Effect of Dietary Calcium and Phosphorus Levels on Performance of Local and Exotic Pigs

by

J. O. ILORI, A. A. ADEGBOLA,
S. A. ADEYANJU AND T. A. OMOLE
Department of Animal Science
University of Ife, Ile-Ife

SUMMARY

AN experiment involving 30 Local and 30 Large White pigs was conducted to study the effect of dietary calcium and phosphorus levels on rate and efficiency of gain, carcass and bone characteristics of growing-finishing pigs.

Rate and efficiency of gain and carcass quality were not significantly different among local pigs fed varying levels of calcium and phosphorus when the same calcium; phosphorus (Ca: P) ratio was maintained at all dietary levels. In contrast, exotic pigs receiving similar diets had a significant improvement in rate of gain. Dietary calcium and phosphorus levels affected metacarpal length, weight and also metacarpal and turbinate ash in both breeds. Growth rate and carcass quality of local pigs were however, lower than those of exotic pigs on similar diets.

INTRODUCTION

Several investigators (Zimmerman, Speer, Hays and Carton, 1963; Libal, Peo, Andrews and Vipperinan 1969 and Cromwell, Hays, Scherer and Overfield 1972) have shown that the calcium and phosphorus requirements for optimum gain and feed efficiency may be different from that required for optimum skeletal development in pigs. Brown, Krook and Pond (1966) concluded that high levels of calcium and phosphorus were necessary to prevent atrophy of the turbinate bones. Cromwell *et al* (1972) showed that rate and efficiency of gain and ash content of the turbinate and metacarpals were not significantly improved by increased phosphorus levels. However, they showed low dietary phosphorus levels to result in slower and less efficient gains, fatter carcasses, lower ash content in the metacarpals and a marked reduction in the ash content of the turbinates. Again, since no precise information is available on the calcium and phosphorus

requirement of local pigs for optimum performance and bone development, this study was undertaken to study the effect of different dietary calcium and phosphorus levels on the live performance, carcass traits and certain bone characteristics of growing-finishing local pigs and to compare the results thus obtained with those of exotic pigs receiving the same dietary treatments.

MATERIALS AND METHODS

Experimental Animals

Sixty pigs consisting of 30 Large White (exotic) and 30 local pigs were used in this study. The exotic and local pigs averaging 58.6 ± 2.2 kg and 36.8 ± 1.8 kg in weight respectively were all raised on the University of Ife Pig Unit. Both the exotic and local pigs were each randomly allotted on basis of initial weight, litter mates and sex to three experimental diets such that in each group of 10 pigs, there were 5 barrows and 5 gilts. Pigs in each group were housed in 7.3×1.8 meter concrete-floored pens, in an enclosed building of asbestos roofing and wooden side walls.

Experimental Diets

The diets for the three treatments were formulated to contain calcium and phosphorus levels of 0.325, 0.25; 0.65, 0.5 and 0.975, 0.75 respectively. The calcium: phosphorus ratio was kept constant at 1.3: 1 in all the diets. The desired levels of calcium and phosphorus were attained by varying the amounts of dicalcium phosphate and oyster shell. Maize-groundnut cake meal diets fortified with vitamins, minerals and antibiotics and formulated

TABLE 1
Composition of Experimental Diets

Items	Dietary treatments		
	1	2	3
Yellow maize	80.0	78.00	76.00
Groundnut cake	17.56	18.12	18.68
Dicalcium phosphate	1.40	2.80	4.20
Oyster shell	0.04	0.08	0.12
Salt	0.50	0.50	0.50
Mineral-vitamin premix ¹	0.50	0.50	0.50
Total	100.00	100.00	100.00
Calculated values			
Protein	15.00	15.00	15.00
Calcium	0.325	0.65	0.975
Phosphorus	0.25	0.50	0.75
Calcium: Phosphorus ratio	1.3:1	1.3:1	1.3:1

The vitamin-antibiotic premix supplied 440 mg riboflavin 880 mg calcium pantothenate, 2g niacin, 2.2 g choline chloride, 15 mg folic acid, 1 mg vitamin B₁₂, 500,000 I.U. vitamin A, 6,600. I.U. vitamin D₂ and 1,000,12 I.U. vitamin E per 50 kg of diet. It also supplied 24 ppm copper, 2 ppm iodine, 34 ppm manganese, 50 ppm zinc and 100 ppm iron.

to contain 14% protein were used. The composition of the diets is presented in Table 1. Each of the three dietary calcium and phosphorus levels was fed to one of the three groups of local and exotic pigs. Each pen was equipped with a self feeder and a concrete water trough.

Data Collection

Pigs in each pen had access to feed and water *ad libitum*. Records of body weight changes and feed consumption were taken and summarised every two weeks. Local and exotic pigs were individually removed from the experiment as soon as they reached their market weights of 63.4 ± 1.6 kg and 88.7 ± 2.2 kg respectively, after which they were slaughtered and standard carcass measurements were obtained.

One front leg from each pig was obtained following slaughter and the 2nd and 5th metacarpal bones were excised for determining the effect of dietary calcium and phosphorus levels on their ash content. Weight and length of the 3rd and 4th metacarpals were also measured. The

snout of each pig was also removed and the turbinates including the cartilage were then excised for ash determination. The metacarpal and turbinate bone samples were ground through a Wiley mill and dried in a vacuum oven (29 inches of mercury) for 24 hours. Fat was removed from the samples by consecutive 24 hour extractions with ethyl alcohol and anhydrous ether and the resulting samples were ashed for about 18 hours at 550°C.

All data were analysed by the analysis of variance and treatment means compared using Duncan's multiple range test procedure as outlined by Steel and Torrie (1960).

RESULTS AND DISCUSSION

A summary of the gain, feed to gain, carcass and bone characteristics data is presented in table 2. Dietary calcium and phosphorus levels had significant effects on the rate of gain of exotic pigs. Exotic pigs on the three diets had daily weight gains of 0.31, 0.49 and 0.64 kg for diets 1, 2 and

3 respectively, and the differences between them were significant ($P < 0.05$). In contrast, local pigs receiving the same diets had non-significantly ($P > 0.05$) different daily weight gains of 0.38, 0.41 and 0.39 kg, respectively. Local pigs on diet 1 outgained their exotic counterpart on the same diet (0.38 kg vs 0.31 kg), though not significantly. Exotic pigs on diet 2 outgained non-significantly the local pigs on the same diet (0.49 to 0.41 kg). At calcium to phosphorus levels of 0.975: 0.75% respectively, exotic pigs significantly ($P < 0.05$) outgained local pigs (0.64 kg vs 0.39 kg).

The National Research Council (NRC, 1968) recommended level of 0.50: 0.4% calcium to phosphorus respectively, with an allowance of about 20% up, is the level used in most of our growing-finishing pig rations at the University of Ife, Swine Unit. Our observations showed that at a calcium and phosphorus level of 0.975 and 0.75% respectively, rate of gain of the exotic pigs was still on the increase. This would seem to suggest that there might have been some

under-estimation of the requirement of growing-finishing exotic pigs for calcium and phosphorus under Nigeria conditions. Again, results as obtained in this study would seem to suggest that while the exotic pig was more sensitive to level of calcium and phosphorus, the local pig was more sensitive to Ca:P ratio rather than dietary levels, for their optimum growth. Feed/gain in both exotic and local pigs were also affected by dietary calcium and phosphorus levels. Feed/gain within breeds were not significantly different at the various dietary calcium and phosphorus levels tested, though feed/gain values tended to improve as dietary calcium and phosphorus levels was increased. Exotic pigs receiving 0.65, 0.5 and 0.975 0.75% calcium to phosphorus, respectively, had feed/gain values significantly ($P < 0.05$) higher than those of local pigs on all the dietary calcium and phosphorus levels. Feed efficiency values within breeds as obtained in this study are in agreement with those of Libal, Peo, Andrews and

TABLE 2

Effects of Dietary Calcium and Phosphorus Levels on Growth, Carcass and Bone Characteristics of Pigs

	<i>Exotic Treatment</i>			<i>Local Treatment</i>		
Calcium level, %	0.325	0.65	0.975	0.325	0.65	0.975
Phosphorus level, %	0.25	0.50	0.75	0.25	0.50	0.75
Diet Number	1	2	3	1	2	3
<i>Growth Data</i>						
Av. daily gain, kg.	0.31 ^c	0.49 ^b	0.64 ^a	0.38 ^{bc}	0.41 ^{bc}	0.39 ^{bc}
Feed/pig, kg	1.09	1.63	2.09	1.56	1.56	1.48
Feed/Gain	3.5 ^{ab}	3.32 ^a	3.28 ^a	4.1 ^c	3.8 ^{bc}	3.8 ^{bc}
<i>Carcass Data</i>						
Yield, %	68.1	69.4	69.2	61.3	65.1	62.2
Carcass length, cm	77.5	77.2	78.2	67.5	68.7	69.8
Loin eye area, cm ²	27.6	28.4	29.2	21.5	23.2	23.1
Backfat thickness, cm	3.5 ^{ab}	3.3 ^a	3.2 ^a	4.2 ^c	3.8 ^{bc}	3.8 ^{bc}
% Ham and Loin	38.3	37.7	38.6	36.4	37.2	37.0
<i>Bone Data</i>						
Metacarpal ash, % ²	56.2	57.4	57.2	50.2	52.2	51.7
Turbinat ash, % ²	36.8	37.7	38.4	33.6	34.2	34.6
Metacarpals 3rd & 4th						
Length, mm	40.6	41.4	41.2	34.4	35.1	35.8
Weight, g.	9.8	10.1	10.5	7.7	8.4	8.1

² Expressed on a moisture free, fat free basis

abc Means within rows with different superscripts are significantly different ($P < 0.05$.)

Vipperman, (1969) who reported no significant differences in feed conversion in pigs fed various calcium and phosphorus levels.

Carcass yield and % ham and loin were not significantly influenced by dietary calcium and phosphorus levels in both local and exotic pigs. Carcass length and *longissimus dorsi* muscle of exotic pigs were appreciably higher than those of local pigs. A discrepancy could arise in comparing absolute values of these two parameters since the animals being compared were of varying sizes (88.7 kg vs 63.4 kg, for exotic and local pigs, respectively) at slaughter. The two parameters were hence not subjected to statistical analysis, since the slaughter weights were not subjected to constant body weights by covariance analysis. Exotic pigs had carcasses significantly ($P < 0.05$) leaner at the two higher dietary calcium and phosphorus levels than local pigs on all the other treatments. Dietary increases of calcium and phosphorus tended to decrease back fat thickness in both local and exotic pigs.

Weight of the metacarpal bone (third and fourth) was greater as dietary calcium and phosphorus level of ration was increased in the exotic pigs and at the two lower dietary levels in the local pigs. Metacarpal bone length was found to be longer in both local and exotic pigs up to a dietary level of 0.65 and 0.5% calcium and phosphorus, respectively, after which it decreased in both breeds. Metacarpal bone length and weight were lower in local pigs than the exotic pigs probably because of their smaller sizes. Metacarpal

ash in both local and exotic pigs increased up to 0.65 and 0.5% calcium and phosphorus, respectively, whereas turbinate ash increased in both breeds with increases in dietary calcium and phosphorus levels. Cromwell *et al* (1972) reported that the ash content of the turbinates was not significantly correlated with the ash content of the metacarpals, thus suggesting differences in their rates of calcification. This might explain the differences in ash content relative to dietary levels of calcium and phosphorus fed in this study.

REFERENCES

- BROWN, W. R., KROOK, L. and POND, W. G. (1966.) Atrophic rhinitis in swine. Etiology, pathogenesis and prophylaxis. *Cornel Vet. Suppl.* 1, vol. 56.
- CROMWELL, G. L., HAYS, V. W., SCHERER, C. W. and OVERFIELD, J. R. (1972.) Effect of dietary calcium and phosphorus on performance and carcass, metacarpal and turbinate characteristics of swine. *J. Anim. Sci.* **34**, 746-751.
- LIBAL, G. W., PEO, JR. E. R., ANDREWS R. P. and VIPPERMAN JR P. E. (1969.) Levels of calcium and phosphorus for growing-finishing swine. *J. Anim. Sci.* **28**, 331-336.
- N. R. C. (1968.) Nutrient Requirements of Swine. Nutrient Requirements of Domestic Animals: 6th Edition. 5 Publication 1599. National Academy of Sciences, Washington, D. C.
- STEEL, R. G. and TORRIE J. H. (1960.) Principles and Procedures of Statistics. McGraw-Hill Book Co., New York.
- ZIMMERMAN, D. R., SPEER, V. C., HAYS, V. M. and CARTON D. V. (1963.) Effect of calcium and phosphorus on baby pig performance. *J. Anim. Sci.* **22**, 658-664.

The efficacy of four anthelmintics in adult cattle under field conditions

by

T. W. SCHILLHORN VAN VEEN
Faculty of Veterinary Medicine
Ahmadu Bello University

SUMMARY

FOUR anthelmintics bithionol-sulphoxide 35-40 mg/kg. (BS) bithionol-sulphoxide combined with thiabendazole at 100 mg/kg (BS + TB-100) and at 80 mg/kg (BS + TB-80), hexachlorophene 10-15 mg/kg, (HX) and rafoxanide 6-8 mg/kg (RF) were used in adult cattle under Nigerian field conditions. Two treatment schemes were used: 1. one treatment a month (March) before the beginning of the rains (and the period that *Fasciola* infections were obtained), 2. two treatments, one a month before and one a month after the beginning of the rains.

The weight gains, egg counts, and number of animals found infected were recorded from March till August.

The total weight gain over the five months period was 37, 24.5, 23, 24.5, 15.5, 17 and 14 kg for the cattle treated with BS + TB-100, BS + TB-80, BS (once), RF (twice), RF (once), HX (twice) and controls respectively.

The number of *Fasciola* infected animals decreased by the following percentages 2 weeks after treatment: 93% for BS, 75% for RF and 28% for HX; the controls showed a definite increase.

None of the treatments showed a significant reduction in the number of trichostrongyle infected animals and in egg counts, except the BS + TB-100 group.

INTRODUCTION

In Nigerian cattle the helminths of the general *Haemonchus*, *Oesophagostomum*, *Bunostomum* and *Fasciola* are considered of major economic importance in causing poor growth, disease or death (Lee, Armour & Ross, 1960; Sewell, 1966). Haemonchosis is mainly observed during the wet season whereas oesophagostomiasis is more common during the dry season. Chronic and acute fascioliasis are mainly observed during the end of the dry season and at the beginning of the rains. Helminth infections due to *Ostertagia*,

Nematodirus and lungworms which are of importance in other parts of the world are however absent (Lee *et al.*, 1960; Schillhorn van Veen, 1976).

This restricted number of clinically important helminth species is of interest since it offers opportunities for anthelmintics with a narrower efficacy spectrum than those currently manufactured and used in areas with temperate climate, including Europe, America and Australia. These opportunities are not solely of scientific but also of economic importance.

Among such anthelmintics are those with a combined efficacy against *Haemonchus* and *Fasciola* such as rafoxanide and those with a combined effect against *Oesophagostomum* and *Fasciola*, for instance bithionol sulphoxide.

This paper describes a trial with such anthelmintics under Nigerian field conditions during the end of the dry and beginning of the wet season of 1974.

MATERIALS AND METHODS

The trial was carried out during the period March/August on the Ahmadu Bello University farm where a mixed cattle and sheep herd was grazing at day time around the farm grounds. The animals were kraaled at night during which period they received about 1 kg mais-silage each and free access to salt-licks.

The 93 adult female cattle with naturally acquired helminth infections were divided into seven groups and treated as follows:

- (i) (11 animals) treated with bithionol sulphoxide a. (40 mg/kg) on the 15th of March and with a combination b. of bithionol sulphoxide (40 mg/kg) and thiabendazole (100 mg/kg)c. on the 15th of May.
- (ii) (11 animals) treated as I but the dosage of Thiabendazole was 80 mg/kg. d.
- (iii) (10 animals) treated with bithionol sulphoxide (40 mg/kg) on the 15th of March.
- (iv) (15 animals) treated with rafoxanide e. (7.5 mg/kg) on the 15th of March and on the 15th of May.
- (v) (15 animals) treated with rafoxanide (7.5 mg/kg) on the 15th of March.
- (vi) (16 animals) treated with hexachlorophene f. (15 mg/kg) on the 15th of March and on the 15 of May.
- (vii) (15 animals) constituted the control group which received no treatment.

Table 1 gives a schematic presentation of the treatment scheme. The animals were assigned to groups in such a way that

the age, weights and level of helminth infection (as measured by egg counts) were comparable.

During the trial however some of the cattle calved and although they were equally distributed over the groups, these animals were eliminated from the trial as far as their weights were concerned, reason why there was a difference in the average weight per group at the beginning of the trial on the 15th of March.

Rectal faecal samples were taken and animal weights recorded on every first Friday of the month from April till August.

Faecal examination was performed according to the modified McMaster egg counting technique (Whitlock, 1948) for nematode eggs and according to the modified formal ether method (Sapero and Lawless, 1953) for the trematode egg.

RESULTS

The treatment with all anthelmintics on the 15th of March (table 2) caused a reduction in number of animals in which *Fasciola* eggs could be detected, and in the

TABLE 1
Treatment Scheme Used in University Farm Cattle

Group	Treatment on 15th March	Treatment on 15th May
I		Bithionol-sulphoxide and Thiabendazole 100 mg/kg
II	Bithionol-sulphoxide	Bithionol-sulphoxide and Thiabendazole 80 mg/kg
III		Nil
IV	Rafoxanide	Rafoxanide
V		Nil
VI	Hexachlorophene	Hexachlorophene
VII	Nil	Nil

a. Disto-5 (Cogla Cy. -paris)

b. Wormy-10 (Cogla Cy. -paris)

c. Thiabendazole (Merck, Sharp & Dohme - Rahway, U.S.)

d. Wormy 1-8 (Cogla Cy. -paris)

e. Ranide (Merck, Sharp & Dohme - Rahway, U.S.)

f. Facsol (Cooper, McDougal & Robertson, Berkhamsted U.K.)

TABLE 2

Number of Animals out of Total with Eggs Detected at Day of Treatment (15th of March) and 2 and 6 Weeks Afterwards

Treated with:	Total number of animals	Animals with <i>trichostrongyle</i> eggs			Animals with <i>Fasciola</i> eggs		
		T ₀	T+2	T+6	T ₀	T+2	T+6
Bithionol-sulphoxide	32	18	14	18	14	1	4
Rafoxanide	30	16	16	16	12	3	14
Hexachlorophene	16	8	6	11	7	5	5
Non-treated control	15	9	7	11	6	6	10

TABLE 3

Number of Animals out of Total with Eggs Detected 2 Weeks before, 2 Weeks after and 6 Weeks after Treatment (15th of May)

Treatment groups:	Total number of animals	Animals with <i>trichostrongyle</i> eggs			Animals with <i>Fasciola</i> eggs		
		T+2	T+2	T+6	T+2	T+2	T+6
I	11	7	1	5	2	0	1
II	11	7	2	5	1	0	2
III	10	4	4	5	1	4	5
IV	15	10	8	7	8	6	9
V	15	6	9	12	6	6	11
VI Control	16	11	9	10	3	4	5
VII Control	15	11	10	10	10	6	10

number of *Fasciola* eggs per animal. None of the drugs reduced the number of animals with detectable trichostrongylid infections.

The treatment on the 15th of May (table 3) confirmed this result. The effect of the thiabendazole was noticed in that the number of animals with a detectable gastro-intestinal trichostrongylid infection as well as their average trichostrongylid egg counts, declined considerably. The difference in mean egg counts was however not statistically significant.

Paramphistome-eggs were rarely found during March and April but were demonstrated in five control animals, two rafoxanide and three hexachlorophene treated animals in May-June. In July - August however 20 animals were found infected, one group III, 3 of IV, 6 of V and 5 each in group VI and in the control group.

The weight change of the animals during the last months of the dry season were low or negative (figure 2).

The weight gains (or losses) in the animals treated with bithionol sulphoxide

(< 1 kg) and rafoxanide (-2 kg) were statistically lower ($P < 0.05$) than those treated with hexachlorophene (-6 kg) and the non-treated control (-6 kg). After May however the weights increased and the weight gain over the period May-August of the groups one to seven was 36, 22.5, 22.5, 24.5, 20, 23 and 20 kg respectively. The total weight gain over the period March-August was respectively 37, 24.5, 23, 24.5, 17 and 14 kg. Only the weight gain in group 1 was statistically different from the controls ($P < 0.05$).

DISCUSSION

The efficacy of the drugs used in this field trial was not very convincing in that none of the utilised drugs completely eliminated the helminth-infection within the group. With regards to fascioliasis however it should be pointed out the treatments were carried out during the period that freshly acquired flukes developed; a few cases of (fatal) acute fascioliasis were recorded in sheep grazing in the same

herd during April. Boray (1971) in a review on the chemotherapy of *F. hepatica* mentioned that hexachlorophene at 15 mg/kg had little or no effect on juvenile flukes, rafoxanide only at a dosage of 7–10 mg/kg. Also bithionol sulphoxide has little effect on flukes of less than 8 weeks.

Especially the effect of rafoxanide was below expectation. The reduction in number of infected animals was transient (table 1) and could well be due to a temporary reduction egg production. This is in contradiction with various other reports on the efficacy of rafoxanide against *F. gigantica* (Bouchet, Daynes & Birgi, 1971; Snyders, Louw, 1971) and it may be useful to repeat the trial with a higher number of animals before drawing definite conclusions on the efficacy against *F. gigantica*. Snyders, Horak and Louw (1971) found a 100% reduction in the number of cattle infected with adult *F. gigantica* but noticed that the drug at a dosage rate of 5–7.5 mg/kg was less efficient in reducing the juvenile fluke population.

Also Presidente and Knapp (1972) still found *F. hepatica* eggs in artificially infected calves after treatment with rafoxanide, especially at the dosage of 7.5 mg/kg or less.

It seems interesting that neither bithionol sulphoxide with a claimed efficacy against *Oesophagostomum* spp. nor rafoxanide with a claimed efficacy against *Haemonchus* spp. caused any reduction in trichostrongylid egg counts. Only when combined with thiabendazole was the reduction detectable (figure 1). The trichostrongylid egg counts were generally low, the highest recorded was 250 e.p.g. and only half of these (adult) animals had a detectable number of eggs in the faeces. It is possible however that the detected eggs were mainly *Cooperia* eggs, which were not affected by the drugs used. Lee *et al.* (1960) in the adjacent Shika Research Station found that *Cooperia* eggs were especially prevalent in faecal samples of cattle during the period May–July. Since the rains started late in 1974, it is unlikely that *Haemonchus* sp. recently developed in the pasture could contribute to the egg counts during April and May. The first period with a rainfall of more than 5 cm.

per week, a requirement for optimal development of *Haemonchus*, was the second week of June.

Better weight gains were recorded in the animals treated twice, which indicated that the elimination of the residual adult fluke population as well as the recently developed flukes was of detectable benefit to the host. The difference in weight loss 6 weeks after the first treatment shows that the reduction of the adult fluke population only as done by hexachlorophene seems less important than the reduction of adult and juvenile flukes as affected by rafoxanide and bithionol. It is possible however that this picture was biased since the latter two drugs do also affect a part of the nematode population and show some activity against paramphistomes. The effect of rafoxanide against these stomach flukes was rather poor which is in agreement with the results of Bouchet *et al.* (1971).

This difference in weight gains was less obvious however during the beginning of the rainy season when fodder condition improved. This is in accordance with findings of Graber (1971) who postulated that the deteriorating effect of Liverfluke infections is especially evident in animals on a low nutritional level.

The long term effects of the treatment were less obvious; the differences in weight gain during the last two months of the trial were minor.

Concluding it should be stated that the two treatments were justified in that the weight gains in these groups (I, II, IV) were at least 23 kg higher than the non-treated controls. The costs of drug and treatment were below one naira per animal whereas the profit, based on a price No. 60 per kg live weight, was over 12 naira per animal.

The single treatment in March showed little effect and was probably ill-timed at a period that juvenile flukes were just obtained and not affected by the drugs used.

REFERENCES

- BORAY, J. G. 1971. Fortschritte in der Bekämpfung der Fasciolose. Schweiz. Arch. Tierheilk, **113**, 361–386.

- POUCHET, A., DAYNES, P. and BIRGI, E. (1971.) Etude de l'action anthelmintique d'un derive halogene de la salicylanilide vis-a-vis de *Fasciola gigantica*. Rev. d'Elev. Med. Vet. Pays tropic. **24**, 542-549.
- GRAEBER, M. (1971.) Role du facteur alimentaire dans la distomatose bovine et ovine a *Fasciola gigantica*. Bull. epizoot. Dis. Afr. **19**, 45-60.
- LEE, R. P., ARMOUR, J. and ROSS, J. G. (1960.) The seasonal Variations of strongyle infestations in Nigerian zebu cattle. The Brit. Vet. J. **116**, 1-13.
- PRESIDENTE, P. J. A. and KNAPP, S. E. (1972.) Anthelmintic effect of rafoxanide against immature *Fasciola hepatica* in calves. Am. J. Vet. Res. **33**, 1603-1610.
- SAPERO, J. J., and LAWLESS, D. I. (1953.) The M.J.F. stain-preservation technic for the identification of intestinal protozoa. Am. J. Trop. Med. Hyg. **2**, 613-619.
- SCHILLHORN VAN VEEN T. W. (1976.) Some notes on anthelmintic treatment in Nigerian ruminants. J. Med. Pharm. Marketing **4**, 273-275.
- SEWELL, M. M. H. (1966.) The pathogenesis of Fascioliasis. Vet. Rec. **78**, 98-105.
- SNYDERS, A. J., LOUW, J. P. and SERRANO, F. M. H. (1971.) Trials with rafoxanide. 1. *Fasciola gigantica* in cattle in Angola J. S. Afr. Vet. Med. Ass. **42**, 249-251.
- SNYDERS, A. J., HORAK, I. G. and LOUW, J. P. (1971.) Trials with rafoxanide. 2. Efficacy against *Fasciola gigantica* in cattle. J. S. Afr. Vet. Med. Ass. **42**, 253-257.
- WHITLOCK, J. H. (1948.) Some modifications of the McMaster egg counting technique and apparatus. J. Counc. Scient. Industr. Res. Austr. **21**, 177-180.