Protein Requirements and Non-protein Nitrogen Supplementation in Fattening Bulls

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1. INTRODUCTION

In the period 1967-70 in Hoorn a range of feeding experiments with fattening bulls was carried out. The objective was to determine the effect of a number of energy levels (SE) and of two protein levels on fattening performance (daily gain and feed conversion) and on slaughter quality (Boer *et al.*, 1971). Results of these experiments showed no differences in effect from the protein levels.

Some years before, an inquiry from EAAP in several countries had revealed large differences in energy and protein allowances within classes of fattening cattle (Boer, 1964, 1971, 1974).

These observations led to the assumption that (1) the protein allowances for (young) fattening cattle were weakly founded, and (2) protein requirements might be lower than generally was accepted.

Taking into account that in numerous places in the world protein is very scarce, provoking relatively high prices for protein-rich feeds, it was thought appropriate to start a series of experiments on protein requirements of young fattening bulls.

Again, induced by high prices of protein-rich feeds, there is a steady pressure to replace part of the feed protein by non-protein nitrogen (NPN) sources, e.g. urea.

However, if in experiments with urea and/or other NPN sources the protein requirements are set at a higher level than physiologically needed the NPN application may not be useful or cheap at all.

It is very likely indeed that only in a situation of sub-minimal protein feeding a positive effect of NPN supplementation can be expected.

These considerations led in the period of 1968-75 to a number of fattening experiments with young bulls in Hoorn. Some data are mentioned in Table 1.

Stimulated by the menace of food shortage in quite a number of countries, research activities on the application of feeds, being not or less suitable as food for mankind, in animal husbandry have been intensified in The Netherlands in recent years.

So in this range of experiments cattle were fed on rations consisting mainly of concentrates composed of feed never or hardly used in human nutrition.

2. EXPERIMENTAL PROCEDURE

All experiments comprised three or four groups, including a negative and a positive control group. In Hoorn (H) animals were housed and fed individually, in both other locations bulls were kept in loose-housing and fed in groups. Rations mainly consisted of concentrates. In addition 1 or 1.5 kg hay was fed per head daily. Apart from experiments Maarheeze (Mh) 68 and Mh 69, the main part in the concentrate mixture was dried sugar-beet pulp, roughly 80-90%. Some protein-and fat-rich feeds together with 2-3% of mineral and vitamin supplements made up the remaining part of the mixtures.

The feeding value of the concentrate mixtures was calculated from Dutch feed table values and from feed analysis. Neglecting the unavoidable variations between experiments, the SE value was on average 650. SE value of dried beet-pulp was - according to Dutch feed tables - set at 670.

The crude protein (CP) content in feed mixtures was for the negative control group about 8%, compared with 13% (10-15%) in positive and experimental groups. Consequently in the complete rations the CP content was 9-15% in dry matter. Feed was weighed daily in general; refused feed was collected and weighed.

Bulls were weighed every fortnight. Every 6-8 weeks during the experiments the slaughter quality was estimated. After killing, the carcass quality was assessed by visual judgement. In some experiments (Mh 71, H 71, H 72, Mh 72, H 73, Mh 73, Vessem (Ve) 73) 3 rib-cuts (7, 8, 9) were dissected, combined in experiments H 72, Mh 72, H 73, Mh 73 and Ve 73 with specific gravity determination of the rib-cuts in water (Bergström and Boer, in Press).

For several reasons - having nothing to do with experimental treatments - 13 bulls altogether died prematurely. So 327 fattening bulls out of 340 completed the experimental period.

3. RESULTS

In Table 2 some important data from the series of 11 experiments are given. To facilitate comparability of the experiments and the applied experimental treatments, SE and CP given are expressed per unit of metabolic weight ($W^{0.75}$).

Some data in Table 3 show the relation of NPN and feed protein in the relevant groups.

Slaughter and carcass quality was generally very similar in positive control groups and experimental groups 1 and 2. Animals from the negative control groups compared on average unfavourably with those. For that reason in Table 4 only data from positive and negative control groups are mentioned.

In five experiments N-balance trials were carried out. Some summarized results are shown in Table 5.

4. DISCUSSION

Data in Table 2 suggest strongly that, in general, the daily gain in the negative control groups was depressed by low protein supplementation. The depression of the gain was moderate, however, when protein intake was in the range of 9-10 g CP per $W^{0.75}$. If protein supplementation causes a CP intake below that level, daily gain and energy intake decline very markedly.

Information in Tables 2, 3 and 5 relate to averages for the complete experimental period. Because of the greater part that protein deposition plays in their metabolism and gain, it is supposed that young bulls, e.g. of a live weight below 275 kg, will react in a different way to low protein supplementation compared to bulls in the live weight range over 375 kg (last part of the fattening experiment). Therefore in every experiment the total weight range has been split up into three parts and within each part the daily gain, protein intake and protein balances have been calculated.

This approach shows that in the weight range up to 275 kg (age of about 9 months) the daily gain and protein deposition are positively affected by increasing protein gifts. However, this relation fades away rapidly when the daily protein intake surpasses 11 g CP per $W^{0.75}$ (Fig. 1).

In the positive relation of protein deposition and protein intake no such switching point is showing up (Fig. 2). Protein supplementation induces higher protein deposition, even when more than 11 g CP per $W^{0.75}$ is consumed. However, the number of results above that level is small.

In the weight range of 275-375 kg (Fig. 3) the daily live weight gain and protein intake hardly show any positive relation. If so, there seems to be a faint positive one as long as CP intake stays below 9 g CP per $W^{0.75}$. Protein intake and protein deposition do not appear to be correlated. A mere detailed analysis of data in Fig. 4 reveals that the highest protein deposition values at all protein allowances generally correspond to bulls with live weights of about 300 kg and less.

These observations suggest that hardly any correlation exists between protein intake and protein deposition in fattening bulls at live weights over 300 kg. In fattening bulls with live weights over 375 kg (age of about 12 months) there is no relationship between protein intake and live weight gain (Fig. 5) or protein deposition (Fig. 6), when the protein intake is above 8 g CP per $W^{0.75}$.

These results have led to the conclusion that 11 g CP per $W^{0.75}$ is sufficient for a daily live weight gain of around 1100 g in fattening bulls of 275 kg and less, down to about 175 kg. For fattening bulls in the live weight range of 275-375 kg about 9 g CP per $W^{0.75}$ seems to be appropriate, while 8 g CP per $W^{0.75}$ will suffice for fattening bulls of a heavier live weight.

Transposed to real live weights and taking into account the relatively strong effect of metabolic faecal N, apparent digestible crude protein (DCP) requirements can be calculated as mentioned in Table 6.

These requirements are substantially lower than those used in most countries.

The daily gain has been affected considerably by NPN only in two experiments (H 71, Mh 70), as Table 2 shows. It was clearly smaller in experiments Mh 71, H 72 and Mh 72 and not visible in experiments Mh 68 and Mh 69.

The data from the NPN experiments were examined more closely. Clear effects of NPN addition were only found when the CP intake, apart from NPN, was below the standards of Table 6 (see also Table 3).

Data from the (small number of) protein-balance experiments support this observation.

That means that in fattening bulls NPN supplementation will be useful only when the basic ration contains a (very) low amount of protein.

In the live weight range 250-300 kg protein utilization declines considerably, as Fig. 7 shows, at all protein levels. Protein gifts (NPN included) above the amounts given in Table 6 will lead easily to an enlarged urinary N excretion and consequently to an inefficient protein utilization.

That means that, in general, it is not appropriate to add NPN to rations for fattening bulls weighing over 300 kg. In practical conditions of intensive bull fattening, as is practised in many parts of western Europe, it causes some difficulties in composing rations which provide sufficiently low protein levels (< 8.5% CP in dry matter) to produce a favourable effect of NPN supplementation.

Provided that other properties of the ration (such as sufficient amount of minerals, vitamins and of easily degradable energy) are all right, NPN supplementation to rations for fattening bulls below 300 kg live weight will be most promising. In many feeding experiments with NPN addition, too little attention was paid to the true N requirements of the animal in the various parts of the growth period.

5. SUMMARY

The effect of different feed protein levels on daily live weight gain, carcass quality and protein deposition was measured in 11 feeding experiments with 340 fattening bulls and in 105 N-balance trials with bulls.

In all experiments, exclusive Mh 68 and Mh 69, compounds feeds made up the main part of the ration and consisted of feeds (dried beet pulp) rather than food.

From these experiments it is concluded, that:

1. Protein requirements of fattening bulls appear to be substantially lower than usually recommended.
2. Appropriate effects of NPN supplementation in rations for fattening bulls can be expected only if the basic rations contain a (very) low protein content (about 10% CP in dry matter and lower).

Quite a lot of feeding experiments with NPN addition have been carried out all over the world in which this prerequisite for NPN utilization was not taken into account.

TABLE 1. Fattening Experiments with Young Bulls in Hoorn (H), Maarheeze (Mh) and Vessem (Ve)

Experiment code and year of start	Number of		NPN sources (%)			Number N balances	Breed	Weight range (kg)
	Animals	Groups	Urea	Biuret	BM*			
Mh 68	24	4	+ (2)	-	-	-	MRIJ	100-500
Mh 69	24	4	+ (2)	-	-	-	MRIJ	100-450
Mh 70	24	3	+ (3)	-	-	23	MRIJ	150-450
Mh 71	24	3	+ (3)	-	-	23	MRIJ	150-450
H 71	12	3	-	+ (0.85)	-	-	MRIJ	275-400
H 72	12	4	-	+ (1)	+ (12)	12	MRIJ	275-425
Mh 72	24	4	-	+ (1)	+ (9.6)	23	MRIJ	175-475
H 73	12	4	Protein levels**			24	MRIJ/FH	175-475
Mh 73	24	4	Protein levels**			-	MRIJ/FH	175-475
Ve 73	80	4	Protein levels**			-	MRIJ/FH	175-450
Ve 74	80	4	Protein levels**			-	MRIJ/FH	175-450
	340					105		

*BM = dried poultry manure.
**Protein levels: 5, 6, 7 and 8 g DCP $W^{0.75}$.

TABLE 2. Daily Gain (g), SE ($\frac{SE \times 1000}{100}$) and CP (g) Fed per $W^{0.75}$ in 11 Bull-fattening Experiments in Hoorn, Maarheeze and Vessem

Experiment code	Positive control			Experimental group 1*			Experimental group 2			Negative control		
	D. gain	SE	CP	D. gain	SE	CP	D. gain	SE	CP	D. gain	SE	CP
Mh 68	1150	56	12.3	1080	58	14.5	1060	58	14.0	1050	57	9.8
Mh 69	1070	57	12.6	990	59	15.0	1040	58	13.9	1000	58	10.2
Mh 70	1190	67	13.8	1280	66	16.2	-	-	-	790	54	8.1
Mh 71	1120	66	14.3	1280	67	16.9	-	-	-	1030	62	8.8
H 71	970	52	9.5	1050	53	8.9	-	-	-	690	45	6.4
H 72	1010	59	10.6	1150	57	11.4	1050	55	10.1	990	54	8.2
Mh 72	1110	70	13.0	1190	64	12.3	1050	66	12.5	980	64	10.5
H 73	1120	55	11.2	1070	57	10.6	1080	59	10.6	750	49	6.9
Mh 73	1300	68	13.8	1200	63	11.9	1240	70	11.2	1150	67	10.6
Ve 73	1080	65	13.1	1100	63	11.2	1060	65	10.0	830	58	7.5
Ve 74	1150	62	11.9	1200	64	10.8	1120	65	9.8	930	60	8.3

*In experiments Mh 68 through Mh 72, NPN was added in experimental groups 1, as was done in experiment group 2 in Mh 68 and Mh 69.

TABLE 3. Crude Protein (from Feed) per $W^{0.75}$ in Seven Experiments Applying NPN Supplementation

Experiment code	Positive control	Experiment group 1 (NPN)	Experiment group 2	Negative control
Mh 68	12.3	10.1	9.8	9.8
Mh 69	12.6	10.7	9.6	10.2
Mh 70	13.8	9.2	-	8.1
Mh 71	14.3	9.0	-	8.8
H 71	9.5	7.2	-	6.4
H 72	10.6	-	8.1	8.2
Mh 72	13.0	-	10.4	10.5

TABLE 4. Slaughter Quality and Dissection Data (3 rib-cuts) in 11 Bull-fattening Experiments in Hoorn, Laarheeze and Vessem

Experiment code	Positive control				Negative control			
	Score (meat)	Score (fat)	Meat (%)	Fat (%)	Score (meat)	Score (fat)	Meat (%)	Fat (%)
Mh 68*	8-	8+	-	-	7.5	7+	-	-
Mh 69	4+	2	-	-	4	1+	-	-
Mh 70	3.6	2.6	-	-	3.2	1.8	-	-
Mh 71	4.5	2.7	61.3	20.9	4.2	2.4	61.9	20.1
H 71	3.4	3.2	53.3	28.8	2.9	2.5	54.5	25.0
H 72	3.9	3.0	52.3	30.5	3.6	2.1	54.9	27.3
Mh 72	4.4	3.3	56.0	27.8	4.6	2.7	56.3	24.5
H 73	4.2	2.2	56.2	26.2	2.6	1.4	58.7	24.1
Mh 73	4.2	3.0	53.6	28.9	4.2	2.6	57.4	24.5
Ve 73	4.0	2.8	54.9	27.6	3.6	2.4	56.7	24.6
Ve 74	3.9	3.0	-	-	3.5	2.7	-	-

*Score maximum 10. In all other experiments score maximum is 6.

TABLE 5. CP Intake and N Balance, g per $W^{0.75}$ (average for each experimental group)

Experiment code	Positive control		Experiment group 1		Experiment group 2		Negative control	
	CP intake	CP balance N x 6.25	CP intake	CP balance N x 6.25	CP intake	CP balance N x 6.25	CP intake	CP balance N x 6.25
Mh 70	9.7	1.9	12.1	2.3			5.6	1.5
Mh 71	10.0	2.0	11.4	1.7			7.0	1.9
Mh 72	9.6	2.2	8.8	1.7	9.3	2.0	7.6	2.1
H 72	9.1	2.3	9.0	2.7	9.8	2.0	7.5	2.1
H 73	11.5	2.7	10.7	2.4	9.1	2.2	7.0	2.2

TABLE 6. CP and DCP Requirements Calculated from Fattening Bull Experiments in Hoorn, 1968-1974 (daily live weight gain 1000-1100 g)

Live weight (kg)	$W^{0.75}$	$CP/W^{0.75}$	Requirement (g/day)	
			CP	DCP*
250	62.9	11	690	410
300	72.1	10.25	740	440
350	80.9	9.5	770	460
400	89.4	8.75	780	470
450	97.7	8	780	470

*Assumed dig. coefficient 60.

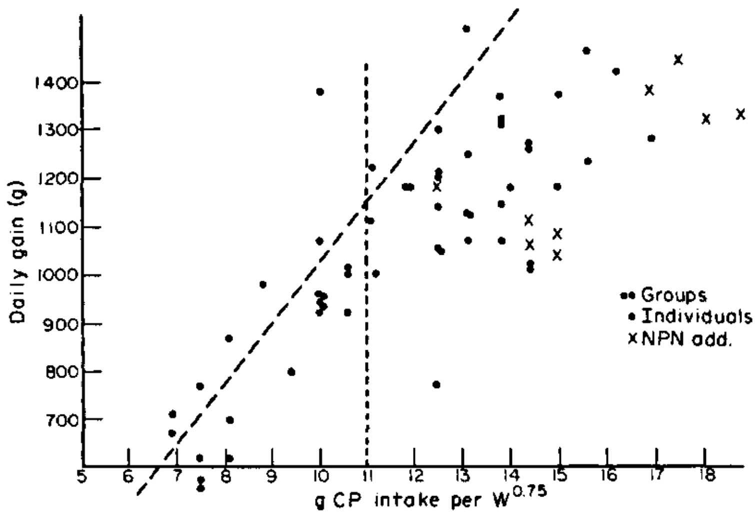

Fig. 1. Protein intake and daily gain: weight range less than 275 kg.

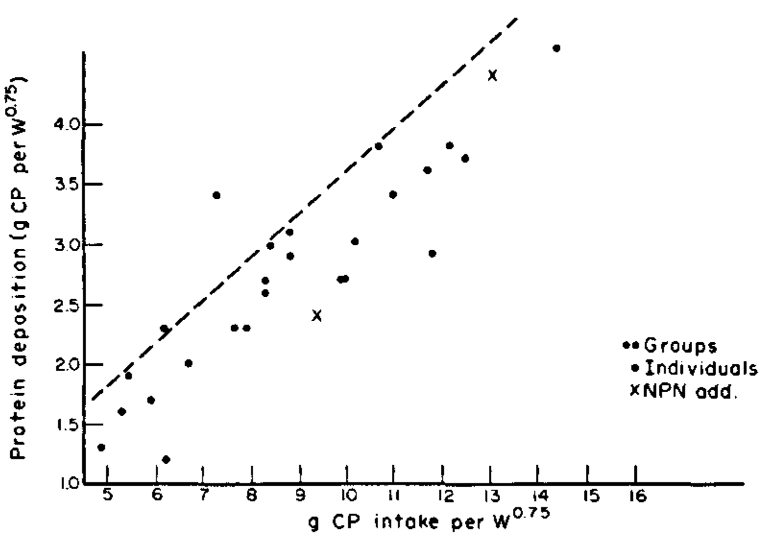

Fig. 2. Protein intake and protein deposition: weight range less than 275 kg.

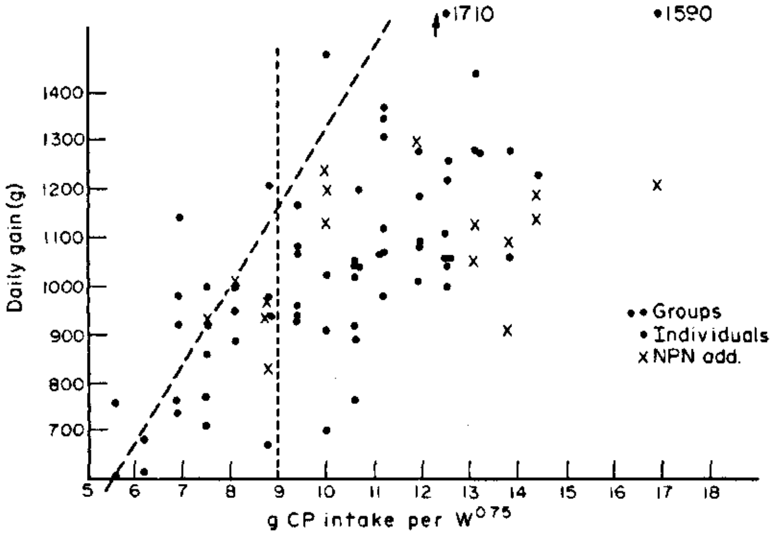

Fig. 3. Protein intake and daily gain: weight range 275-375 kg.

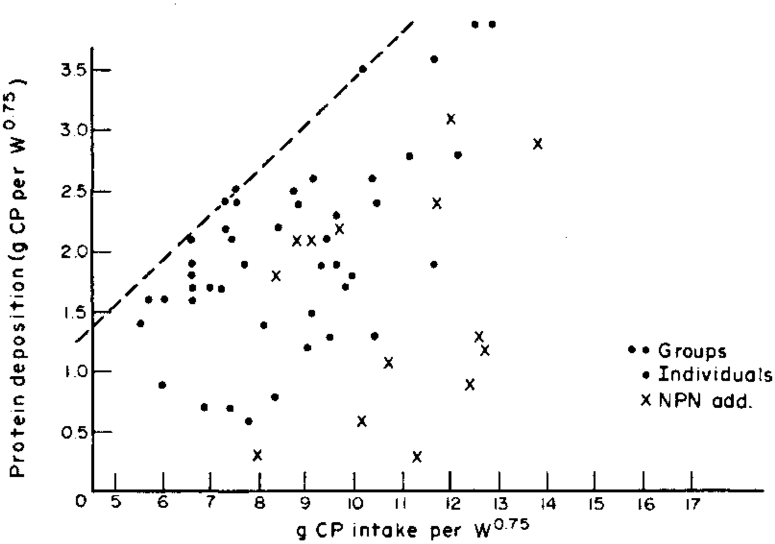

Fig. 4. Protein intake and protein deposition: weight range 275-395 kg.

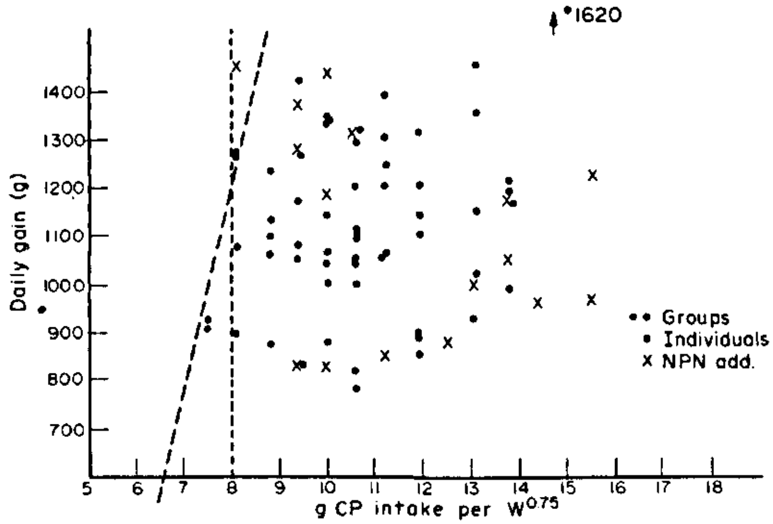

Fig. 5. Protein intake and daily gain: weight range greater than 375 kg.

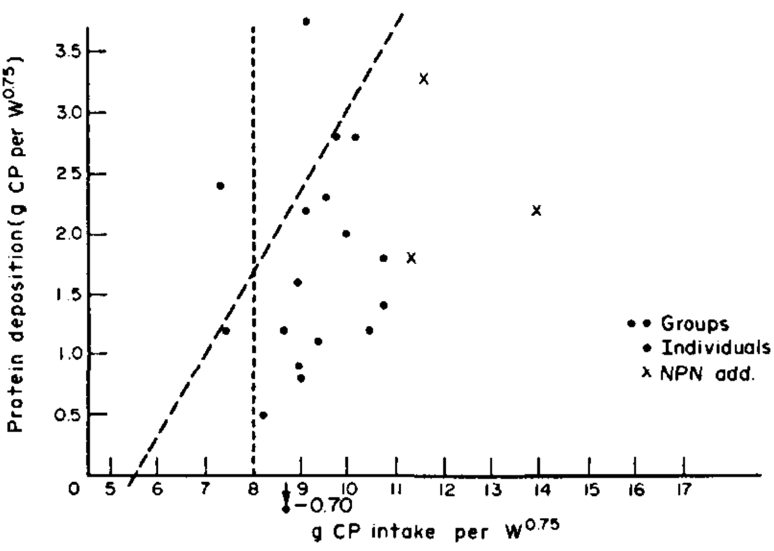

Fig. 6. Protein intake and protein deposition: weight range greater than 375 kg.

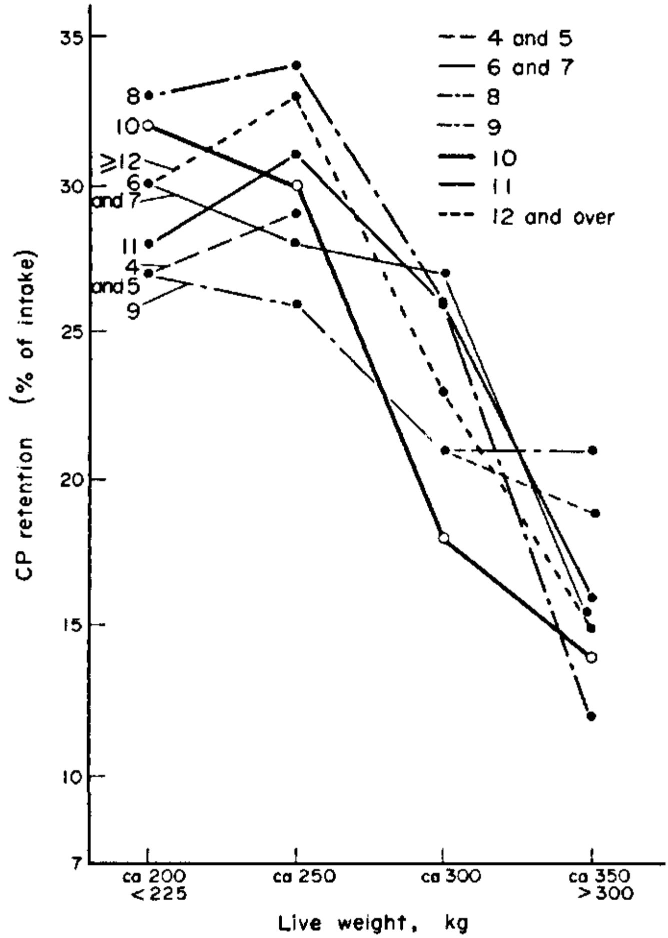

Fig. 7. Live weight and CP retention at variou CP intake levels (g CP per $W^{0.75}$).

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