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Effect of Crossing on the Size of Digestive System in Growing Cockerels

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One hundred and five cockerels from three pure breeds, Fayoumi, white Leghorn and Rhode Island Red and four reciprocal crosses of Fayoumi wih the two other breeds were killed at 10, 12, 16, 20 and 24 weeks of age. The following results were obtained from the slaughter tests of the cockerels :

1. Most of the development in the complete digesive system, as well as different parts of it, absolute weight and relative weight were acheived at the age of 10 to 12 weeks of age.

2. Maternal effects were observed in the total weight of the complete digestive system and also in the weights of its different parts.

3. It seems that the absolute weight of the proventriculus and the caeca could be considered as a measurement of feed efficiency especialy when comparing breeds with crosses.

Extensive studies were done on the microscopic anatomy of the digestive system parts of mature chickens (Calhoun, 1954). However, little was done on the differential growth of this system either on microscopic or gross anatomy. Also, most of the morphological studies dealt with the measurements of the different parts of the digestive system. (Kersten, 1912 ; Marsden, 1940 and Calhoun, 1954).

In this study, the gross anatomy of the different parts of the digestive system was studied at the period of the highest body growth for different breeds and crosses to investigate the differential growth of this system and the effect of crossbreeding on its size.

In general, the alimentary canal is an early maturing system as it is considered to be essential link for the phsiological welfare of the bird at the early ages of life (Hafez, 1955 ; and Yamani, 1963). In ducks, most of development in the digestive system is attained before the first two to three weeks of life. However, some of the digestive system parts tend to mature earlier than the others (Yamani, 1963). Liver absolute or proportionol weight is at its highest value at one week of age, then decrease until 10 weeks of age (Schoettle *et al.*, 1956).

Material and Methods

Males from three pure breeds, Fayoumi (F), Rhode Island Red (Ri and white Leghorn (L) were available. Crossbred males were secured from the following four types of matings :

Rhode Island Red females	×	Fayoumi males	(RF)	;
White Leghorn females	×	Fayoumi females	(LF).	
Rhode Island Red males	×	Fayoumi males	(LF)	and
White Leghorn males	×	Fayoumi females	(RF)	;

At the ages of 10, 12, 16, 20 and 24 weeks, three males out of each of the seven matings (a total of 105 cockerels) were taken for test. These males were brooded, reared and managed together under the same conditions. During the first 8 weeks the chicks were fed a balanced starting ration containing 21 percent protein, consisting of the following percentages : corn 20, corn glutin 20 ; extracted rice bran 5 ; wheat bran 8.5 ; rice starch by-products 10 ; decorticated cotton-seed cake 30 ; bone meal 2 ; calcium carbonate 1 ; sodium chloride 0.5 and minerll salt mixture 3. Later (from 8 weeks onwards), and 18 per cent protein growing ration was used ; consisiting of the following percentages ; corn 20 ; corn glutin 20, extracted rice bran 20; wheat bran 2 ; calcium carbonate 1 ; sodinm chloride 0.5 and mineral salt mixture 3. The diet was supplemented by green feed, animal protein source, antibiotic and vitamins according to the bird's requirements. The green food was applied as Egyptian clover.

Birds were weighed alive in the early morning before feeding. The experimental animals were sacrifiecd after) fasting for 12 hr to standardize the differences due to digestive canal contents. Sacrification was achieved by cutting the blood vessels at the end of the jaw. After dressing the birds, the digestive organs were carefully separated from the viscera. Each part was weighed full and empty from food, and food contents were obtained by difference. All the values used in the results were for the empty parts. Total contents of food were calculated for the whole digestive canal. The parts studied were esophagus, crop, proventriculus, gizzard, duodenum, pancreas, liver, caeca, small and large intestines. Total digestive system size was obtained by adding to that the sizes of all the previous parts. Also, the total intestine length was obtained by adding the lengths of duodenum, caeca, small and large intestines. The relative weight of each part was calculated in relation to the absolute body weight or to the total digestive

$$\% \ (1) = \frac{\text{The organ wt.}}{\text{Body wt.}} \times 100$$

system weight as follows : $\% \ (2) = \frac{\text{The organ wt.}}{\text{Total dig. system wt.}} \times 100$ and

The analysis of variance was carried out according to the method of more than one item in the subclass, (Snedecor, 1956).

Results and Discussion

Body weight

The live weights of all cockerels sacrificed showed rapid increase through all the ages of study (Table 1). The period from 16 to 20 weeks was characterized by the utmost increase in all the cockerels. (F) cockerels were the lightest among all the pure and crossbred cockerels, and (FR) cross was the heaviest. The (R) cockerels showed the highest increase among the purebred cockerels, while the (F) showed the least. Among the crossbreds, the increase in live weight of (FR) cockerels was higher than all other crosses. It seems that the rate of increase in body weight of crossesis greatly influenced by maternal effects. The crossbred cockerels hatched from (F) eggs showed the lowest rate of increase and body weights in all ages (compared to those hatched from (L) or (R) eggs. However, the maternal effect is more expressed when the (R) breed were used. The (R) dams produced the heaviest crossbred cockerels with larger bodies than did the (L) ones. All the differences between ages, breeds and crosses and the interaction were highly significant, (Table 11).

The whole digestive system

(*a*) The total degestive system weight increased in all the breeds and crosses throughout the experiment until 24 weeks of age, (Table 1).

The highest increase in the digestive system weight was achieved during the period from 12 to 16 weeks of age, no appreciable changes were observed thereafter, (F) and (LF) had the lightest digestive organs among the pure and crossbred cockerels, while the (R) showed the heaviest. It seems that the rate of increase in digestive system weight of crosses is greatly influenced by maternal effects. The crossbred cockerels hatched from (F) eggs showed the lowest rate of increase and the lowest sizes in all ages as compared to those hatched from (L) or (R) eggs. The maternal effect was also more expressed when (R) breed was used. The (R) dams produced cockerels having the heaviest digestive system. All the differences betwen ages, breeds and crosses and the interaction were highly significant, (Table 11).

The weights of the digestive organs followed the same trend observed in body weight previously discussed. The growth in absolute body weight of course should be correlated with the development in digestive system

(*b*) The relative digestive system weight to body weight was high at the tenth week of age then decreased slightly thereafter until the end of experiment (Table 1). It seems that the digestive system is an early developing mechanism as it is supposed to play an important role in converting the food stuff, during the early stages of life during which the rapid growth occurs.

TABLE 1. Age, breed and cross differences in body weight and total digestive system weight and the percentage of digestive system to body weight.

Items	Age in weeks	Breeds and crosses						
		F	R	L	FR	RF	FL	LF
Body wt.	10	420	520	440	492	593	537	477
	12	518	600	615	660	595	617	575
	16	742	910	977	1148	795	938	812
	20	1058	1078	1180	1483	1275	1293	1125
	24	1150	1727	1610	1528	1595	1352	1120
Total digestive system wt.	10	52.5	57.5	54.7	64.0	67.1	66.7	56.2
	12	58.6	77.3	73.3	73.4	67.0	74.1	65.8
	16	93.4	106.8	102.9	123.7	95.6	107.5	84.3
	20	92.8	104.5	97.8	114.8	100.7	109.5	97.4
	24	93.4	147.2	120.6	104.7	115.8	115.6	89.4
Total digestive system % (1)	10	12.5	11.1	12.4	13.0	11.3	12.4	11.8
	12	11.3	12.9	11.9	11.1	11.3	12.0	11.4
	16	12.5	11.7	10.5	10.8	12.0	11.5	10.4
	20	8.8	9.7	8.3	7.7	7.9	8.5	8.6
	24	8.1	8.5	7.5	6.9	7.3	8.6	8.0
Total digestive system length (cm)*	10	125	136	127	143	144	141	140
	12	146	170	151	166	148	164	141
	16	169	211	181	206	174	181	171
	20	176	182	173	197	182	195	177
	24	174	218	180	177	193	196	169

* Total intestine length included the length of ducudenam, small and large intestines and both lobes of caeca.

TABLE 2. Age, breed and cross differences in esophagus and crop weight, percentage to body weight and percentage to digestive system weight

Items	Age in weeks	Breeds and crosses							Av.
		F	R	L	FR	RF	FL	LF	
Esophagus and crop wt. (g)	10	4.6	5.2	4.7	4.8	4.9	4.9	4.1	4.7
	12	4.8	5.6	6.3	5.1	5.6	5.4	4.8	5.4
	16	5.9	6.8	7.2	8.4	6.7	7.0	6.4	6.9
	20	7.1	8.2	8.8	8.7	7.7	9.0	7.0	8.1
	24	5.1	8.7	9.1	7.6	7.4	8.5	7.1	7.7
	Av.	5.5	6.9	7.2	6.9	6.9	7.0	5.9	—
Esophagus and crop % to body (1)	10	1.10	1.00	1.07	0.98	0.83	0.91	0.86	0.95
	12	0.93	0.93	1.02	0.77	0.94	0.88	0.83	0.90
	16	0.79	0.75	0.74	0.73	0.84	0.75	0.78	0.76
	20	0.67	0.76	0.75	0.59	0.60	0.70	0.62	0.67
	24	0.44	0.50	0.57	0.50	0.46	0.63	0.63	0.53
	Av.	0.71	0.71	0.75	0.65	0.67	0.74	0.72	—
Esophagus and crop % to digestive (2)	10	8.8	9.0	8.6	7.5	7.3	7.3	7.3	7.9
	12	8.2	7.2	8.6	6.9	8.4	7.3	7.3	7.7
	16	6.3	6.4	7.0	6.8	7.0	6.5	7.6	6.8
	20	7.7	7.8	9.0	7.6	7.6	8.2	7.2	7.9
	24	5.5	5.9	7.5	7.3	6.4	7.4	7.9	6.9
	Av.	7.0	7.0	8.0	7.2	7.3	7.4	7.5	—

Similar trend in digestive system development has been observed in chickens by Hafez (1955) and in ducks by Yamani (1963).

The (R) had the highest relative digestive system weight to body weight among the pure and crossbred cockerels. The (L) crossbreds, however, showed higher relative digestive system weight as compared to the (R) crosses. Although the (R) had the highest values by the end of the experiment, its digestive system matured later than the other two light breeds, possibly due to heritable effect since the crosses of the two light breeds (LF) and (FL) had matured digestive system earlier than (FR) and (RF) crosses. Difference due to the effect of age, breed and crosses were significant (Table 11).

Esophagus and crop

(*a*) Esophagus and crop absolute weight increased gradually until 20 weeks then slightly decreased afterwards in almost all the breeds and crosses (Table 2). The (R) and (L) esophagus and crop seem to mature later, with respect to the other groups as their weights continued to increase until the end of the experiment. In general, it could be said that these parts are early maturing parts of the digestive system as their function is associated with the reception of feed stuff.

The highest weight of crop and esophagus was observed in the (L) cockerels and the lowest in the (F) among the pure and crossbred cockerels. It Could be said that the rate of development and the sizes of esophagus and crop of crossbred cockerels are greatly affected by maternal influences. Crossbreds hatching from (F) eggs showed smaller sizes and lower rates of increase in all ages compared to these hatching from (L) or (R) eggs.

The maternal effect was more pronounced in the differences between the two reciprocal crosses (LF) and (FL), and became more clear with advanced age. Difference due to age, breed and crosses were significant (Table 11).

(*b*) The reative esophagus and crop weights with respect to body weight were high at 10 weeks of age and decreased gradually until 24 weeks of age in all the breeds and crosses studied (Table 2). This also emphasize that these parts are early maturing organs and are more important in young than in the adult ages. The (L) cockerels had the highest values, while the (R) crosses had the lowest. The esophogus and crop of the two light breeds (L) and (F) matured earlier than those of the heavy breed (R). This character was transmitted to the crosses and caused the crossbred birds of (L) blood (FL) and (LF) to have higher values as compared to the crosses.

(*c*) As the esophagus and crop were early maturing digestive organs, their relative weights with respect to total digestive system weight were high at the early ages and decreased afterwards until the end of the experiment. As far as the breeds and crosses used were concerned, the relative weight of crop and esophagus to total digestive system weight followed the same trend previously discussed with respect to their weight relative to body weight.

Proventriculus

Progressive increase in proventriculus absolute weight was observed during the period of study (Table 3). Anmog the purebreds. (R) showed the highest weight at the 5 ages studied. The (L) averages were always higher than the (F) ones. The crossbreds did not show a clear trend, but generally they had higher weights at all ages compared to the (F) parent. The average of the 5 ages of the crosses was almost exactly as the average of the two parents. However, the crossbreds of (L) blood showed some sort of maternal effect, which could not be of a certain significance if we examined the trend of weights in the 5 ages separately.

The (R) breed, known to be the heaviest among the purebred used, seems to develop heavier weights of proventriculus at earlier ages. This is, however, expected, since it is the most important part of the digestive canal in the production of enzymic secretions. It could be suggested that the high efficiency of feed utilization is correlated with the development of this part of the digestive tract. When we study the relative weight of the proventriculus to body weight, still the (R) ranks the first in almost every age among crossored. But the differences between breeds become less clear. It can be seen, however, that there is no clear effect of crossing as regards this character. The Fayoumi White Leghorn Crosses, however, showed higher values thas the (R) crosses. A clear effect of age is shown in all crossbreds and purebreds between breeds.

The proventriculus percentage to digestive system weight showed almost the same trend as its percentage to body weight. It seem that the absolute weight of the proventriculus is a better measurement of feed efficiency especially breeds.

Gizzard

The absolute weight of gizzard showed progressive increase with age in all breeds and crosses throughout the experimental period, (Table 4). Among pure breds the (L) generally ranked first and the (F) ranked the last in the 5 ages studied. With respect to the crossbreds, a clear maternal effect was observed. This organ of the digestive tract could be of no definite importance to the efficiency of feed conversion or rapid growth rate during the early period of the birds life. For both (R) and (L) had doubled the weight of gizzard during the course of this study. The gizzard is gaining importance with advanced age as it is specialized in grinding food, while chicks food is supposed to have low percentage of fibers.

The gizzard percentage to body weight and to digestive tract showed negative trends with the advancement of age. In the earlier ages the (L) and (FL) birds had the highest figures, this maternal effect was still clear at the 24*th* week of age. The (R), however, which followed the (F) with respect to the percentage of gizzard to body and digestive tract weights did not show the maternal effect clearly in its crosses.

TABLE 3. Age breed and cross differences in proventriculus weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breeds and crosses							
		F	R	L	FR	FR	FL	LF	Av.
(*a*) Proventriculus wt. (g)	10	2.0	2.6	2.3	2.4	2.6	2.6	2.1	2.4
	12	2.2	2.9	2.7	2.7	2.9	2.9	3.1	2.8
	16	3.6	3.8	3.6	4.2	3.4	4.6	3.5	3.8
	20	3.2	4.6	3.7	4.0	3.8	4.3	4.0	3.9
	24	3.2	5.1	4.5	3.9	4.3	4.0	3.1	4.0
	Av.	2.8	3.8	3.4	3.4	3.4	3.7	3.2	—
(*b*) Prov. % to body (1)	10	0.48	0.50	0.52	0.49	0.43	0.48	0.44	0.48
	12	0.42	0.48	0.44	0.41	0.48	0.47	0.54	0.47
	16	0.49	0.42	0.37	0.37	0.43	0.49	0.43	0.42
	20	0.30	0.43	0.31	0.27	0.30	0.33	0.36	0.32
	24	0.28	0.30	0.28	0.26	0.27	0.30	0.28	0.28
	Av.	0.36	0.39	0.35	0.32	0.35	0.39	0.39	—
(*c*) Prov. % to digestive (2)	10	3.8	4.5	4.2	3.8	3.9	3.9	3.7	4.0
	12	3.8	3 8	3.7	3 7	4.3	3.9	4.7	4 0
	10	3.9	3.6	3.5	3 4	3.6	4.3	4.2	3.7
	20	3.4	4.4	3.8	3.5	3.8	3.9	4.1	3 8
	24	3.4	3.5	3.7	3.7	3.7	3.5	3.5	3.6
	Av.	3.6	3.9	3.8	3.5	3.8	3.9	4.1	—

TABLE 4. Age, breed aud cross differences in gizzard weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breed and crosses							
		F	R	L	FR	RF	FB	BF	Av.
Gizard wt. (g)	10	14.0	17.0	17.2	17.2	17.6	21.3	16.3	17.2
	12	14.2	18.8	20.5	18.5	16.9	20.3	18.4	18.2
	16	27.3	26.2	30.5	29.7	23.0	28.2	21.8	26.7
	20	21.7	25.1	28.6	28.9	23.5	28.2	25.0	25.9
	24	23.4	43.2	38.1	27.1	31.5	34.2	24.5	31.7
	Av.	20.1	26.1	27.0	24.3	22.5	26.5	21.2	—
Gizzard % to body (1)	10	3.33	3.27	3.91	3.49	2.97	3.97	3.42	3.46
	12	2.74	3.13	3.33	2.80	2.84	3.29	3.20	3.04
	16	3.68	2.87	3.12	2.59	2.89	3.01	2.68	2.96
	20	2.05	2.33	2.42	1.95	1.84	1.18	2.22	2.14
	24	2.03	2.50	2.37	1.77	1.97	2.53	2.19	2.20
	Av.	2.58	2.70	2.80	2.29	2.32	2.79	2.58	—
Gizzard % to digestive (2)	10	26.7	29.5	31.4	26.9	26.2	31.9	29.0	28.8
	12	24.2	24.3	27.9	23.2	25.2	27.4	27.9	26.0
	16	29.2	24.5	29.6	24.0	24.1	26.2	25.9	26.2
	20	23.4	24.0	29.2	25.2	23.3	25.8	25.7	25.3
	24	25.1	29.3	31.6	26.9	27.2	29.6	27.4	22.0
	Av.	25.7	26.4	30.1	25.3	25.2	27.9	26.0	—

Duodenum

Among purebreds, at the ages of 10 weeks, the weight of duodenum was lower in (F) than both (R) and (L) which showed similar weights, (Table 5). The (R) crosses had higher weights than those crosses of (L), while all crosses at that age had higher weights for the duodenum as compared to the purebreds. At the age of 24 weeks, (R) ranked the first among all breeds and crosses. It could be seen from Table 5, that in all purebureds and crosses, that the duodenum almost ceased growth after the 16*th* week of age, except in the case of (R) which probably continued to grow until the 24*th* week of age.

The duodenum weight as a percentage of body weight tended to decrease with advanced age. At 12 weeks of age the (R) had the highest figure among the purebreds and crossbreds. The crossbreds had higher figure as compared to the (F) breed. At the 24*th* week of age (F) and (R) had similar figures and were higher than (L). The (R) crosses showed lower figures than their partental purebreds, while the (L) crosses had higher figures than their parental purebreds.

The duodenum percentage with respect to digestive tract weight tended to decrease with advanced age, although, this trend was not continued clearly after the 12*th* week of age. At the 24*th* week of age the (F) showed the highest percentage, while the (L) was the lowest among the birds studied. All the crosses had almost the similar percentages at the age of 24 weeks.

Pancreas

As was expected, the pancreas showed increase in weight with advanced age, (Table 6). At the 10*th* week of age, the pancreas of the (R) breed had the heaviest among the purebred. The (R) reciprocal crosses showed almost similar weights, and were heavier than the parental purebreds, and were also heavier than the (L) crosses. At the 24*th* week of age, the (L) almost doubled its pancreatic weight with respect to its weight at the 10*th* week of age, and got the heaviest pancreas among the purebreds. In all ages studied, the (F) showed, nearly the lowest figures among the purebreds and crosses investigated, this could be related to the efficiency of feed utilization of that breed.

However, the pancreatic weight as a percent of body weight did not vary significantly among the different purebreds and/or crosses. Therefore, if the pancreatic weight could be related to the efficiency of feed utilization, then its absolute weight rather than its percent to body weight, could be considered.

Liver

At 10 weeks of age, the (F) liver was the heaviest as compared to the (R) and (L) breeds, while the weights in the case of the crosses were even heavier than their parental purebreds, (Table 7).

TABLE 5 Age, breed and cross differences in duodenum weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breeds and crosses							
		F	R	L	FR	RF	FL	LF	Av.
duodenum wt. (g)	10	2.6	3.1	3.1	4.0	4.0	3.2	3.3	3.3
	12	4.2	6.7	5.1	5.6	5.4	5.5	4.6	5.3
	16	5.5	8.0	8.0	8.4	7.2	7.1	5.3	7.1
	20	6.6	7.7	6.0	7.6	7.0	6.8	6.5	6.9
	24	6.5	9.9	7.0	6.6	7.7	7.7	5.8	7.3
	Av.	5.1	7.1	5.8	6.4	6.3	6.1	5.1	—
duodenum % to body (1)	10	0.62	0.60	0.70	0.81	0.67	0.60	0.69	0.66
	12	0.81	1.12	0.83	0.85	0.91	0.89	0.80	0.89
	16	0.74	0.88	0.82	0.73	0.91	0.76	0.65	0.79
	20	0.62	0.71	p.51	0.51	0.55	0.53	0.57	0.57
	24	0.57	0.57	0.43	0.43	0.43	0.57	0.52	0.51
	Av.	0.66	0.73	0.60	0.60	0.65	0.64	0.62	—
duodenum % to digestive (2)	10	4.9	5.4	5.7	6.3	6.0	4.8	5.9	5.5
	12	7.2	8.7	7.0	7.6	8.1	7.4	7.0	7.6
	16	5.9	7.5	7.8	6.8	7.5	6.6	6.3	7.0
	20	7.1	7.4	6.1	6.6	7.0	6.2	6.7	6.7
	24	7.0	6.7	5.8	6.3	6.6	6.7	6.4	6.5
	Av.	6.5	7.2	6.5	6.7	7.1	6.4	6.5	—

TABLE 6. Age, breed and cross, difference in pancreas weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breeds and crosses							Av.
		F	R	L	FR	RF	FL	LF	
Pancreas wt. (g)	10	1.79	2.17	1.76	2.24	2.23	1.67	1.83	1.96
	12	1.27	2.16	1.81	2.07	1.61	1.50	1.59	1.71
	16	2.31	2.56	2.61	3.77	3.22	2.80	2.37	2.81
	20	2.47	3.37	2.83	3.53	2.77	3.07	3.00	3.00
	24	2.63	3.17	3.27	2.83	3.50	3.07	2.30	2.97
	Av.	2.09	2.68	2.64	2.89	2.66	2.42	2.22	—
Pancreas % to body (1)	10	0.42	0.41	0.40	0.46	0.38	0.31	0.38	0.39
	12	0.24	0.36	0.29	0.31	0.27	0.24	0.27	0.29
	16	0.31	0.28	0.27	0.33	0.41	0.29	0.29	0.31
	20	0.23	0.31	0.24	0.24	0.22	0.24	0.27	0.25
	24	0.23	0.18	0.20	0.19	0.22	0.23	0.21	0.21
	Av	0.27	0.28	0.26	0.27	0.27	0.26	0.27	—
Pancreas to digestive % (2)	10	3.4	3.8	3.2	3.5	3.3	2.5	3.3	3.3
	12	2.2	2.8	2.5	2.8	2.4	2.0	2.4	2.4
	16	2.5	2.4	2.5	3.0	3.3	2.6	2.8	2.7
	20	2.7	3.2	2.9	2.4	2.8	2.8	3.1	2.9
	24	2.8	2.2	2.7	3.3	3.0	2.7	2.6	2.6
	Av.	2.7	2.7	2.7	3.0	3.0	2.5	2.3	—

TABLE 7. Age, breed and cross differences in liver weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breeds and crosses							Av.
		F	R	L	FR	RF	FL	LF	
Liver wt. (g)	10	12.0	11.1	10.3	15.8	14.8	14.2	12.1	12.9
	12	13.4	16.1	15.4	18.8	15.5	17.7	14.9	15.9
	16	22.7	25.0	23.7	32.3	22.1	26.6	20.5	24.7
	20	28.5	27.0	24.5	31.9	28.3	29.2	22.8	27.5
	24	24.2	38.2	27.4	28.8	32.2	29.7	24.0	29.2
	Av.	20.1	23.5	20.3	25.5	22.6	23.5	18.9	—
Liver% to body (1)	10	2.86	2.13	2.34	3.21	2.50	2.64	2.53	2.60
	12	2.59	2.68	2.50	2.85	2.61	2.87	2.59	2.66
	16	3.06	2.75	2.43	2.81	2.78	2.83	2.52	2.74
	20	2.69	2.50	2.08	2.15	2.22	2.26	2.03	2.27
	24	2.10	2.21	1.70	1.88	2.02	2.20	2.14	2.03
	Av.	2.58	2.43	2.11	2.40	2.33	2.48	2.29	—
Liver % to digestive (2)	10	22.9	19.3	18.8	24.7	22.1	21.3	21.5	21.6
	12	22.9	20.8	21.0	25.6	23.1	23.9	22.6	22.7
	16	24.3	23.4	23.0	26.1	23.1	24.7	24.3	24.2
	20	30.7	25.8	25.1	27.8	28.1	26.7	23.4	26.8
	24	25.9	26.0	22.7	27.5	27.8	25.7	26.8	26.0
	Av.	25.7	23.9	22.6	26.5	25.3	26.3	20.0	—

The liver III weight continued to increase with advanced age. At 24*th* week the (R) breed reached more than 3 times the weight of its 10 weeks liver, while the (F) breed almost doubled its liver weight, and the (L) liver was III intermediate. A clear difference between the reciprocal crosses is seen in Table 7, those of (F) sires had heavier liver weights than those of (F) dams.

The liver weight as a percent of body weight showed no clear trend with advanced age in different groups studies. However, if the liver was taken as a percent of digestive tract weight, it tended to increase from the 10*th* up to the 24*th* weeks of age.

Since the liver is of particular importance in connection with the metabolism of steroid hormones, and since the light breeds are known to reach puberty and sexual maturity at earlier ages compared to heavy breeds, it seems logic to study the liver in connection with sexual development in different breeds of birds.

Small intestine

At 10 weeks of age, the small intestine of the (F) breed was heavier than the other two purebreds, while all crosses had heavier weights as compared to their parental purebreds. However, the weight of the small intestine of the (R) breed exceeded those of the other purebreds and crosses from the 12*th* week of age and throughout the experimental period, careful examination of Table 8 shows that the growth of small intestine almost slowed down after 16 weeks of age in the different groups studied. As the body weight increased after that age, the percent of small intstine to body wegiht was lower. The same trend was observed with respect to the percent of small intestine to digestive tract weight.

Generally, it could be shown that the growth of small intestine is accelerated during the period from 10 to 16 weeks age, after which time the rate of growth is slowed down, reaching nearly the same percent with respect to total digestive tract weight. This trend was observed in all groups investigated, and could be related to the rate of absorption of digestible nutritions at different growing periods of animals.

Large intestine

The overall averages of large intestine weight throughout the experimental period showed no effect due to age on the weight of this organ of the digestive tract. Therefore the decrease, of its percent to body and to digestive tract weights, could be expected with advancing age. Surprisingly, the weight of that organ was lower at the age of 24 weeks as compared to that weight at 10 weeks of the animals age, in the (RF) and (FL) crosses. The typical fluctuation in the weights of that organ at all ages studied, could indicate that this part of the digestive canal was almost fully developed at 10 weeks of age (Table 9).

TABLE 8. **Age, breed and cross differences in small intestine weight, percentage to body weight and percentage to digestive system weight.**

Items	Age in weeks	Breeds and crosses							Av.
		F	R	L	FR	RF	FL	LF	
S. intestine wt. (g)	10	11.0	10.9	10.5	11.6	13.4	12.4	11.1	11.6
	12	14.3	18.6	15.6	14.7	13.3	13.8	13.8	15.1
	16	19.5	25.2	20.6	27.0	21.9	24.3	18.3	22.4
	20	19.6	20.2	15.9	20.7	19.9	21.7	21.8	20.0
	24	21.2	28.8	22.8	19.5	21.3	21.5	15.9	21.6
	Av.	17.1	20.7	17.1	18.7	17.9	19.1	16.2	—
S. intestine % to body (1)	10	2.61	2.10	2.39	2.35	2.26	2.31	2.33	2.33
	12	2.76	3.10	2.54	2.23	2.24	2.49	2.40	2.53
	16	2.63	2.76	2.11	2.35	2.75	2.59	2.25	2.48
	20	1.85	1.87	1.35	1.40	1.56	1.68	1.93	1.65
	24	1.84	1.67	1.42	1.28	1.34	1.59	1.42	1.50
	Av.	2.20	2.14	1.77	1.75	1.84	2.01	1.97	—
S. intestine % to digestive (2)	10	20.9	18.9	19.2	18.1	20.0	18.6	19.8	19.4
	12	24.4	24.1	21.3	20.0	19.9	20.8	20.9	21.6
	16	20.9	23.6	20.0	21.8	22.9	22.6	21.7	22.0
	20	21.1	19.3	16.3	18.0	19.8	19.8	23.3	19.5
	24	22.7	19.6	18.9	18.6	18.4	18.6	17.8	19.2
	Av.	21.8	21.1	19.0	19.5	20.1	21.4	17.1	—

TABLE 9. Age, breed and cross differences in large intestine weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breeds and crosses							Av. LF
		F	R	L	FR	RF	FL	LF	
Large intestine wt. (g)	10	2.66	2.75	2.09	3.21	5.56	3.79	2.95	3.13
	12	1.67	2.33	2.40	2.80	1.97	2.27	1.77	2.09
	16	2.90	2.80	3.50	4.00	2.90	2.27	2.86	3.03
	20	2.70	3.17	2.80	4.17	3.30	2.80	3.20	3.16
	24	3.30	3.63	3.47	3.63	2.93	2.43	2.47	3.12
	Av.	2.64	2.94	2.85	3.44	3.11	2.71	2.65	—
L. intestine % to body (1)	10	0.63	0.53	0.48	0.65	0.75	0.71	0.62	0.62
	12	0.32	0.39	0.39	0.33	0.33	0.37	0.31	0.35
	16	0.39	0.31	0.36	0.35	0.36	0.24	0.35	0.34
	20	0.26	0.29	0.24	0.28	0.26	0.22	0.28	0.26
	24	0.29	0.21	0.21	0.24	0.18	0.18	0.22	0.22
	Av.	0.34	0.30	0.30	0.32	0.32	0.29	0.32	—
L. intestine % to digestive (2)	10	5.1	4.8	3.8	5.0	6.6	5.7	5.2	5.2
	12	2.8	3.0	3.3	3.0	2.9	3.1	2.7	3.0
	16	3.1	2.6	3.4	3.2	3.0	2.1	3.4	3.0
	20	2.9	3.0	2.9	3.6	3.3	2.6	3.3	3.1
	24	3.5	2.5	2.9	3.5	2.5	2.1	2.8	2.8
	Av.	3.4	3.0	3.2	3.6	3.5	3.0	2.8	—

TABLE 10. Age, breed and cross differences in caeca weight, percentage to body weight and percentage to digestive system weight.

Items	Age in weeks	Breeds and crosses							Av.
		F	R	L	FR	RF	FL	LF	
Cae.a wt. (g)	10	2.00	2.60	2.70	2.90	3.03	2.60	2.41	2.6
	12	2.50	4.10	3.50	3.80	3.82	3.20	2.71	3.4
	16	3.61	6.51	5.10	6.10	5.10	4.70	3.30	4.9
	20	4.22	5.24	4.51	5.31	4.50	4.51	4.10	4.6
	24	3.70	6.56	4.90	4.70	4.80	4.40	3.70	4.7
	Av.	3.22	5.02	4.11	4.60	4.32	3.90	3.20	—
Caeca% to body (1)	10	0.48	0.50	0.61	0.58	0.51	0.48	0.51	0.52
	12	0.48	0.68	0.57	0.58	0.64	0.52	0.47	0.57
	16	0.49	0.72	0.52	0.53	0.64	0.50	0.41	0.54
	20	0.40	0.49	0.38	0.36	0.35	0.35	0.36	0.38
	24	0.32	0.38	0.30	0.31	0.30	0.33	0.33	0.33
	Av.	0.41	0.52	0.42	0.43	0.44	0.41	0.39	—
Caeca% to digestive (2)	10	3.8	4.5	4.9	4.5	4.5	3.8	4.3	4.3
	12	4.3	5.3	4.8	5.2	5.7	4.3	4.1	4.9
	16	3.9	6.1	5.0	4.9	5.3	4.4	3.9	4.8
	20	4.5	5.0	4.6	4.6	4.5	4.1	4.2	4.5
	24	4.0	4.5	4.1	4.5	4.1	3.8	4.1	4.2
	Av.	4.10	5.10	4.60	4.80	4.80	4.10	4.10	—

TABLE 11. Summary of analysis of variance of different digestive system parts as effected by different ages, breeds and crosses.

Items	Among ages	Among breeds and crosses	Interaction
Body wt. (g)	××	××	××
Total digestive system wt. (g)	××	××	××
Total digestive system % (1)	××	×	N.S.
Esophagus and crop wt. (g)	××	×	N.S.
Esophagus and crop % (1)	××	N.S.	N.S.
Esophagus and crop % (2)	N.S.	N.S.	N.S.
Proventriculus wt. (g)	××	×	N.S.
Proventriculus% (1)	××	N.S.	N.S.
Proventricalus % (2)	N.S.	N.S.	N.S.
Gizzard wt. (g)	××	×	N.S.
Gizzard % (1)	××	×	N.S.
Gizzard % (2)	××	×	N.S.
Duodenum wt. (g)	××	××	×
Duodenum %(1)	××	×	N.S.
Duodenum % (2)	××	N.S.	N.S.
Pancreas wt. (g)	××	××	×
Pancreas % (1)	××	×	N.S.
Pancreas % (2)	N.S.	×	N.S.
Liver wt. (g)	××	××	×
Liver % (1)	×	×	N.S.
Liver % (2)	××	×	N.S.
Small intestine wt. (g)	××	××	×
Small intestine % (1)	×	×	N.S.
Small intestine % (2)	×	×	N.S.
Large intestine wt. (g)	N.S.	××	N.S.
Large intestine % (1)	××	N.S.	N.S.
Large intestine % (2)	××	×	N.S.
Caeca wt. (g)	××	××	×
Ceace % (1)	××	×	×
Caeca % (2)	×	×	N.S.
Total length	××	×	N.S.

Caeca

Among purebreds, the (R) showed the highest weight of caeca at all ages studied. In general, all crosses tended to get higher weights of caeca as iompared to (F). The crosses also got weight of caeia which were intermediate between their parental puribreds.

The percent of caeca to body or to digestive tract weights showed that the (R) had the highest figures among the purebreds, and the (R) crosses were also superior to (L) crosses. These percentages, however, tended to be lower after the 16*th* week of age, (Table 10).

Intestine length

At all ages studied, the (R) had the longest intestine as campared to those of (L) and (F). The intestinal length, did not continue to increase after the 16*th* week of age, (Table 1).

Concerning the (L) crosses, the (FL) showed longer intestine than the (LF). In the (R) crosses, the (FR) had longer intestine than (RF) at the ages of 12, 16 and 20 weeks of age.

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تأثير الخلط على الجهاز الهضمى فى الديوك

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استخدم فى هذه التجربة ١٠٥ ديك من ثلاث أنواع من الدجاج هى الفيومى والبلدى الأبيض والرود أيلاند الأحمر والخليط العكسى لها وهى أربعة مجاميع ، وذلك فى أعمار ١٠ و ١٢ و ١٦ و ٢٠ و ٢٤ أسبوع . ووجد أن معظم النمو فى جميع أجزاء الجهاز الهضمى تمت عند عمر ١٠ و ١٢ أسبوع. لوحظ تأثير كبير للام فى وراثة الصفات المختلفة للجهاز الهضمى . لوحظ أنه يمكن اعتبار وزن المعدة الحقيقية والأعورين مقياس لكفاءة الطائر على التحويل الغذائى عند مقارنة الأنواع والخلطان المختلفة بالنسبة لكفاءتها فى التحويل الغذائى .