balance trial[4]	100	93	-

1 - Long *et al*, (1956)

2 - Arrington *et al*., (1963)

3 - Ammerman *et al*., (1965)

4 - O'Donovan *et al*., (1965)

reported that phosphate supplementation did not prevent heavy live weight losses of cattle fed on native pastures during the dry season. The year round supplementation of phosphorus was not effective in increasing growth when compared to supplementation during the season of active pasture growth only (Bishop, 1964).

Cohen (1972) observed that beef steers grazing on phosphorus deficient pastures, did not show any effect on mean live weight when supplemented. In low phosphorus native pastures of Australia, South Africa and USA, live weight losses from 0.03 kg to 0.078 kg per day in cattle were observed (Cohen, 1975).

Three possible mechanisms for response to phosphorus supplements reported are (1) an increase in digestibility of dietary components, (2) an increase in voluntary food intake and (3) an increase in metabolic efficiency. The phosphorus supplements had no effect on apparent digestibility of dry matter, nitrogen or energy (Playne, 1969; Cohen, 1972). However, the apparent digestibility of phosphorus was increased by supplementation of up to 4 grams a day and this did not increase further than 4 to 8 grams a day. However, the apparent retention continued to increase (Cohen, 1972).

Little (1970) concluded that the initial response to phosphorus supplements in phosphorus deficient animals was an increase in voluntary food intake. This mechanism does not seem to always apply. Increased feed intake with phosphorus supplementation was recorded in sheep fed Townsville stylo (Styloshanthes humilis) but not in sheep fed spear grass (Hateropogon contortus) (Playne, 1969).

Phosphorus deficiency in cattle is diagnosed by combination of visible signs, blood inorganic phosphorus level and fecal analysis.

Inorganic phosphorus in blood plasma appears to be closely related to the phosphorus intake. A correlation of 0.6162 ± 0.0646 between forage phosphorus and blood phosphorus was reported (Knox et al., 1941).

Blood serum phosphorus levels are sensitive to the variation of phosphorus in the diet. And thus are a valuable aid in diagnosing the adequacy of phosphorus. Low forage phosphorus levels have been reported in 35 tropical countries, 13 of which also reported low serum phosphorus in cattle (McDowell, 1976).

Bishop (1964) has reviewed the role of dietary phosphorus on blood inorganic phosphorus levels in calves, growing steers, breeding heifers and breeding cows. In calves, levels increased from 6.4 to 8.1 mg per 100 ml during the first 15 days of life and decreased to 4.2 mg per 100 ml at weaning. The inorganic phosphorus levels were not affected by feeding of supplements to their dams. In growing steers of 12-39 months of age, inorganic phosphorus levels declined from an average of 5.8 to 4.5 mg per 100 ml. The inorganic phosphorus levels were significantly lower in steers not receiving supplementation. In breeding heifers and cows, inorganic phosphorus levels were highest in two-year-old heifers (4.4 mg per 100 ml) and declined progressively in three to four-year-old cows (3.9 and 3.7 mg per 100 ml respectively). Levels were lower in heifers and cows not receiving phosphorus supplementation.

Phosphorus deficiency begins when blood plasma levels go below 5 mg per 100 ml in cows (Cunha et. al. 1976). The normal concentration of blood inorganic phosphorus was reported to be 4 to 8 mg per 100 ml (Hemingway, 1969)

Cohen (1973a) showed that plasma inorganic phosphorus levels varied greatly between sampling times but were not significantly correlated with pasture phosphorus content. These results were obtained from blood samples taken at intervals of three months during a one year period from fifteen yearling Angus x Hereford calves fed carpet grass (*Axonopus affinis*). In other experiments, Cohen (1973b) concluded that phosphorus supplementation of 35 and 70 g per head per week had no effect on plasma inorganic phosphorus when compared with unsupplemented steers grazed on carpet grass (*Axonopus affinis*) of low phosphorus content. Supplementation caused an increase in the amount of phosphorus in dry fat and bone, but this effect was not apparent in the first three months of supplementation. He also concluded that phosphorus and calcium measurements in bone provided the most sensitive indication of the phosphorus and calcium status of beef cattle. When phosphorus had no effect on liveweight of beef steers, its effect on the demineralization of bone tissue may justify its use, particularly in areas where poor bone development and lameness occur.

Webb *et al*. (1975) reported that phosphorus supplementation in growing finishing beef steers, resulted in increased average daily gains, feed intake, final weight and serum inorganic phosphorus. However, serum calcium levels were significantly lower, when phosphorus was supplemented in the diet. Cohen (1974) demonstrated that blood plasma inorganic phosphorus concentration in cattle had a significant relationship with phosphorus intake. However, the relationship varied with the time of day at which samples were collected.

The most suitable calcium-phosphorus (Ca:P) ratio for farm animals, other than poultry, is generally within the range 1:1 to 2:1 although there is evidence suggesting that ruminants can tolerate higher ratios (McDonald *et al*., 1973). Growing steer calves fed a