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Studies on the Sodium, Chlorine and Iodine Requirements of Young Pheasants and Quail

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Previous studies from this laboratory have dealt with the protein, calcium, phosphorus, vitamin D, manganese, zinc, riboflavin, niacin and choline requirements of pheasants (Scott, et al., '54, '58a, '59). The phosphorus requirements of young Bobwhite quail also have been reported (Scott, et al., '58b).

Although many studies have been made on the effects of various levels of salt in rations for chickens, little has been reported on the sodium and chlorine requirements of this species, and nothing on either salt, sodium or chlorine requirements of young pheasants and quail. Since iodine is usually supplied to practical rations in the form of iodized salt, it was considered desirable to determine not only the sodium and chlorine requirements, but also to determine whether or not the amount of iodized salt needed to supply these requirements would also supply sufficient iodine for normal growth and thyroid development in young pheasants and quail. The results of these experiments are presented in this report.

EXPERIMENTAL

All experiments were conducted at the Ithaca Game Farm of the New York State Conservation Department. Both the pheasants and quail were housed in wire pens with raised wire floors. Each pen was equipped with a thermostatically-controlled electric hover. The basic diet used in all experiments is presented in table 1. According to the A.O.A.C. ('55) method for total chlorides, the diet contained 0.048% of chlorine. Sodium was determined by flame spectrophotometry and was found

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TABLE 1

Sodium, chlorine and iodine deficient pheasant and quail starter diet

Ingredients	pounds/ton
Cornmeal, yellow	800
Corn oil	40
Soybean oil meal, dehulled, 50% protein	770
Corn gluten meal	200
DL-Methionine	2
Brewers' dried yeast	100
Stabilized vitamin A (5,000 I.U./gm)	5
d-α-Tocopheryl acetate[1]	0.5
Vitamin D_3-activated animal sterol (3,000 I.C.U./gm)	1
Dicalcium phosphate	40
Calcium carbonate	40
Manganese sulfate, feed grade	1
	gm/ton
Zinc sulfate	112
Aureomycin·HCl, crystalline	15
Santoquin antioxidant	112
Menadione sodium bisulfite[2]	6
Vitamin B_{12}	0.006
Niacin	40
$Ca(IO_3)_2$[3]	1
Analysis	
Protein, %	29.5
Metabolizable energy, Cal./pound	1331
ME/P	45
Fat, %	4.2
Fiber, %	2.5
Calcium, %	1.44
Phosphorus, %	0.84
Sodium, %	0.025
Chlorine, %	0.048
Iodine, ppm	0.56

[1] Myvamix, 20,000 I.U./pound, Distillation Products Industries, Rochester, New York.

[2] Klotogen F, Abbott.

[3] $Ca(IO_3)_2$ was omitted and 0.25% NaCl added when iodine requirements were determined. Under these conditions, basal diet contained 0.2 ppm of iodine.

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to be present at 0.025% of the basal diet. Iodine determinations were conducted according to a modification of the Elmslie-Caldwell Method as described by the A.O.A.C. The basic diet showed a level of iodine of 0.2 ppm. Feed and water were supplied ad libitum. For the pheasant studies, each experimental lot contained 50 Ringneck pheasant chicks of mixed sex at the start of the experiment. There were 25 quail per lot. All treatments were run in duplicate. The pheasants were distributed among 32 6′ by 6′ pens; the quail treatments were distributed among 24 4′ by 4′ pens.

Pheasants

Sodium and chlorine. Experiment 1. The first experiment was conducted to compare the effects of graded levels of sodium chloride, ranging from 0.25 to 2.0% in the diet of young pheasants to 4 weeks of age. Sodium bicarbonate at 0.36% (sodium equivalent to that in 0.25% sodium chloride) and 0.32% of potassium chloride (chloride equivalent to that in 0.25% sodium chloride) were also fed singly and in combination. The experimental plan and results of experiment 1 are presented in table 2. Exceedingly poor growth was observed in the pheasants receiving the basal diet without any supplemental salt. The results further showed that the basal diet was severely deficient in sodium and somewhat deficient in chlorine. Since the lowest level of salt (0.25%) added to the basal diet produced approximately maximum growth, it is not possible from this experiment to determine the exact sodium chloride requirement of pheasants receiving this diet.

Experiment 2. The second experiment was conducted to determine more precisely the salt requirement, and also to attempt to determine both the sodium and the chlorine requirements. Sodium chloride was fed in graded levels from 0.1 to 0.25%. In an effort to determine the sodium requirement, several lots were fed graded levels of sodium bicarbonate in the presence of 0.32% of potassium chloride. Studies on the chlorine requirement were conducted by feeding graded levels of potassium chloride in the presence of 0.36% of sodium bicarbonate. The experimental outline and results of experiment 2 are presented in table 3.

These results show that when the diet contained sufficient chlorine, the sodium requirement was met by the addition of approximately 0.06% of sodium to this diet. Since the basal diet contained 0.025% sodium, the total sodium requirement of pheasant chicks, under the conditions of this experiment, was approximately 0.085% of the diet. The sodium requirement was met either by the addition of 0.15% of sodium chloride or by the addition of 0.216% of sodium bicarbonate with adequate chlorine supplied in the form of potassium chloride.

When sodium bicarbonate was the only supplement to the diet, pheasant weights were reduced due to a lack of chlorine. The addition of the lowest level of KCl (0.128%) appeared to furnish sufficient chlorine, thereby indicating that the chlorine requirement is no higher than that

TABLE 2

Results of first experiment on sodium and chlorine requirements of pheasants

Treatment	Av. weight, 4 weeks	Mortality
	gm	%
Basal diet (no salt)	87 (85–88)[1]	6
Basal diet + 0.25% salt (NaCl)	193(178–208)	5
Basal diet + 0.50% salt	204(198–209)	7
Basal diet + 1.00% salt	208(203–213)	4
Basal diet + 2.00% salt	206(199–213)	11
Basal diet + 0.36% sodium bicarbonate (Na^+ equivalent to that in 0.25% salt)	176(174–178)	7
Basal diet + 0.32% potassium chloride (Cl^- equivalent to that in 0.25% salt)	104(103–105)	13
Basal diet + 0.36% $NaHCO_3$ + 0.32% KCl	203(201–204)	12

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

TABLE 3

The sodium, chlorine and total salt requirements of pheasants

Treatment	Av. weight, 4 weeks
	gm
Basal diet + 0.1% NaCl	195(189–201)[1]
Basal diet + 0.15% NaCl	226(225–227)
Basal diet + 0.20% NaCl	231(229–232)
Basal diet + 0.25% NaCl	230(225–234)
Basal diet + 0.32% KCl	76(73– 78)
Basal diet + 0.32% KCl + 0.144% $NaHCO_3$ (0.04% Na)	169(166–171)
Basal diet + 0.32% KCl + 0.216% $NaHCO_3$ (0.06% Na)	227(223–231)
Basal diet + 0.32% KCl + 0.288% $NaHCO_3$ (0.08% Na)	225(224–226)
Basal diet + 0.32% KCl + 0.36% $NaHCO_3$ (0.1% Na)	232(228–236)
Basal diet + 0.36% $NaHCO_3$	176(174–178)
Basal diet + 0.36% $NaHCO_3$ + 0.128% KCl (0.066% Cl)	216(208–223)
Basal diet + 0.36% $NaHCO_3$ + 0.192% KCl	224(223–224)

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

obtained when 0.066% of supplementary chlorine was added to this diet. The basal diet contained approximately 0.048% of chlorine. Therefore, the total chlorine requirement of pheasant chicks under these conditions was more than 0.048% but no more than 0.11%. More than 0.11% of chlorine was supplied when the diet was supplemented with 0.15% of sodium chloride, which was the amount needed to meet the sodium requirement. Thus, this level of salt satisfied both the sodium and the chlorine requirements of pheasant chicks receiving this basal diet.

Experiment on salt toxicity. An experiment was conducted to determine the amount of salt which is toxic to pheasants, and also to determine the effects of high levels of salt upon the moisture content of the droppings in pheasants.

The experimental plan and results of this experiment are presented in table 4. These results show that only when the salt content of the diet reached 7.5% was growth markedly depressed and mortality increased. The moisture content of the droppings increased appreciably as the salt content of the diet increased.

TABLE 4

Studies on salt toxicity in pheasants

Salt levels in diet	Average pheasant weight, 4 weeks	Mortality	Moisture content of feces
%	*gm*	%	%
0.25	230(225–235)[1]	4	74
1.0	232(229–234)	5	78
2.0	223(218–227)	3	86
3.0	219(217–220)	6	88
4.0	218(215–221)	5	89
5.0	197(196–197)	7	—
7.5	165(158–171)	23	—

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

Iodine. One experiment was conducted with pheasants to determine the iodine requirement. For this experiment the basal diet presented in table 1 was modified by the omission of the calcium iodate and the addition of 0.25% of NaCl.

Since iodized salt contains 0.007% of iodine and is usually added to poultry rations at a level of 0.25% of the diet, this amount of salt would supply approximately 0.18 mg of iodine per kg of diet (0.18 ppm). In view of this, the experiment on iodine requirements of pheasants was designed so that one lot of pheasants received 0.18 mg of iodine per kg of diet; other lots received levels of iodine above and below this level. The results of the experiment, (table 5) show that iodine supplementation of the basal diet had no effect upon growth of pheasant chicks to 4 weeks of age. On the other hand, the average thyroid weights of the pheasants receiving the basal diet were significantly larger than those of the pheasants receiving iodine supplementation. Among the iodine-supplemented groups, including and above that receiving 0.09 mg of added iodine per kg of diet, the thyroid weight bore no significant relationship to the level of iodine added. Microscopic examination of the thyroids showed practically normal follicle development in all of the pheasants. Measurements of epithelial heights of the

TABLE 5

Studies on the iodine requirement of pheasants

Treatment	Av. pheasant weight, 4 weeks	Thyroids	
		Average weight	Epithelial height
	gm	*mg*	*μ*
Basal diet	217(214–220)[1]	14.7	3.60
Basal diet + 0.0625 mg $Ca(IO_3)_2$/pound (0.045 mg I_2/kg [ppm])	213(212–214)	13.6	3.76
Basal diet + 0.125 mg $Ca(IO_3)_2$/pound (0.09 mg I_2/kg [ppm])	213(210–215)	10.7	3.47
Basal diet + 0.25 mg $Ca(IO_3)_2$/pound (0.18 mg I_2/kg [ppm])	207(203–211)	11.1	3.03
Basal diet + 0.50 mg $Ca(IO_3)_2$/pound (0.36 mg I_2/kg [ppm])	213(211–214)	9.9	3.13
Basal diet + 0.75 mg $Ca(IO_3)_2$/pound (0.45 mg I_2/kg [ppm])	207(207–207)	11.9	3.33

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

TABLE 6

Results of first experiment on sodium and chlorine requirements of quail

Treatment	Av. quail weight, 4 weeks
	gm
Basal diet (no salt)	27.0(26.5–27.6)[1]
Basal diet + 0.25% salt (NaCl)	56.9(56.6–57.2)
Basal diet + 0.50% salt	55.1(53.0–57.2)
Basal diet + 1.00% salt	61.7(58.4–65.0)
Basal diet + 2.00% salt	60.8(60.6–61.0)
Basal diet + 0.36% sodium bicarbonate (Na^+ equivalent to that in 0.25% salt)	49.0(47.3–50.7)
Basal diet + 0.32% potassium chloride (Cl^- equivalent to that in 0.25% salt)	32.0(31.1–32.6)
Basal diet + 0.36% $NaHCO_3$ + 0.32% KCl	58.5(57.2–59.7)

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

thyroids (table 5) showed no consistent relationship between epithelial heights and level of iodine supplementation. Since the basal diet contained 0.20 mg of iodine per kg of diet, it appears that the total iodine requirement of pheasants under the conditions of this experiment was not greater than approximately 0.30 mg of iodine per kg of diet.

Quail

Sodium and chlorine. Experiment 1. The sodium and chlorine requirements of quail were determined by the same procedures used to determine the requirements for pheasants. The experimental plan and results of the first experiment are presented in table 6. These results were very similar to those obtained with the pheasants. The omission of salt or the inclusion of only sodium bicarbonate or only potassium chloride alone resulted in decreased growth of the quail, indicating that the basal diet was deficient in both sodium and chlorine for quail. Furthermore, it appeared that the level of 0.25% of added salt was sufficient to produce near maximum growth in quail receiving this diet.

Experiment 2. The second experiment was conducted to determine more precisely the salt requirements of quail, and also to attempt to deterine both the sodium and chlorine requirements. The experimental outline and results of this experiment are presented in table 7. While

the results with 0.1% of sodium chloride indicated this level to be sufficient for maximum growth, the results obtained when increasing levels of sodium bicarbonate were added to the diet in the presence of 0.32% KCl, indicated that the amount of added sodium needed was approximately 0.06% which is the amount of sodium supplied by 0.15% of sodium chloride. Thus the sodium and the salt requirements of quail appear to parallel very closely those of the pheasants, the total sodium requirement being approximately 0.085% of the diet.

The slight reduction in growth obtained when sodium bicarbonate alone was added to the diet indicated that this diet was slightly deficient in chlorine for quail. The addition of 0.128% of potassium chloride, which supplied 0.066% of chlorine, was sufficient to produce maximum growth, indicating, therefore, that the level of 0.15% of sodium chloride also would supply sufficient chlorine for quail receiving this diet, and that the chlorine requirement of quail is no higher than 0.11% of the diet.

An experiment on salt toxicity in quail. An experiment was conducted to determine the amount of salt which is toxic to quail. The experimental plan and results of the experiment are shown in table 8. These observations also are similar to those obtained with the pheasants and indicate that young quail can tolerate levels of salt up to and including 5% before showing signs of toxicity. A definite decrease in growth and an increase in mortality was caused by 7.5% of salt. Although fecal moisture determinations were not made, it was noted that the droppings showed an increasingly moist consistency as the level of salt was increased.

Iodine requirements of quail. One experiment was conducted on the iodine requirement of quail. The experimental plan and weights of the quail receiving the various iodine levels are shown in table 9. It is apparent from these results that the omission of iodine from the basal diet had

TABLE 7

The sodium, chlorine and total salt requirements of quail

Treatment	Av. weight, 4 weeks
	gm
Basal diet + 0.10% NaCl	54.4(53.8–54.7)[1]
Basal diet + 0.15% NaCl	53.4(52.6–53.7)
Basal diet + 0.20% NaCl	55.1(54.8–55.3)
Basal diet + 0.25% NaCl	55.0(53.2–56.7)
Basal diet + 0.32% KCl	22.8(21.9–23.7)
Basal diet + 0.32% KCl + 0.144% $NaHCO_3$ (0.04% Na)	46.3(44.7–48.0)
Basal diet + 0.32% KCl + 0.216% $NaHCO_3$ (0.06% Na)	55.6(55.0–56.2)
Basal diet + 0.32% KCl + 0.288% $NaHCO_3$ (0.08% Na)	53.7(51.3–56.0)
Basal diet + 0.32% KCl + 0.36% $NaHCO_3$ (0.1% Na)	54.0(53.0–55.0)
Basal diet + 0.36% $NaHCO_3$	49.0(47.3–50.7)
Basal diet + 0.36% $NaHCO_3$ + 0.128% KCl (0.066% Cl)	55.3(55.0–55.6)
Basal diet + 0.36% $NaHCO_3$ + 0.192% KCl	54.1(52.3–56.2)

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

TABLE 8

Studies on salt toxicity in quail

Salt levels in diet	Average quail weight, 4 weeks
	gm
Basal diet (no salt)	24.9(23.2–26.7)[1]
Basal diet + 0.1% NaCl	59.4(58.0–61.3)
Basal diet + 0.15% NaCl	60.8(60.2–61.3)
Basal diet + 2.5% NaCl	59.9(59.7–60.0)
Basal diet + 5.0% NaCl	60.0(57.2–62.7)
Basal diet + 7.5% NaCl	54.2(51.3–57.0)

[1] Figures in parentheses show range of values for the duplicate lots on each treatment.

TABLE 9

Studies on the iodine requirements of quail

Treatment	Average quail weight, 4 weeks	Thyroid weight 4 weeks[1]
	gm	*mg*
Basal diet	62.2(62.1–62.2)[2]	3.16
Basal diet + 0.125 mg $Ca(IO_3)_2$/pound (0.09 mg I_2/kg [ppm])	60.7(59.3–62.0)	2.83
Basal diet + 0.25 mg $Ca(IO_3)_2$/pound (0.18 mg I_2/kg [ppm])	59.8(59.3–60.2)	2.70
Basal diet + 0.50 mg $Ca(IO_3)_2$/pound (0.36 mg I_2/kg [ppm])	60.9(58.7–63.0)	2.80

[1] Thyroid weights average of 6 quail per treatment.
[2] Figures in parentheses show range of values for the duplicate lots on each treatment.

no effect on quail growth. These results also are similar to those obtained with pheasants. Based upon thyroid weights (table 9), it appears that the first level of added iodine produced normal thyroid glands. Therefore, according to these experiments, the iodine requirement of quail also appears to be no greater than 0.3 ppm, which is that supplied by the lowest level of iodine supplementation.

DISCUSSION

Mitchell and Carman ('26) reported that chicks fed a cereal ration containing no added salt showed retarded growth with decreased efficiency of feed utilization. They concluded that the retarded growth was due to a deficiency of sodium rather than of chlorine. These results have been confirmed by Prentice ('33) and Burns et al. ('53). Burns and associates found that the minimum amount of sodium required by chicks was between 0.1 and 0.3% whereas the minimum amount of chlorine required was less than 0.06%. Neither the requirement for sodium nor that for chlorine has been established with any degree of precision.

With the improved methods of flame spectrophotometry it has been possible to determine accurately the sodium content of the basal ration used in the present studies. Therefore, it appears that the sodium requirement of pheasants and quail of 0.085% is precise under the conditions of these experiments.

Under various conditions in previous experimental work, evidence has been obtained from time to time indicating an interrelationship between sodium requirements and potassium levels in the diet. It should be noted, therefore, that the sodium requirements observed here were determined using a practical diet naturally high in potassium. However, one should also note that the sodium requirement obtained upon supplementing the diet with potassium chloride and sodium bicarbonate was approximately the same as that obtained by supplementing the diet with sodium chloride. Thus, the increased potassium level in the presence of potassium chloride did not appear to change the sodium requirement.

The iodine requirement of chicks, according to Patton et al. ('39), Wilgus et al. ('41) and Gassner and Wilgus ('40) was originally estimated to be approximately 1 mg of iodine per kg of diet, for optimum growth and prevention of goiter. These workers observed congenital goiter in baby chicks hatched from hens receiving 0.025 mg of iodine per kg of breeder ration. On the other hand, Godfrey et al. ('53) found the iodine requirement of chicks to be between 0.03 and 0.15 mg per kg of diet. Later, Creek et al. ('54) reported that 0.05 mg of iodine per kg of diet or less failed to support normal growth, while 0.075 mg per kg of diet was sufficient for normal growth. Somewhat higher amounts, however, were considered to be required for completely normal thyroid histology, since slight abnormalities were noted when the level was below 0.3 mg of iodine per kg of diet.

It is possible that some of the discrepant results obtained by these various

workers are due to variations in precision of the various methods of iodine analysis. On the other hand, they may be due to variations in stability and/or availability of the iodine in the iodine supplements used. Griem et al. ('42) showed that tests of a number of samples of iodized salts (presumably containing potassium iodide) showed losses of iodine up to 76%. Calcium iodate[1] was used in the present studies because it is one of the most stable iodine compounds.[2]

SUMMARY

Studies have been presented which indicate that, under practical conditions, the sodium requirement of both pheasants and quail is approximately 0.085%; the chlorine requirement is between 0.048 and 0.11%; and the iodine requirement is no more than 0.3 ppm of diet.

The results of these studies indicate that the sodium and chlorine requirements of both pheasants and quail are satisfied by the addition to a practical ration of 0.15% of sodium chloride. If iodized salt is used, containing 0.007% of iodine, this level of 0.15% of salt also appears to satisfy the iodine requirement of both pheasants and quail.

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[1] Calcium iodate was kindly supplied by Dr. C. D. Looker, International Salt Company, Watkins Glen, New York.

[2] Mallinckrodt Technical Information Unit X-367, code 2404.