CCLXXIX. MAINTENANCE NUTRITION IN THE PIGEON. VITAMIN B₅

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CARTER *et al.* [1930, 1, 2] characterized a factor, vitamin B₅, which they claimed to be necessary for maintenance nutrition in the pigeon in addition to vitamins B₁ and B₃. The factor was shown to be present in wheat, yeast and certain yeast extracts such as marmite. It was stable to autoclaving at 115° and to heating with $N/2$ NaOH at 100° for 30 min. in such extracts. The evidence for the existence of vitamin B₅ was based on the observation that large doses of vitamin B₁ administered in the form of a $N/10$ HCl eluate of activated norite charcoal failed to establish weight maintenance. On the other hand, both marmite and an extract obtained by eluting activated norite with 50% acid alcohol (Peters's concentrate) arrested falling weight and induced partial weight restoration. Much evidence as to the nature of the components of the vitamin B complex has accumulated during recent years from several laboratories and certain of the arguments which led Carter *et al.* to distinguish vitamin B₅ from vitamins B₂ and B₃ are now open to criticism. The assumption that the Peters concentrate containing vitamin B₅ was free from vitamin B₂ was based on a rat growth test in which, as can now be recognized, the limiting factor was almost certainly flavin. This is made clear by the more recent evidence of György [1935] and Chick *et al.* [1935]. Thus the relation of vitamin B₅ to the components of the vitamin B₂ complex, particularly vitamin B₆, is still unsettled. The differentiation of vitamin B₅ from vitamin B₃ was originally based on the fact that pigeons depleted on a basal polished rice diet could not be restored to maximum weight even with massive doses of the Peters concentrate. It was inferred that the concentrate contained no significant amounts of vitamin B₃. On the other hand Carter & O'Brien [1935] found that restoration to maximum weight was usually obtained on administration of the Peters concentrate provided that the basal diet was rendered adequate in respect to its protein content and that the preliminary depletion was not carried below 70% of the maximum weight. This evidence indicates that sufficient vitamin B₃ is retained during the depletion period to ensure full weight restoration and/or that the Peters concentrate contains significant amounts of this vitamin. The more recent observation [Carter & O'Brien, 1937] that a small proportion of birds on a basal synthetic diet can be restored to maximum weight by the administration of crystalline vitamin B₁ alone emphasizes the importance of storage of other factors in certain cases. The possibility that vitamin B₃ is present in Peters's concentrate in significant amounts is not excluded by this observation.

The present paper records evidence confirming the original finding of Carter *et al.* of a factor present in addition to vitamin B₁ in the Peters concentrate which is necessary for the pigeon. A more detailed analysis of the components of this concentrate will be reported in a subsequent paper.

METHODS

The procedure was similar to that adopted by us in the study of the influence of vitamin B₃ concentrates on the nutrition of the pigeon [Carter & O'Brien, 1936]. Following the period of depletion on polished rice or a synthetic diet resulting in a decline in weight to about 70% of maximum weight and usually accompanied by symptoms of polyneuritis, the birds were given daily 40γ of crystalline vitamin B₁ until a stationary weight was maintained. The influence of vitamin B₅ has been investigated when supplementing the other pigeon factors. For this purpose three groups of birds on the following supplements have been studied: (a) vitamin B₁ and vitamin B₅; (b) vitamin B₁, flavin and vitamin B₅; (c) vitamin B₁, flavin, vitamin B₃ and vitamin B₅. In group (a), substitution of the vitamin B₅ concentrate (Peters's concentrate) for the crystalline vitamin B₁ was made when stationary weight was attained. In groups (b) and (c), vitamin B₅ was administered after stabilization in weight subsequent to the addition of flavin and of flavin plus vitamin B₃ respectively had occurred.

Since the vitamin B₅ concentrate used in these experiments is rich in vitamin B₁ and contains some vitamin B₆ [O'Brien, 1937], it was not possible to study the effects of vitamin B₅ alone. When substitution of the vitamin B₅ concentrate was made for the crystalline vitamin B₁, it was administered in doses sufficient to maintain the intake of vitamin B₁ constant, i.e. equivalent to 40γ vitamin B₁. In some birds the dose of crystalline vitamin B₁ was increased to as much as 80γ daily prior to substitution of the Peters concentrate to exclude the possibility of lack of vitamin B₁ as a limiting factor. No improvement in response was observed in such cases.

The vitamin B₃ concentrates were prepared from liver in the same manner as was reported in an earlier paper [Carter & O'Brien, 1936].

EXPERIMENTAL

The effect of vitamin B₁ and vitamin B₅

Table I shows the rise in weight of 6 birds following the substitution of the Peters concentrate for the crystalline vitamin B₁. The average total gain in weight amounted to 54 g. representing an average daily gain of 3.0 g. It will be

Table I. *Effect of vitamin B₅ after vitamin B₁*

Bird	Max. wt. g.	Initial wt. g.	Final wt. g.	Gain in wt. g.	Days	Gain in wt. per day g.	Diet*
84	436	355	411	56	24	2.33	R
860	380	310	346	36	28	1.28	R
77	435	367	435	68	18	3.77	R
770	465	384	442	58	32	1.81	R
316	427	379	445	66	9	7.33	S
153	486	423	463	40	21	1.90	S

* R=rice diet; S=synthetic diet [Carter & O'Brien, 1937].

noted that full restoration of maximum weight was only attained in two cases and in these it must be presumed that the storage of vitamin B₃ and flavin made this possible. The need of these other factors for full weight restoration has already been demonstrated [Carter & O'Brien, 1936] and further evidence is detailed below.

The effect of vitamin B₁, flavin and vitamin B₅

Table II records the weight increase of those birds which were given vitamin B₅ after receiving daily 40γ vitamin B₁ and 40–80γ flavin until a constant weight was established. This group showed an average total gain of 70 g.

Table II. *Effect of vitamin B₅ after vitamin B₁ and flavin*

Bird	Max. wt.	Initial wt.	Final wt.	Gain in wt.	Days	Gain in wt. per day	Diet
	g.	g.	g.	g.		g.	
541	444	403	412	9	11	0·81	R
561	456	379	409	30	11	2·72	R
868	350	301	345	44	13	3·38	R
83	413	338	423	85	33	2·57	R
86	432	345	430	85	33	2·57	R
857	419	316	421	105	32	3·28	R
287	405	355	422	67	8	8·37	S
308	415	284	400	116	17	6·82	S
291	395	370	424	54	10	5·40	S
75	435	308	380	72	26	2·77	S
85	490	322	383	61	43	1·41	S
286	390	274	386	112	21	5·33	S

representing an average daily gain of 3·8 g. On comparison with the data for group (a) it may perhaps be concluded that the addition of flavin improved the response to vitamin B₅. Moreover the proportion of the birds in group (b) regaining maximum weight is higher, 7 out of 12. The hypothesis that the response of the birds in groups (a) and (b) is determined by the degree to which the preliminary depletion has exhausted their reserves of flavin and vitamin B₃ can be tested by examining the later history of those birds in these groups which failed to regain maximum weight, or having reached it, failed to maintain it. Table III recording the effects of successive additions of flavin and vitamin B₃ appears to justify this hypothesis.

Table III

Bird	Max. wt.	Final wt. after vit. B ₁ and flavin	Gain in wt.	Days	Final wt. after vit. B ₁ and flavin and vit. B ₅	Gain in wt.	Days	Final wt. after vit. B ₁ and flavin and vits. B ₅ and B ₃	Gain in wt.	Days	Diet
	g.	g.	g.		g.	g.		g.	g.		
75	435	307	30	21	381	74	26	446	65	6	S
85	480	322	18	21	358	36	43	500	142	12	S
308	415	278	— 9	13	396	118	35	431	35	6	S

Bird	Max. wt.	Final wt. after vits. B ₁ and B ₅	Gain in wt.	Days	Final wt. after vits. B ₁ and B ₅ and flavin	Gain in wt.	Days	Final wt. after vits. B ₁ and flavin and vit. B ₃	Gain in wt.	Days	Diet
	g.	g.	g.		g.	g.		g.	g.		
84	436	397	42	37	408	11	13	422	14	6	R
77	435	427	60	45	409	— 18	10	440	31	12	R
770	465	408	23	37	467	59	15	—	—	—	R
860	380	346	36	28	380	34	9	—	—	—	R

In two cases, birds 770 and 860, addition of 40γ flavin daily completely restored maximum weight. In five cases, birds 75, 77, 84, 85, 308, maximum weight was only restored after the addition of vitamin B₃. Two birds failed to respond further even on a whole wheat diet and they must be regarded as exceptional. One bird died during the course of the experiment.

Effect of vitamins B₁, B₃, B₅ and flavin

Group (c) consisted of birds which received the vitamin B₅ concentrate only after successive additions of vitamin B₁, flavin and vitamin B₃ had been made. In the birds under consideration these supplements did not restore maximum weight though they did induce a substantial rise. In consequence a high maintenance level had already been attained at the time when the administration of vitamin B₅ was begun and the resulting rise in weight was correspondingly lower than in groups (a) and (b). Nevertheless the response is definite (Table IV).

Table IV. *Effect of vitamin B₅ after vitamin B₁, flavin and vitamin B₃*

Bird	Max. wt. g.	Initial wt. g.	Final wt. g.	Gain in wt. g.	Days	Gain in wt. per day g.	Diet
986	500	474	500	26	4	6.50	S
766	430	359	442	83	30	2.76	S
47	500	442	500	58	5	11.60	S
87	480	439	450*	11	13	0.84	S

* Not improved on wheat.

SUMMARY

The evidence which is presented confirms the presence in Peters's concentrate in addition to vitamin B₁ of a pigeon factor or factors essential for the restoration of maximum weight after depletion. The presence in this concentrate of significant amounts of vitamin B₃ in addition to vitamins B₁ and B₅, which was foreshadowed in an earlier paper [Carter & O'Brien, 1936], would go far to explain certain points at present obscure. Our results give further support to the view that not less than four distinct factors of the vitamin B complex, namely vitamins B₁, B₃, B₅ and flavin, are essential in pigeon nutrition.

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