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# A Comparison of Methods for Organ-Weight Data Adjustment in Chicks[1]

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*ABSTRACT* An experiment was conducted with 168 Arbor Acre X Peterson unsexed, crossbred broiler chicks to compare methods of expressing organ-weight data and to assess changes in organ weights and physiological parameters as body weight (97 to 791 g) and age (5 to 26 days) increased. Actual wet weight of liver, heart, intestine, spleen, and pancreas and percent bone ash increased ($P<.01$) as age and body weight increased. Tibia length-to-width ratio decreased ($P<.01$) as age and body weight increased. Blood hemoglobin, hematocrit, and plasma protein were not affected ($P>.1$) by age or by body weight. Liver, heart, and intestinal weight decreased ($P<.01$) and spleen weight increased ($P<.01$) as body weight and age increased when these tissue weights were expressed as percent of body weight. Liver weight adjusted for body weight by covariance analysis, however, remained constant; adjusted heart and intestinal weights decreased ($P<.01$), and adjusted spleen weights increased ($P<.01$) with increasing age and body weight. The covariate, body weight, was not significant ($P>.1$) for pancreas weight, tibia length-to-width ratio, and percent bone ash. Except for spleen, adjustment by covariance analysis more effectively reduced variation due to body weight than did expression as percent of body weight. Adjustment for body weight with covariance analysis is a more appropriate method of correcting organ-weight data than is expressing organ weight as percent of body weight.
*(Key words:* chicks, age, body weight, organ weights)

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## INTRODUCTION

Scientists in the areas of nutrition, physiology, toxicology, and related disciplines use varying criteria to evaluate an animal's response to a particular set of conditions or treatments. One of these criteria is organ weight, which is routinely expressed as percent of body weight. This is done in an attempt to correct for differences in body weight among treatments. Often the organ of choice in these studies is the liver, and less frequently, the pancreas. In a preliminary investigation, Southern *et al.* (1984) reported that liver weight of chicks expressed as percent of body weight declined linearly as body weight increased. Similar results were obtained by Leeson and Summers (1980) and by Plavnik and Hurwitz (1982). These results suggest that small chicks have a higher liver weight as percent of body weight than large chicks of equal age regardless of the treatments imposed. Therefore, one might misinterpret liver weight as percent of body weight data in chicks with different body sizes.

The purpose of this investigation was to compare methods of expressing organ-weight data, and to assess changes in organ weights and physiological parameters as body weight and age change.

## MATERIALS AND METHODS

Arbor Acre X Peterson unsexed, crossbred broiler chicks were used in this investigation. They were fed a conventional corn-soybean meal diet (Table 1) from hatching to 4 days posthatching. After an overnight fast, the chicks were inspected for navel infection and fecal pasting, then weighed, wingbanded, and randomly assigned to 14 equal-weight replicates of 12 chicks per replicate. They were maintained on a 24-hr constant light schedule in

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TABLE 1. *Composition of basal diet*[1]

| Ingredient | (%) |
|---|---|
| Corn (8.5% CP) | 47.14 |
| Soybean meal (44% CP) | 42.50 |
| Corn oil | 5.00 |
| Alfalfa meal, dehydrated (17% CP) | 2.00 |
| Defluorinated rock phosphate | 2.10 |
| Oyster shell flour | .40 |
| Sodium chloride | .40 |
| Vitamin premix[2] | .25 |
| DL-Methionine | .15 |
| Manganese sulfate•$H_2O$ (32.5% Mn) | .05 |
| Zinc carbonate | .01 |

[1] Contained the following: crude protein (CP), 23.0%; metabolizable energy, 3033 kcal/kg; lysine, 1.37%; methionine and cystine, .89%; calcium, .99%; total phosphorus, .79%.

[2] Vitamin premix provided per kilogram of diet: vitamin A, 6614 IU; vitamin $D_3$, 1653 IU; vitamin E, 6.6 IU; vitamin $B_{12}$, 11 μg; riboflavin, 6.6 mg; niacin, 33 mg; d-pantothenic acid, 11 mg; choline, 551 mg; menadione sodium bisulfite, 4.4 mg; folic acid, .7 mg; pyridoxine, 1.1 mg; thiamine, 1.1 mg; biotin, 55 μg.

heated, thermostatically-controlled starter batteries (mean temperature of 35 C) with raised wire floors. The chicks were allowed *ad libitum* access to tap water and the basal diet (Table 1), which was formulated to meet or exceed the nutrient requirements of the growing chick (National Research Council, 1977).

At the initiation of the experiment and for every 3 days thereafter for 21 days (eight periods), one chick from each replicate (14 total chicks) was randomly selected, weighed, bled by cardiac puncture, and then killed by cervical dislocation. The blood was analyzed immediately for hematocrit (Cohen, 1967) and hemoglobin content (Crosby *et al.*, 1954). Plasma was analyzed for total protein by the biuret procedure (Layne, 1957). The liver, heart, pancreas, spleen, and intestine (from the junction of the duodenal loop with the ventriculus to the ileal-cecal junction) were quantitatively removed, blotted dry, and weighed. The lumen of the intestine was cleared of digesta and rinsed before weighing. Left tibias were taken from each chick except those killed on Day 0 of the experiment. The diameter and length of the dry, fat-free tibias were determined with calipers. To determine bone ash, the dry, fat-free tibias were dry ashed at 600 C for 24 hr.

The data were analyzed by analysis of variance and analysis of covariance procedures (Steel and Torrie, 1980). Linear and quadratic components of age were determined within each parameter by appropriate orthogonal coefficients. Least squares means of the wet organ weights were adjusted for body weight by covariance analysis with age as the main effect.

## RESULTS AND DISCUSSION

The results of this investigation are presented in Table 2. As expected, age and body weight were highly correlated ($r^2$ = .98). The actual wet weight of the liver, heart, intestine, spleen, and pancreas and percent bone ash increased quadratically ($P<.01$, except intestine, which was $P<.04$) as body weight increased. Tibia length-to-width ratio concomitantly decreased ($P<.01$) quadratically.

Liver weight expressed as percent of body weight declined ($P<.01$) as age and body weight increased, a phenomenon that has been reported previously (Leeson and Summers, 1980; Plavnik and Hurwitz, 1982; Southern *et al.*, 1984). Liver weight adjusted for body weight with covariance analysis, however, remained constant ($P>.1$). Thus, when comparing liver weights among treatments resulting in different body weights, it would appear much more appropriate to adjust liver weight for body weight with covariance analysis than to express the liver weight as percent of body weight. The latter could result in erroneous conclusions; for example, a particular treatment may depress body weight and have no direct effect on liver weight; yet, liver weight as percent of body weight would be observed to increase.

Heart and intestinal weight expressed as percent of body weight both declined ($P<.01$) with increasing age. In contrast to the liver, however, heart and intestinal weight adjusted for body weight with covariance analysis decreased ($P<.01$). with age. The fact that adjustment for body weight did not remove the tendency for heart and intestinal weights to decrease with age indicates that the development and growth of these two organs is somewhat dependent on age regardless of body weight. The heart and intestine appear to increase in size with age at a slower rate than body weight, whereas liver and body weight increase in size in approximately equal proportions, within the weight ranges of chicks used in this investigation.

TABLE 2. *Organ weights of chicks as percent of body weight or corrected for body weight with covariance analysis*[1]

| Age | Body weight | Liver[2,3] | | | Heart[2,3] | | | Intestine[2,3] | | | Spleen[2,3] | | | Pancreas[2] | | | Tibia[2] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | WT | PBW | AWT | WT | PBW | AWT | WT | PBW | AWT | WT | PBW | AWT | WT | PBW | AWT | L:W | Ash |
| (days) | (g) | (g) | (%) | (g) | (g) | (%) | (g) | (g) | (%) | (g) | (g) | (%) | (g) | (g) | (%) | (g) | (mm/mm) | (%) |
| 5 | 97 ± 1.9 | 4.09 | 4.23 | 12.15 | .63 | .66 | 2.33 | 4.98 | 5.15 | 15.49 | .08 | .08 | .29 | .45 | .46 | .67 | ... | ... |
| 8 | 144 ± 2.1 | 6.03 | 4.19 | 12.79 | .92 | .64 | 2.33 | 7.31 | 5.08 | 16.13 | .14 | .09 | .31 | .77 | .53 | .96 | 13.2 | 49.4 |
| 11 | 215 ± 5.7 | 7.73 | 3.61 | 12.54 | 1.30 | .60 | 2.31 | 9.42 | 4.39 | 15.69 | .17 | .08 | .30 | .90 | .42 | 1.04 | 12.4 | 50.4 |
| 14 | 295 ± 7.4 | 8.91 | 3.02 | 11.51 | 1.69 | .58 | 2.24 | 11.39 | 3.86 | 14.77 | .27 | .09 | .33 | 1.11 | .38 | 1.19 | 11.8 | 51.0 |
| 17 | 397 ± 9.0 | 11.14 | 2.80 | 10.93 | 2.30 | .58 | 2.25 | 13.26 | 3.33 | 12.99 | .38 | .10 | .37 | 1.43 | .36 | 1.43 | 11.5 | 51.8 |
| 20 | 522 ± 8.9 | 14.99 | 2.87 | 11.35 | 2.83 | .54 | 2.06 | 17.60 | 3.37 | 12.85 | .52 | .10 | .42 | 1.79 | .34 | 1.69 | 11.6 | 51.5 |
| 23 | 656 ± 17.1 | 18.03 | 2.75 | 10.70 | 3.75 | .57 | 2.21 | 19.55 | 2.97 | 10.00 | .77 | .12 | .58 | 2.17 | .33 | 1.96 | 11.5 | 52.0 |
| 26 | 791 ± 13.4 | 20.38 | 2.58 | 9.33 | 4.00 | .50 | 1.68 | 22.78 | 2.88 | 8.38 | .93 | .12 | .64 | 2.45 | .31 | 2.15 | 11.8 | 51.3 |
| CV[4] | | 15.41 | 13.19 | 12.84 | 13.14 | 10.28 | 9.15 | 17.37 | 14.66 | 14.52 | 28.98 | 24.99 | 28.39 | 14.89 | 15.25 | 14.83 | 7.11 | 3.10 |
| Pooled SEM | | .47 | .11 | .39 | .08 | .02 | .05 | .62 | .15 | .52 | .03 | .01 | .03 | .06 | .02 | .05 | .23 | .42 |
| Age linear[5] | | .01 | .01 | NS | .01 | .01 | NS | .01 | .01 | .05 | .01 | .01 | NS | .01 | .01 | .01 | .01 | .01 |
| Age quadratic[5] | | .01 | .01 | NS | .01 | NS | .01 | .04 | .01 | .01 | .01 | NS | .01 | .01 | NS | NS | .01 | .01 |

[1] Data are means of 14 unsexed chicks.

[2] WT = Actual wet weight of organ; PBW = organ weight expressed as percent of body weight; AWT = organ weights adjusted for body weight with covariance analysis; L:W = tibia length-to-width ratio; ash = percent bone ash of dry, fat-free tibia.

[3] The covariate body weight was significant ($P<.02$) in the covariance analysis of organ weights adjusted for body weight.

[4] CV = Coefficient of variation, $(s/\bar{X}) \times 100$.

[5] Probability of a larger F value. NS = Not significant ($P>.10$).

Spleen weight responded differently from liver, heart, or intestine in that actual spleen weight, spleen weight as percent of body weight, and spleen weight adjusted for body weight all increased ($P<.01$) with age. As with heart and intestine, the data suggest that the development of the spleen is somewhat, but not entirely, dependent on age, regardless of body size. Unlike the heart and intestine, however, the spleen apparently increases in size at a faster rate than body size.

Pancreas weight expressed as percent of body weight declined linearly ($P<.01$) with increasing age. The covariate, body weight, was not significant ($P>.1$) in the covariance analysis. Therefore, little change resulted from adjusting the actual wet pancreas weight values for body weight with covariance analysis as shown in Table 2. Also, the covariate, body weight, was not significant ($P>.1$) for tibia length-to-width ratio and percent bone ash.

Blood hemoglobin and hematocrit values and total plasma protein were not affected ($P>.1$) by age or by the covariate body weight. Mean values for these parameters over all ages were 8.59 ± .19 g/100 ml, 28.2 ± .8%, and 3.23 ± .08 g/100 ml, respectively.

Covariance analysis was more effective in reducing variation due to body weight than was expression as percent of body weight. This was particularly evident in the liver data where adjustment with covariance analysis totally eliminated the tendency for adjusted liver weight to decrease with age and body weight. Additionally, with the exception of the spleen data, coefficients of variation were comparatively smaller in organ-weight data adjusted for body weight with covariance analysis than in organ-weight data expressed as percent of body weight.

The results of this investigation indicate that expression of organ weights as percent of body weight may lead to erroneous conclusions and that correction of organ weights for body weight by covariance analysis may be a more appropriate method.

## REFERENCES

Cohen, R. R., 1967. Anticoagulation, centrifugation time and sample replicate number in the microhematocrit method for avian blood. Poultry Sci. 46:214–218.

Crosby, W. H., J. I. Munn, and F. W. Furth, 1954. Standardizing a method for clinical hemoglobinometry. US Armed Forces Med. J. 5:693–703.

Layne, L., 1957. Spectrophotometric and turbidimetric methods for measuring proteins. III. Biuret method Pages 450–451 *in* Methods in Enzymology. Vol. III. S. P. Colowick and N. O. Kaplan, ed.

Leeson, S., and J. D. Summers, 1980. Production and carcass characteristics of the broiler chicken. Poultry Sci. 59:786–798.

National Research Council, 1977. Nutrient Requirements of Poultry No. 1. Nutrient Requirements of Domestic Animals. 7th ed. Natl. Acad. Sci., Washington, DC.

Plavnik, I., and S. Hurwitz, 1982. Organ weights and body composition in chickens as related to the energy and amino acid requirements: Effects of strain, sex and age. Poultry Sci. 62:152–163.

Southern, L. L., D. H. Baker, and D. D. Schmeisser, 1984. *Eimeria acervulina* infection during aflatoxicosis in the chick. Nutr. Rep. Int. 29:35–45.

Steel, R.G.D., and J. H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2nd ed. McGraw-Hill Book Co., Inc., New York, NY.