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Some factors affecting the levels of the serum calcium and phosphorus of normal rabbits.

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At intervals throughout the past year, with the exception of the summer months, we had occasion to make a considerable number of determinations of the inorganic calcium and phosphorus content of normal rabbits' sera. The results are of interest in that they reveal certain progressive variations due apparently to seasonal changes in the environment, and they also show an effect of caging that should be taken into account.

As received from various dealers, 144 male rabbits showed a blood calcium level of 12.31 mg. per 100 cc. of serum.[1] This general average was obtained, however, from figures that varied considerably for different months of the year, (Table I.) From a low level of 11.74 mg. in January, high levels were reached in May and November of 12.92 and 12.88 mg. Similar variations were found in the blood calcium level of 82 normal rabbits (110 determinations) which had been caged, individually, indoors in a well lighted and ventilated room, and fed hay, oats and cabbage for periods of 1 to 7 weeks. The figures for these rabbits parallel those obtained on admission, but show the blood calcium to be

[1] Method of Kramer, B., and Tisdall, F. F., *J. Biol. Chem.*, 1921, xlvii, 475.

TABLE I.

Month	Calcium*		Phosphorus*	
1924	On Admission	After Caging	On Admission	After Caging
Jan.	11.74 ± 0.11	12.40 ± 0.11	6.35 ± 0.20	6.24 ± 0.62
Feb.	....	13.15 ± 0.18	....	....
March	12.61 ± 0.13	13.32 ± 0.33	7.44 ± 0.69	7.69 ± 0.40
April	12.64 ± 0.16	13.20 ± 0.12	6.97 ± 0.31	6.71 ± 0.21
May	12.92 ± 0.26	13.62 ± 0.12	4.22 ± 0.24	6.60 ± 0.25
June	....	13.53 ± 0.25	....	5.51 ± 0.31
Sept.	12.35 ± 0.08	12.44 ± 0.10	7.03 ± 0.16	7.08 ± 0.44
Oct.	12.42 ± 0.12	12.92 ± 0.23	5.31 ± 0.15	7.45 ± 0.15
Nov.	12.88 ± 0.14	13.47 ± 0.16	5.83 ± 0.15	6.24 ± 0.20
Dec.	12.31 ± 0.17	....	6.26 ± 0.33	....

*In milligrams per 100 cc. blood serum. Probable errors calculated by Peters' formula.

at a uniformly higher level—13.12 mg. per 100 cc. serum—with the January low level at 12.40 mg., and the May and November peaks at 13.62 and 13.47 mg. respectively. We have already noted[2] that the caging of normal rabbits, under conditions that obtain with us, results in a definite rise in the blood calcium. It remains to be seen how the apparent seasonal variations in the blood calcium can be correlated with the changes in the size and functional activity of certain elements in the endocrine system which Drs. Brown, Pearce and Van Allen have observed at the same seasons of the year.[3]

Fifty-five of the normal rabbits were examined on admission and at intervals thereafter up to a period of 7 weeks. In general, the longer the animals were caged, the higher the blood calcium rose, showing an increase from 12.52 mg. to 13.65 mg. per 100 cc. serum during this period (Table II). These animals served as controls for successive groups of rabbits irradiated daily with a quartz mercury arc lamp over corresponding periods of time. The irradiated rabbits showed a similar increase in blood calcium during the first four weeks of exposure—the period of progressive parathyroid hypertrophy under the influence of ultraviolet light.[2] Coincident with the subsequent drop in the size of the parathyroid glands that occurred in those rabbits that were irradiated for five to seven weeks, the five-week group showed a

[2] Grant, J. H. P., and Gates, F. L., *J. Gen. Physiol.*, 1924, vi, 635.

[3] Brown, W. H., Pearce, L., and Van Allen, C. M., PROC. SOC. EXP. BIOL. AND MED., 1924, xxi, 373.

TABLE II.

Days	Calcium*		Phosphorus*	
	Caged	Radiated	Caged	Radiated
0-6	12.52 ± 0.11	12.33 ± 0.05	6.56 ± 0.18	6.20 ± 0.17
7-13	12.56 ± 0.25	12.88 ± 0.18	7.24 ± 0.22	5.83 ± 0.21
14-20	13.25 ± 0.11	12.95 ± 0.20	6.10 ± 0.14	7.21 ± 0.33
21-27	12.93 ± 0.13	13.00 ± 0.13	6.41 ± 0.25	8.19 ± 0.27
28-34	13.31 ± 0.13	12.48 ± 0.09	6.89 ± 0.51	7.29 ± 0.24
35-41	13.40 ± 0.21	12.86 ± 0.21	....	7.23 ± 0.27
42-49	13.65 ± 0.20	13.05 ± 0.12	....	5.74 ± 0.21

*In milligrams per 100 cc. blood serum. Probable errors calculated by Peters' formula.

drop in blood calcium to the level for the whole group on admission. The groups radiated for six or seven weeks gave somewhat higher figures. These observations are in line with our suggestion that, while parathyroid activity is necessary to the maintenance of the calcium level, other independent factors, as yet not understood, determine the upper limit of calcium concentration in the blood.

In the tables we have recorded the observations on inorganic phosphorus[4] in most of the specimens of blood used for the calcium determinations. Hess and Lundagen[5] have observed seasonal variations in the blood phosphorus of infants, with a low level in March. So little is known of the causes and significance of changes in the blood phosphorus level that we present these figures only for record, and without an attempt at interpretation. It may be noted, however, that, in general, between March and December the higher calcium levels were accompanied by lower phosphorus levels in the blood, and *vice versa.* Howland and Kramer[6] have observed that in tetany a rise in calcium may be accompanied by a corresponding fall in phosphorus, so that the product of their concentrations may be actually decreased. On the other hand, the figures in Table II show that in the irradiated rabbits the highest levels of both phosphorus and calcium coincided with the period of most marked parathyroid hypertrophy, and that both elements in the blood fell during the following period when the glands were undergoing regression.

[4] Method of Tisdall, F. F., *J. Biol. Chem.*, 1922, ii, 329.

[5] Hess, A. F., and Lundagen, M. A., *J. Am. Med. Assn.*, 1922, lxxix, 2210.

[6] Howland, J., and Kramer, B., *Monatsch. fr. Kinderheilk.*, 1923, xxv, 279.