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Correlation between liver weight and blood serum biochemical parameters in force fed interspecific hybrid ducks

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Summary. Interspecific hybrid ducks, obtained by crossing domestic with Muscovy, are crammed and compared to controls. Cramming causes significant differences in the blood serum GOT, GPT, cholesterol and amylase levels. Significant differences in the major parameters are also found between large-liver and small-liver animals and with high weight gain or low gain.

The following correlations are : liver size and GOT, $r = +0.583$; liver size and GPT, $r = +0.490$; liver size and cholesterol, $r = +0.324$. The correlation between relative gain during force feeding and GOT level is $r = +0.483$; between that gain and GPT it is $r = +0.421$.

Introduction

Because of the large demand for goose liver and its high price, interspecific hybrid ducks are used for large-liver production. These birds are crosses of Muscovy, Pekin and other domestic duck breeds ; they are raised to a large extent in Japan, France and Hungary. Stasko (1973) reported on the production of these hybrids and their performance in Czechoslovakia.

There has been much work done in the last ten years on the physiological factors affecting liver development in goose. Structural alteration of hepatic tissue due to force feeding is summarized by Baldissera-Nordio (1974) and Trefny *et al*, (1974). According to Blum *et al.* (1970), serum albumin level is closely correlated to liver size. Cornelius (1970) advances a similar opinion. Nir (1972) found a significant negative correlation between liver weight and serum protein ($r = -0.341$) and serum albumin ($r = -0.543$). Yaman *et al.* (1973) reported that serum albumin increased during force feeding while the globulin decreased.

Blum *et al.* (1970), Baldissera-Nordio (1971) and Sova and Nemec (1972) observed a higher bilirubin level in the serum after force feeding. Sova *et al.* (1971) reported that cholesterol augmented from 143 to 233 mg as a result of force feeding. This rise was also observed by Blum *et al.* (1970) and Baldissera-Nordio (1971). Niespodziewanski (1971) studying the effect on the liver of force feeding, recorded an increase in cholesterol, protein, hydrocarbon and red blood count values. Sevcikova *et al.* (1974) found a decrease in α-lipoprotein level from 60.9 and 62.8 p. 100 to 26.6 and 19.5 p. 100, respectively, during force feeding. A β-lipoprotein increase was noted.

Ivorec-Szylit and Szylit (1969) observed that plasma LDH (lactate dehydrogenase) level of geese, force fed for liver production, rose from day 5 to day 8 of force feeding. It then dropped in all birds with positive steatosis. Losonczy (1970) and Link and Losonczy (1971) reported that geese with a lower amylase level at the end of force feeding had fatter (larger) livers. These authors believed this result could be used as an index of optimum slaughter time ; geese slaughtered when amylase level was minimum had a 30 p. 100 heavier liver than the controls.

Leclercq and Blum (1971) in three force feeding experiments on geese, noted variations in blood serum GOT (glutamate oxalacetate transaminase), GPT (glutamate pyruvate transaminase) and LDH levels. They observed significant positive correlation between GOT and GPT levels and liver weight at the end of the experiments, and a slight correlation between GPT and liver weight.

In this report, we study some biochemical indicators of liver steatosis in interspecific hybrid ducks to determine if these indices can be used to estimate liver size.

Material and methods.

Five combinations (3 males and 3 females each) of interspecific hybrid ducks were used in this experiment. Muscovy drakes were mated with Small broiler duck, Pekin, Campbell and with interbred hybrids Campbell $\times$ Small broiler duck and Small broiler duck $\times$ Campbell.

The Alsace force feeding method was employed ; birds were crammed twice daily with steamed maize for 21 days. The animals were 142 days old at the end of the force feeding. Feed comsumption was 6-7 kg/kg of body weight gain and 22-28 kg/kg of liver produced.

Live weight was ascertained at the beginning of force feeding and a 10 ml blood sample was drawn from the wing vein. At the end of force feeding live weight was noted ; true body gain was expressed in kg and relative body gain as a percentage of the initial weight. A blood sample was taken for a second time after fattening. Five birds died during force feeding. They were replaced by animals of the same combination, the fattening test being carried out with a larger number of birds. Thus, the correlation between biochemical markers determined at the beginning of fattening and the performance of birds at the end of the period is not evaluated in this study.

GOT and GPT levels were measured using the Biotest from Labora Brno (Reitman and Frankel, 1957). Cholesterol level was determined by Watson's method (1960). Blood serum refraction was measured at 20 °C with an Abbe model refractometer. Total sugar content was determined using Smith and Roe's Antron method (1949).

Results.

Biochemical variation due to force feeding.

There was no significant difference in the refractometric values of serum proteins and lipids in the force fed and control animals. Total sugar content was similar in the two groups, while there was high individual variability within the groups. Force feeding increased blood cholesterol from 219.8 to 339.6 mg (54 p. 100 increase). Individual variability of this character was rather low, particularly in the controls. However, we found a highly significant difference in serum cholesterol between force fed and control ducks.

The most evident variations caused by force feeding were noted in the transaminases. Before force feeding GOT level usually reached 0.784 μmol ; after four weeks of force feeding it increased to 3.45 μmol (30 p. 100 increase). This difference in enzyme level prior to and at the end of fattening is highly significant (table 1). Individual

TABLE 1

Marker traits in force fed and control ducks

Physiological state		Marker traits							
		Refraction	Total sugar mg/100 ml of serum	Cholesterol mg/100 ml of serum	GOT μmol/ml of serum	GPT μ mol/ml of serum	Amylase units/ml of serum	Liver weight g	Relative gain p. 100
Prior to force feeding	$\bar{x}_1$	1.344 5	150.0	219.8	0.784	0.532	35.16	—	—
	s_1	0.22	82.0	38.2	0.423	0.370	12.20	—	—
At the end of force feeding.	$\bar{x}_2$	1.344 7	152.0	339.6	3.450	2.950	44.80	297.2	52.7
	s_2	0.20	74.0	85.5	1.760	1.610	9.49	149.0	16.6
Difference $\bar{x}_1 - \bar{x}_2$		—	—	54	340	454	27	* t 0.05 = 2.05 ** t 0.01 = 2.76 N = 28 * = significant ** = higly significant	
Significance of the difference		0.058	0.66	8.55**	8.69**	8.45**	6.93**		

variability of the character was also high prior to fattening and thus at the end of the period. GPT level reached 0.532 μmol in the controls and 2.95 μmol in the force fed ; this represents a 454 p. 100 increase. The difference between the levels prior to and at the end of force feeding is highly significant. The variability of this enzyme activity is higher than that of GOT before and after fattening.

Amylase content only increased from 35.16 to 44.80 units (27 p. 100) due to force feeding. However, this difference is highly significant. Individual amylase variability was low in force fed birds while it was mean in the controls.

Liver weight and biochemical parameters.

The force fed ducks were divided into two groups of 15 birds each according to liver weight which ranged from 75 g to 575 g. Mean liver weight in better force fed ducks was 421.3 g while in the poorer animals it was 173.1 g. Mean liver weight of the 30 force fed ducks was 297.2 g.

We also whished to see if liver size affected the biochemical parameters used for determining the degree of liver fatness. Duck liver size appeared to be correlated to serum refraction, total sugar content and amylase (table 2). Differences in blood

TABLE 2

Correlation between biochemical traits and liver size

Group		Marker traits						
		Liver weight g	Refraction	Total sugar mg/100 ml of serum	Cholesterol mg/100 ml of serum	GOT µmol/ml of serum	GPT µmol/ml of serum	Amylase units/ml of serum
Large liver ..... n = 15	$\bar{x}_1$	421.3	1.344 8	152.0	375.3	4,64	3.85	44.88
	s_1	81.6	0.203	81	61.8	1.51	1.41	11.20
Small liver ...... n = 15	$\bar{x}_2$	173.1	1.344 5	154.0	303.9	2.25	2.05	44.68
	s_2	81.6	0.202	66.0	93.8	0.94	1.28	7.82
Difference $\bar{x}_1 - \bar{x}_2$ in per cent		143	—	—	23.3	106	87	—
Significance of the difference		4.03**	0.06	1.00	3.91**	7.76**	11.7**	0.09

cholesterol were relatively lower (303.9 mg and 375.3 mg), but significant (23.3 p. 100). GOT level in ducks with smaller livers reached 2.25 µmol, while it was 4.64 µmol in ducks with larger livers (16 p. 100 increase). Thus, the difference between the large-liver and small-liver groups is highly significant. GPT level in the latter group reached 2.05 µmol while in the former it was 3.85 µmol. This constitutes an 87 p. 100 increase and is also highly significant.

Body weight gain and biochemical parameters.

The mean gain in force fed ducks was 52.7 p. 100, ranging from 25.8 to 92.3 p. 100. Birds were divided into two groups according to weight gain, a high-gain group (mean 65.47 p. 100) and a low-gain group (mean 39.90 p. 100). These groups were significantly different.

There was no significant difference between the two groups as to blood serum refraction, total sugar level or amylase. The difference in serum cholesterol was relatively slight (325.4 mg and 353.8 mg) ; it is statistically non-significant. Serum cholesterol showed only a 8.9 p. 100 gain in the high-gain group. The low-gain group had a GOT level of 2.62 μmol and the high-gain group 4.26 μmol. The difference (62.2 p. 100) is highly significant (table 3). GPT level in the low-gain group was 2.18 μmol while it was 3.73 μmol in the high-gain group. This difference (70.6 p. 100) is highly significant.

TABLE 3

Correlation between biochemical traits and weight gain

Group		Marker traits						
		Relative gain p. 100	Refraction	Total sugar mg/100 ml of serum	Cholesterol mg/100 ml of serum	GOT μmol/ml serum	GPT μmol/ml serum	Amylase units/ml of serum
High weight gain...	$\bar{x}_1$	65.47	1.344 4	156.0	353.8	4.26	3.72	44.93
n = 15...........	s_1	11.44	0.157	75,0	58.9	1.63	1.50	11.27
Low weight gain ...	$\bar{x}_2$	39.90	1.344 9	148.0	325.4	2.62	2.18	44.63
n = 15...........	s_2	9.11	0.213	76.0	109.5	1.47	1.40	7.74
Difference $\bar{x}_1 - \bar{x}_2$ in per cent		18.0	—	—	8.9	62.6	70.6	—
Significance of the difference		14.3**	0.04	1.40	1.19	8.63**	10.6**	0.13

Correlations between traits studied (table 4).

Since some biochemical blood serum components increased during force feeding and there was a significant difference in some biochemical traits in high and low per-

TABLE 4

Phenotypic correlation between steatosis markers and performance characteristics

Performance characteristic	Markers					
	GOT	GPT	Cholesterol	Amylase	Weigth gain	
					Relative	True
Liver	+ 0.583**	+ 0.490**	+ 0.324	+ 0.116	+ 0.542**	+ 0.525**
Relative weight gain	+ 0.483**	+ 0.421*	+ 0.080	+ 0.205	—	—

formance birds, we computed the correlation between the traits to determine if they would be useful selection criteria. Calculating the correlation between liver size on one hand, and relative (r = + 0,542) and true (r = + 0.525) body weight gain on the other, we concluded that relative weight gain is a more reliable marker for estimating liver steatosis.

There was a fairly high correlation (r = + 0.583) between liver weight and GOT. Correlation between liver weight and GPT was mean (r = + 0.490) ; between liver weight and cholesterol level it was lower (r = + 0.324), but still fairly evident. Using one character (GOT, GPT or cholesterol level) for selection, we succeeded in choosing the 12 best ducks from the 15 better birds. The correlation between relative weight gain and liver size was r = + 0,542 and it ranks second to GOT.

There is also evident but lower correlation between body weight gain and the markers studied. The highest correlation was found between relative gain and GOT level (r = + 0,483), followed by GPT (r = + 0.421) and amylase (r = + 0.205) ; the correlation between weight gain and cholesterol is practically negligible (r = + 0.080).

Discussion.

Results obtained using biochemical markers to study steatosis in interspecific hybrid ducks are comparable to those obtained in geese. There was no difference in blood sugar between force fed and control ducks. This result does not agree with those of Niespodziewanski (1971) who found an increase in serum sugar of goose. The most surprising find is that blood serum refraction in force fed and control ducks is not different despite the large discrepancies seen in the sera with the naked eye. Blood serum refraction expresses the protein and sugar levels and the alteration of some components due to steatosis may be balanced by increasing or decreasing other components. Decreased albumin and total protein levels are probably balanced by cholesterol increase, as indicated by Nir (1972). This highly significant increase due to force feeding corresponds to results obtained by other authors cited (Blum *et al.*, 1970 ; Baldissera-Nordio, 1971 ; Sova *et al.*, 1971), except that the level is generally higher in geese (Sova *et al.*, 1971). The highly significant differences in GOT and GPT level in force fed and control ducks agree with the results of Leclercq and Blum (1971).

The percentage of blood amylase increase found does not agree with the results of Losonczy (1970) and Link and Losonczy (1971), who report a decrease in serum amylase after force feeding geese. However, our findings do confirm those of Forenbacher (1969) who reported an increase in amylase and lipase levels from week 1 of force feeding. At the end of week 3 these levels stabilized or increased.

There is close correlation between cholesterol, GOT and GPT levels and liver size in ducks in our experiment. The difference in amylase is not significant. Only GOT and GPT levels seem to be correlated with body weight gain ; differences in cholesterol and amylase levels are non-significant.

The correlation between weight gain during force feeding and liver size at the end of force feeding is high (r = + 0.542). This confirms the results of Bögre (1959) who reported a correlation of r = + 0.5 between goose weight gain and liver weight, and those of NIR (1972) who found that *r* = + 0.597. The low mean correlation between liver size and serum cholesterol (r = + 0.324) cannot be compared to other results or to geese because it has not yet been studied. However, it roughly corresponds to cholesterol increase due to force feeding. The correlations between liver weight and GOT and GPT activity observed in interspecific hybrid ducks are similar to the results of Leclercq and Blum (1971) studying goose. However, contrary to these authors, who found a low correlation between liver weight and GPT level, we noted a relatively higher correlation between these indicators.

Blood serum biochemical traits characterize the physiological distinctions between ducks before and after force feeding ; these correlations resemble those in geese. Serum cholesterol, GOT and GPT levels in force-fed birds are reliable criteria for determining liver steatosis, and, to a lesser degree, for characterizing subcutaneous and inner fat deposits.

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Résumé. Chez des canards obtenus par croisement de races domestiques et moscovites, le gavage entraîne des différences significatives dans la teneur du sérum en GOT, GPT, cholestérol et amylase, par rapport aux animaux témoins. Pour les paramètres principaux, on observe également des différences significatives selon que les canards ont un petit ou un gros foie et ont pris plus ou moins de poids.

Les corrélations observées sont les suivantes : poids du foie et GOT : r = + 0,583 ; poids du foie et GPT : r = + 0,490 ; poids du foie et cholestérol : r = + 0,324 ; gain de poids relatif pendant le gavage et GOT : r = + 0,483 ; gain de poids et GPT : r = + 0,421.

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