SOME COMPARATIVE ASPECTS OF ORGAN WEIGHTS IN CANADA GEESE (*BRANTA CANADENSIS INTERIOR*)[1]

HAROLD C. HANSON
Illinois State Natural History Survey, Urbana

Physiological studies of the Canada geese wintering at Horseshoe Lake, Alexander County, Illinois, were initiated in 1954 with a study of organ weights. A series of papers on condition factors (in press), blood chemistry, tissue chemistry, the endocrine organs, nasal glands, and histology of the long bones of the leg are currently under preparation. For background information on the population of geese under discussion, the reader is referred to Hanson and Smith (1950).

Materials and Methods

Organ weights were obtained from 142 geese. The majority of the organs weighed were from geese shot by hunters between dawn and 10.00 A.M. during November and early December.

Prior to weighing the heart, all major blood vessels were excised as completely as possible, and the chambers were cut open and all blood was removed. Spleens were merely freed of excess fascia. The proventriculus was left attached to the gizzard because its function is so intimately related to that of the gizzard and because the juncture of the proventriculus with the esophagus provided a clear-cut margin that could be consistently followed in dissection. All excess fascia and fat attached to the exterior of these organs were removed. They were cut open, rinsed clean of contents, and then excess water was removed by blotting with absorbent paper. Before weighing the liver, the gall bladder was removed, as well as all clotted blood present in the exposed sections of the major veins. The lobes of the pancreas were stripped from the intestine and freed of fat. All weighings were made to one-tenth gram on a triple-beam balance. Age and sex classes of geese were distinguished according to criteria previously presented by Hanson (1949). Immature geese were 5-8 months old, yearlings 17-20 months, and adults 29 or more months of age at the time collections were made. Dr. Horace W. Norton of the College of Agriculture, University of Illinois was consulted on the statistical analyses.

Results

Heart Weights. Weights were obtained of hearts of 142 Canada geese at Horseshoe Lake in late autumn (Table 1). In both sexes a significant absolute increase in heart weight with age is indicated but, as body weight is also higher for each successive age class, there does not appear to be a significant increase in heart weight relative to body weight of age classes except in males

[1] Based on part of a thesis submitted for the Ph.D. degree at the University of Illinois, 1958.

(Table 1). In respect to the correlation of heart weight with body weight, the age-sex class samples proved to be homogeneous; the pooled correlation coefficient was .65 ($P = <.01$). The correlation of heart weight with body weight in each sex-age class was found to be highly significant. Coefficients of variation for heart weights were also the lowest recorded for the five visceral organs studied.

Quiring and Bade (1943) also found the highest correlation of heart-body weight of any organ studied in the house sparrow (*Passer domesticus*). Marsden (1940) found a similarly high correlation for domestic turkeys. Latimer (1927), studying the turkey hen, also found heart weights to have the highest correlation with body weight of the visceral organs. Souba's (1923) data showed a slightly higher correlation of liver weight to body weight than heart weight to body weight in 100 white leghorn cockerels.

The heart weight of the Canada geese studied averaged 0.90 to 0.94 per cent of average body weight. In chickens, heart weight was 0.55 per cent of body weight; in turkeys, 0.53 per cent (Latimer and Rosenbaum, 1926). In white Pekin ducks, heart weight was 0.64 to 0.66 per cent of the body weight (Salgues, 1939). Sixteen passerine species studied by Rensch (1948) had hearts that averaged 0.82 per cent of body weight. Presumably the relatively small heart of domestic chickens, turkeys, and ducks reflects artificial selection and/or their sedentary existence.

Hartman (1955) has reviewed heart weight studies in wild birds and presented much new data for a wide variety of birds. Heart weights varied from 0.2 to 2.4 per cent of body weight. Wide variation was found in the same families of birds. No significant differences were found to be present between age-sex classes, but activity was believed to have an important influence on heart size between species. Mitchell, *et al.* (1926) reported that heart weights in white plymouth rock chickens were higher in cockerels than in both pullets and capons, a difference they attributed to the greater muscular activity of the cockerels. However, it is more likely that these differences, as in the case of pectoral muscles in Canada geese, can be attributed to the nitrogen-conserving effect of the male sex hormones (Hanson, 1961). The relative weight of the heart in Canada geese does not change significantly with age in females despite repeated migrations, but consistently is relatively greater in the older age classes of males than in immatures (Table 1).

Heart weights of white leghorn chickens were also greater relative to body weight in cockerels than in pullets (Mitchell, *et al.*, 1931). Riddle (1947) reported that male ringdoves (*Streptopelia decaocto*) have a slightly larger heart than females, but failed to find a sex difference in the domestic pigeon. Kirkpatrick (1944) found that in both sexes of the ring-necked pheasant (*Phasianus colchicus*) the weight of the heart increased with age.

Smith (1928) concluded that in humans the relative weight of the heart does not increase with age,

TABLE 1.—Heart weights and their relation to body weights in Canada geese at Horseshoe Lake, Illinois in late autumn.

Age and sex	Number	Average weight (grams)	Range (grams)	Per cent of body weight	Standard deviation	Coefficient of variation
Immature male	43	30.0 ± 0.6	22.2-43.0	0.90	4.2 ± 0.5	14.0 ± 1.5
Yearling male	14	36.3 ± 1.2	28.8-43.3	0.94	4.5 ± 0.8	12.4 ± 2.3
Adult male	18	38.2 ± 1.0	32.3-47.7	0.94	4.2 ± 0.7	11.0 ± 1.8
Immature female	34	27.5 ± 0.8	19.2-36.5	0.94	4.4 ± 0.5	16.0 ± 2.0
Yearling female	10	28.4 ± 1.1	23.8-34.8	0.92	3.6 ± 0.4	12.7 ± 1.3
Adult female	23	31.3 ± 0.9	24.6-44.0	0.93	4.3 ± 0.6	13.7 ± 2.0

TABLE 2.—Spleen weights and their relation to body weights in Canada geese at Horseshoe Lake, Illinois in late autumn.

Age and sex	Number	Average weight (grams)	Range (grams)	Per cent of body weight	Standard deviation	Coefficient of variation	Coefficient of correlation
Immature male	43	2.6 ± 0.2	1.1-4.9	0.078	1.1 ± 0.1	38.5 ± 4.1	+0.40
Yearling male	13	2.1 ± 0.2	0.9-3.1	0.054	0.6 ± 0.01	28.6 ± 5.6	+0.14
Adult male	16	2.2 ± 0.3	0.7-5.5	0.054	1.2 ± 0.2	54.5 ± 0.6	+0.49
Immature female	35	2.3 ± 0.1	1.2-4.1	0.078	0.8 ± 0.1	34.8 ± 4.1	+0.05
Yearling female	9	1.7 ± 0.2	0.8-3.1	0.054	0.6 ± 0.1	35.3 ± 8.4	+0.72
Adult female	21	1.1 ± 0.1	0.5-2.6	0.033	0.5 ± 0.1	45.5 ± 7.0	+0.04

irrespective of the weight of the body. The weight of the human heart does, however, increase with increases in weight of the body. In males, the heart is 0.43 per cent of the body weight; in females, 0.40 per cent of the body weight. This latter difference might also be attributable to the differential effect of the sex hormones.

Spleen Weights. The spleens of 137 Canada geese were weighed (Table 2). The spleen in Canada geese tends to decrease in size with age. In immatures and yearlings there is no difference between sexes in the relative size of the spleen; in the adult age class, the males have a markedly larger spleen, both absolutely and relatively. The differentially larger spleens in adult males may reflect an accommodation to the vascular requirements of the more highly developed musculature system of this age-sex class. While size of spleen is not directly related to the red cell count of the blood and hemoglobin level, it is interesting to note that the sex differential in size of the spleen in the adults also corresponds with higher hematocrit and hemoglobin values found for adult males (Hanson, 1958). Harmon, *et al.* (1932) have demonstrated that the spleen of birds apparently can function as a blood reservoir.

The weight of the spleen is extremely variable in Canada geese (Table 2). In nearly all studies of organ weights in chickens and turkeys, the spleen was reported to be the most variable in weight of the visceral organs. Because of the blood reservoir function of the spleen, the variability of spleen weight in Canada geese may reflect the circumstance of death rather than an extreme variability in the mass of the organ tissue *per se*. Geese killed instantaneously may be expected to have a spleen containing more blood than one shot in such a way that its death was in large measure due to loss of blood—whether bleeding occurred internally or externally. Spleen weight in Canada geese tended to be significantly correlated with body weight in males (immatures, $P = .01$; adults, $P = .1 - .05$); in females no significant correlation was found.

Mitchell, *et al.* (1926, p. 126) reported a sex differential in the relative weight of the spleen of white plymouth rock chickens reverse to that found in Canada geese: "The weights of spleen were consistently heavier for pullets than for cockerels." A similar relationship is not evident in their data for white leghorn chickens (Mitchell, *et al.*, 1931).

A highly significant increase in the weight of the spleen in male ring-necked pheasants from 87 to 172 days of age was observed by Kirkpatrick (1944). Spleen weights in captive ringdoves are three times as large in spring and summer as in winter and autumn and the spleens of males are larger than those of females (Riddle, 1929). Opposite seasonal trends in the size of the spleen in ring-necked pheasants have been reported by Kirkpatrick (1944). Male white-crowned sparrows (*Zonotrichia leucophrys gambelii*) have spleens that average larger, absolutely and relatively, than those of the females (Oakeson, 1953). Males of this subspecies attained their lowest average spleen weights in May upon their arrival

TABLE 3.—Combined weight of proventriculus and gizzard and its relation to body weight in Canada geese at Horseshoe Lake, Illinois in late autumn.

Age and sex	Number	Average weight (grams)	Range (grams)	Per cent of body weight	Standard deviation	Coefficient of variation	Coefficient of correlation
Immature male	38	142.5 ± 3.7	114.7-184.5	4.3	22.7 ± 2.6	15.9 ± 1.8	—0.12
Yearling male	9	157.5 ± 5.6	137.0-166.8	4.1	16.8 ± 4.0	10.7 ± 2.5	+0.33
Adult male	7	157.5 ± 11.7	122.1-218.2	4.1	30.5 ± 8.2	19.4 ± 5.2	+0.47
Immature female	28	127.7 ± 2.4	106.0-157.2	4.4	12.9 ± 1.7	10.1 ± 1.3	+0.16
Yearling female	8	144.2 ± 5.9	122.4-163.0	4.7	16.4 ± 4.1	11.4 ± 2.9	—0.06
Adult female	13	140.4 ± 3.3	116.2-157.9	4.4	11.9 ± 2.3	8.5 ± 1.7	+0.49

TABLE 4.—Liver weights and their relation to body weights in Canada geese at Horseshoe Lake, Illinois in late autumn.

Age and sex	Number	Average weight (grams)	Range (grams)	Per cent of body weight	Standard deviation	Coefficient of variation	Coefficient of correlation
Immature male	44	57.8 ± 1.3	40.0- 80.5	1.73	8.9 ± 0.9	15.4 ± 1.6	+0.24
Yearling male	13	55.3 ± 1.7	41.0- 68.8	1.43	6.2 ± 1.2	11.2 ± 2.2	+0.52
Adult male	12	68.0 ± 6.7	50.7- 88.4	1.66	23.5 ± 4.8	34.6 ± 7.1	+0.84
Immature female	37	52.8 ± 1.9	33.0- 89.1	1.79	11.6 ± 1.3	22.0 ± 2.6	+0.29
Yearling female	10	44.7 ± 2.5	25.8-101.1	1.45	8.1 ± 1.8	18.1 ± 4.0	+0.08
Adult female	17	52.5 ± 5.7	36.9-135.7	1.57	23.2 ± 4.0	44.2 ± 7.6	+0.78

in Alaska (Oakeson, 1953). A comparable seasonal trend in spleen weights for a non-migratory race of the white-crowned sparrow (*Zonotrichia leucophrys nuttalli*) was also reported by Oakeson (1956).

Weights of Proventriculus and Gizzard. The weights of gizzards with the proventriculus attached were obtained from 103 Canada geese (Table 3). Second to the heart, the combined weight of these organs was the least variable of those studied. The correlation of the weights of these organs to body weight tended to increase with age, but only in adult females did relationships approach the significant level ($P = .1$).

As the proventriculus accounts for a relatively small per cent of the combined weight of this organ and the gizzard in Canada geese, it is evident from their combined relative size, 4.1 to 4.7 per cent of the body weight, that the gizzard in this species is large. These data suggest that the Canada goose is adapted to feeding on relatively coarse, indigestible foods as well as tender stems and leaves of grasses, sedges, and domestic forage crops. For example, prior to the establishment of the Horseshoe Lake Refuge, the Canada geese which then wintered along the Mississippi River utilized the bark and cambium of the willow shoots growing on the river bars. When food is not readily available on the Horseshoe Lake Refuge, the geese will enter woodlands and eat acorns. In northern Ontario in early spring while there is still a deep snow cover and little food available, the furry catkins of willows are sometimes taken.

Latimer and Rosenbaum (1926) found the gizzard to be the least variable ($V = 6.35$) of the visceral organs of the hen turkey. In turkeys, the gizzard forms 2.4 per cent of the body weight; in chickens, the gizzard forms 2.1 per cent (Latimer and Rosenbaum, 1926). Mitchell *et al.* (1926, p. 109) have stated regarding white leghorn chickens that "the females consistently exceeded the males in weights of gizzard," a finding which the present data on Canada geese support. The gizzard of the starling (*Sturnus vulgaris*) averages 2.79 and 2.97 per cent of the body weight for males and females respectively (Stegman, 1954).

Liver Weights. Liver weights were obtained for 133 Canada geese (Table 4). In autumn, the liver averages higher in absolute weight in males than in females, but when compared on the basis of body weight there were no significant differences. In both sexes, the relative weight of the liver in immatures was markedly higher than in the older age classes, but in both sexes it was relatively greater in adults than in yearlings. However, in adults, the liver is notably more variable in size than in the younger age classes. The best estimates that could be made of the correlation of liver weight to body weight (data pooled by the method of least squares, using the z transformation) were .12 for immatures, .51 for yearlings and .77 for adults, no difference between the sexes being found. While the significance of the values for immatures is nil, the correlation coefficient increases with age and in the adults the values are highly significant

($P = .01$). These comparisons between age-sex classes are considered valid because nearly all of the geese studied were shot by hunters in the morning before the geese had much opportunity to feed. Liver weights of Canada geese at other times of the year will be reported by Hanson (1961, in press).

Marsden (1940) found no significant correlation of liver weight to body weight in a sample of ten turkeys studied. The livers of 12 bronzed turkey hens studied by Latimer and Rosenbaum (1926) composed 2.25 per cent of the body weight as compared with 2.40 per cent for chickens. The coefficient of variability for liver weight in these turkeys was 29.5.

A highly significant correlation of liver weight to body weight in white leghorn cockerels was reported by Souba (1923). Mitchell, *et al.* (1931) found that in white leghorn cockerels between 0.5 and 5.0 pounds, the liver decreased from 3.36 to 2.15 per cent of body weight with increasing body weight. In pullets between 0.5 to 4.0 pounds, the relative weight of the liver decreased from 2.98 to 1.89 per cent of body weight. Between the weights of 0.5 and 7.0 pounds, the livers of cockerel plymouth rock chickens decreased from 3.7 to 1.3 per cent of body weight with increasing body weight; in pullets weighing from 2 to 5 pounds, the liver decreased from 2.5 to 1.9 per cent of body weight (Mitchell, *et al.*, 1926).

Mitchell, *et al.* (1931, p. 107) have stated that "Beyond the 1.5 pound weight, white leghorn pullets possessed a larger average weight of digestive apparatus, both absolute and relative, than the cockerels." They found a decrease in the weight of the viscera with age, particularly in the younger age groups, noting (p. 136) that "The cockerels were clearly distinguished from the pullets by a more rapid decrease in the percentage weight of the digestive tract." The data presented in this paper for the visceral organ weights of Canada geese reflect these same general trends.

It is generally recognized that small animals have proportionately larger organs than large animals (Rensch, 1948). The heart weight of geese appears to be exceptional in this respect, but liver weights are consistent with the rule. Most of the 46 species of small birds (largely passerines) studied by Rensch (1948) had livers that ranged from 3 to 5 per cent of body weight. A single swan (*Cygnus olor*) studied had a liver weight equal to 1.85 per cent of body weight. Liver weights constituted 2.7 to 2.9 per cent of body weight of Pekin ducks (Salgues, 1939) and 5.01 to 5.02 per cent of body weight of the European starling (Stegman, 1954).

The liver weights of migratory white-crowned sparrows (*Zonotrichia leucophrys gambelii*) increased from November through April, highest and lowest values coinciding with the beginning and ending of migration (Oakeson, 1953). The pattern of liver weight change in the nonmigratory race (*Zonotrichia leucophrys nuttalli*) was essentially the same as in the migratory race (Oakeson, 1956). Female ringdoves 15 to 18 months of age have a significantly larger liver than males, and both sexes show an increase of liver

TABLE 5.—Pancreas weights and their relation to body weights in Canada geese at Horseshoe Lake, Illinois in late autumn.

Age and sex	Number	Average weight (grams)	Range grams)	Per cent of body weight	Standard deviation	Coefficient of variation	Coefficient of correlation
Immature male	42	12.8 ± 0.5	6.4-21.6	0.39	3.6 ± 0.4	28.0 ± 3.1	—0.10
Yearling male	10	11.6 ± 0.9	6.4-15.6	0.30	2.7 ± 0.6	23.6 ± 5.3	+0.49
Adult male	12	10.9 ± 0.6	7.4-14.0	0.27	2.1 ± 0.4	19.3 ± 3.9	—0.55
Immature female	34	12.1 ± 0.7	5.8-26.6	0.41	4.3 ± 0.5	35.3 ± 4.3	+0.16
Yearling female	9	10.5 ± 0.7	6.2-13.9	0.34	2.2 ± 0.5	21.0 ± 5.0	+0.04
Adult female	12	10.0 ± 0.7	6.0-17.2	0.32	2.5 ± 0.5	25.3 ± 0.5	—0.10

weights in summer (10.4 per cent in males, 6.1 per cent in females) over winter weights (Riddle, 1928). In a later study, Riddle (1947, p. 122) stated that "In both ring doves and pigeons the livers of females are relatively (usually also absolutely in doves) heavier than those of males. In data from doves this excess averaged 10-14 per cent; in pigeons it was somewhat smaller and more variable."

Pancreas Weights. The weights of the pancreases of 119 Canada geese were obtained (Table 5). The data indicate that pancreas weight declines slightly with age, both absolutely and relatively, and that relatively, the females have a slightly larger pancreas than males. However, no significant correlation between pancreas weight and body weight was found within any age-sex class.

The pancreas is a highly variable organ in birds, being second only to the spleen in this respect. Studies of pancreas weight in chickens by Oakberg (1949) and in turkeys by Latimer (1927) and Marsden (1940) showed no significant correlation between pancreas weight and body weight. However, Souba's (1923) data on 100 white leghorn cockerels indicate a highly significant correlation between pancreas weight and body weight. Perhaps this may be explained by the sample being highly uniform in age and uniformity of the experimental conditions. According to Salgues (1939), the pancreas of Pekin ducks constitutes 0.22 per cent of the total body weight in males and 0.26 per cent in females, values that are considerably lower than for Canada geese. Latimer and Rosenbaum (1926) give 0.15 and 0.20 as values for the turkey hen and chicken respectively. Values for the white plymouth rock and white leghorn chickens given by Mitchell, *et al.* (1926, 1931) are similar to those for the Pekin duck.

Summary

Heart weight was the least variable of the visceral organs of Canada geese and showed the highest correlation with body weight. The spleen was the most variable of the five organs weighed. In respect to body weight, the weight of the spleen of adult males was markedly greater than that of adult females. The proventriculus and gizzard, particularly the latter, were found to be remarkably large in Canada geese, constituting 4.1 to 4.7 per cent of body weight. Liver weights averaged between 1.43 and 1.79 per cent of body weight, values for immatures being highest and those for yearlings lowest of the three age classes. No correlation between liver weight and body weight was found for immatures; in adults the correlation was highly significant. The weight of the pancreas was highly variable and showed no significant correlation with body weight. In most respects, organ weight relationships in Canada geese showed good agreement with findings for other species of birds.

Literature Cited

Hanson, Harold C. 1949. Methods of determining age in Canada geese and other waterfowl. Jour. Wildl. Mgmt., 13: 177-183.

HANSON, HAROLD C. 1958. Studies on the physiology of Canada geese (*Branta canadensis interior*). Ph.D. thesis, University of Illinois, 125 pp.

HANSON, HAROLD C. 1961. The dynamics of condition factors in Canada geese and their relation to seasonal stresses. Arctic Institute of North America, *In press.*

HANSON, HAROLD C. and ROBERT H. SMITH. 1950. Canada geese of the Mississippi Flyway, with special reference to an Illinois flock. Ill. Nat. Hist. Surv. Bull., 25: 67-210.

HARMON, I. W., E. OGDEN and S. F. COOK. 1932. The reservoir function of the spleen in fowls. Am. Jour. Physiol., 100: 99-101.

HARTMAN, FRANK A. 1955. Heart weight in birds. Condor, 57: 221-238.

KIRKPATRICK, C. M. 1944. Body weight and organ measurements in relation to age and season in ring-necked pheasants. Anat. Rec., 89: 175-194.

LATIMER, HOMER B. 1927. Correlation of weights and lengths of the body, systems and organs of the turkey hen. Anat. Rec., 35: 365-377.

LATIMER, H. B. and J. A. ROSENBAUM. 1926. A quantitative study of the anatomy of the turkey hen. Anat. Rec., 34: 15-23.

MARSDEN, S. J. 1940. Weights and measurements of parts and organs of turkeys. Poul. Sci., 19: 23-28.

MITCHELL, H. H., L. E. CARD and T. S. HAMILTON. 1926. The growth of white plymouth rock chickens. Univ. Ill. Agr. Exp. Sta. Bull., 278: 71-132.

MITCHELL, H. H., L. E. CARD and T. S. HAMILTON. 1931. A technical study of the growth of white leghorn chickens. Univ. Ill. Agr. Exp. Sta. Bull., 367: 83-139.

OAKBERG, E. F. 1949. Quantitative studies of pancreas and islands of Langerhans in relation to age, sex and body weight in white leghorn chickens. Am. Jour. Anat., 84: 279.

OAKESON, BARBARA B. 1953. Cyclic changes in liver and spleen weights in migrating white-crowned sparrows. Condor, 55: 3-16.

OAKESON, BARBARA B. 1956. Liver and spleen weight cycles in non-migratory white-crowned sparrows. Condor, 58: 45-50.

QUIRING, DANIEL P. and PAUL H. BADE. 1943. Organ and gland weights of the English sparrow. Growth, 7: 299-307.

RENSCH, BERNHARD. 1948. Organ proportionen und Korpex grosse bei Vogeln und Saugetieren. Zoologische Jahrbucher. Abteilung. fur Allgemeine Zoologie und Physiologie, 61: 337-412.

RIDDLE, OSCAR. 1928. Sex and seasonal differences in weight of liver and spleen. Proc. Soc. Exp. Biol. and Med., 25: 474-476.

RIDDLE, OSCAR. 1929. Endocrine regulation of reproduction. Endocrin., 13: 311-319.

RIDDLE, OSCAR. 1947. Endocrines and constitution in doves and pigeons. Carnegie Inst. of Wash., Publ. No. 572., 306 pp.

SALGUES, R. 1939. Contributions nouvelles a la physiologie de la plume F. L'osteomalaise aviare et ses repercussions sur le plumage. L'Oiseau et la revue Francais d'ornithologie. New Series, 9: 33-51.

SMITH, H. L. 1928. The relation of the weight of the heart to the weight of the body and of the weight of the heart to age. Am. Heart Jour., 4: 79-93.

SOUBA, A. J. 1923. Variations and correlation of the organs of single comb white leghorn cockerels. Anat. Rec., 26: 291-297.

STEGMAN, LEROY. 1954. Variation in a flock of the European starling. Auk, 71: 179-185.

Manuscript received February 28, 1962.