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Compensatory growth in broilers following water restriction

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ABSTRACT

The effects of timing (from 2 days to 6 weeks of age) and duration (1-5 weeks) of restricted water intake on compensatory growth of broilers were studied. In the water restricted groups access to water was limited to three 15-minute periods per day, at 07:00, 12:00 and 17:00 h.

If water was restricted for 1 to 3 weeks, the chicks were able to compensate later for body weight losses. If restriction lasted for 4 or 5 weeks, the chicks did not fully compensate. A one week-period of water restriction imposed during the first 3 weeks of age decreased the body weight of chickens significantly, which was later compensated. The same period of restriction imposed between the third and sixth weeks of age had no effect on the body weight of chickens.

KEY WORDS: broilers, water restriction, compensatory growth

INTRODUCTION

The ability of animals to compensate for a period of growth retardation has been studied by many authors. Some of the main factors affecting the ability of animals to recover from growth depression are severity, duration and the age at the commencement of restriction. Various programs of undernutrition have been the most common forms of restiction (Auckland and Morris, 1971 a,b; Washburn, 1977; Washburn and Bondari, 1978; Marks, 1978, 1979). Recently new papers have appeared concerning compensatory growth in broilers (Plavnik and Hurwitz, 1985, 1988, 1989; Ślósarz and Kapkowska, 1988; Ballay et al., 1992; Lesson et al., 1992; Plavnik and Balnave, 1992; Roth et al., 1993).

Some authors recommend feed restriction. Early-life feed restriction programs, designed to decrease body fat and improve feed efficiency in broiler chickens, rely on the phenomenon of compensatory growth to achieve final body weights equivalent to those of broilers fed *ad libitum*. After a period of severe feed restriction in one-week-old broilers, Plavnik and Hurwitz (1985) observed accelerated growth, responsible for almost complete recovery of body weight at market age. Fontana et al. (1992) stated that broilers were not able to fully compensate in growth when severe feed restriction was imposed early in life.

In view of the inconsistencies reported above, two experiments were conducted to examine further the phenomena of compensatory growth in broilers. Water was the restrictive agent used in these experiments. The role of water, a very important nutrient has usually been overlooked. Marks (1980) suggests that it is possible that appetite in its fullest sense is a composite of both feed and water intake instead of feed intake alone. Gerry (1980), Marks (1980) and Marks and Brody (1984) have studied the influence of water restriction on body weight of broilers, and, conversely, Pinchasov et al. (1984) have investigated the effect of feed restriction in meat type chicks on water intake.

The purpose of this study was to define the influence of water restriction on growth retardation and estimate the ability of broilers to compensate for it.

MATERIAL AND METHODS

This study was carried out in the experimental farm of the University of Maine. Two experiments were conducted using broilers of a commercial strain. The chickens were housed in environmentally controlled rooms in a battery brooder up to 4 weeks and in rearing batteries from 4 to 7 weeks.

Experiment 1 was conducted to study the compensatory growth of broilers following water restriction for one, two, three, four or five weeks, beginning with one-week-old chickens. There were 6 treatments, each treatment was replicated four times with 10 birds per cage.

In Experiment 2, a one-week period of water restriction at various ages of chickens was imposed. Seven treatments, each with four replications, were used with 10 birds per cage. Both experiments were carried out simultaneously using one common control group. For experimental design see Table 1.

During periods of water restriction in both experiments, water access was limited to three 15-minute periods per day, at 07:00, 12:00 and 17:00 h. After the period of restriction chicks were returned to *ad libitum* water supply. All birds were provided with *ad libitum* access to starter diet to 28 days and finisher diet from 29 to 49 days of life (Table 2). The room was lighted from 07:00 to 19:00 h.

TABLE 1

Water access during consecutive weeks of chickens life

	Unlimited	Restricted	Unlimited
Experiment 1			
Treatment 1	Unlimited	throughout	experiment
2	1	2	3–7
3	1	2–3	4–7
4	1	2–4	5–7
5	1	2–5	6–7
6	1	2–6	7
Experiment 2			
Treatment 1	Unlimited	throughout	experiment
2	–	2d–1	2–7
3	0–1	2	3–7
4	1–2	3	4–7
5	1–3	4	5–7
6	1–4	5	6–7
7	1–5	6	7

TABLE 2

Diet composition, %

Ingredients	Starter	Finisher
Ground maize	54.02	60.48
Soyabean meal (48% CP)	29.20	19.80
Lucerne meal	–	1.25
Fish meal	2.50	2.50
Meat-and-bone meal	2.50	2.50
Maize gluten meal	2.50	3.75
DL-Methionine	0.04	–
Dicalcium phosphate	0.50	0.45
Limestone	0.80	0.70
Vitamin mix[a]	1.00	1.00
Mineral mix[b]	0.58	0.58
Iodized salt	0.35	0.35
Stabilized fat	5.75	6.30
Choline chloride	0.26	0.34
Calculated composition:		
Crude protein, g/kg	240.8	209.9
Metabolizable energy, kcal/kg	3219	3302
Lysine, g/kg	12.1	8.7
Methionine + cystine, g/kg	8.7	6.7
Available phosphorus, g/kg	4.2	4.1

a – supplied per kg of diet: vitamin A,12000 IU; vitamin D_3, 3000 ICU; vitamin E, 37.5 IU; riboflavin, 10 mg; pantothenic acid, 20 mg; choline, 2 g; niacin,100 mg; thiamine,10 mg; pyridoxine, 10 mg; vitamin K, 1.5 mg; vitamin B_{12}, 100 mcg; folic acid, 2 mg and ethoxyquin, 150 mg

b – supplied per kg of diet: Mn, 100 mg; Fe, 100 mg; Cu,10 mg; Co,1 mg; I,1 mg; Zn,100 mg

Birds were weighed individually at weekly intervals. Feed intake was recorded weekly for each cage, water intake on a daily basis.

Two-way analysis of variance with interaction for data concerning body weight was conducted, the main factors were sex and treatment (Harvey, 1990).

RESULTS

Experiment 1

Control birds with unlimited access to water consumed at consecutive weeks of age 27, 68, 116, 159, 209, 235 and 255 g of water per day, per chick, respectively. Water/feed intake ratio in respective weeks was 2.0, 1.9, 2.0, 2.0, 2.0, 1.6 and 1.9.

Water-restricted chicks in the first week of restriction drank about 20-28% less than controls, however, with each successive week their water intake increased. Body weights of chicks after one week of water restriction were significantly ($P \leqslant 0.01$) lower in all groups (Table 3) except group 4. The withdrawal of water restriction after one week resulted in an increase in body weights almost up to the level of the control group. Chicks from groups 3 and 4, water-restricted for 2 or 3 weeks, needed a longer period of time (2 weeks) to attain similar body weights as the controls. If water restriction was extended to 4 or 5 weeks, the body weight of chicks at the end of experiment was significantly ($P \leqslant 0.01$) lower than in the control group. Interaction between the main effects was not significant, sex differences were significant in all treatments.

Weight gains (Fig. 1) throughout the period of water restriction were significantly ($P \leqslant 0.01$) lower than in the control group. After reintroducing water *ad libitum* the weight gains were slightly higher than in the controls, however, significantly higher only in group 5.

Water restriction resulted in a decrease in feed intake by 13-20% in the first week, by 14% after 2-4 weeks and by only 6% after 5 weeks of restriction compared to birds watered *ad libitum*. After the withdrawal of water restriction feed intake in the experimental groups was similar to that in the control group.

Throughout 7 weeks of the experiment, only birds from groups 5 and 6 consumed significantly less feed than the controls. Feed efficiency during that time was slightly better in restricted birds but no statistical difference was found. Statistical evaluation of feed consumption and feed efficiency data is presented in Table 5, but those data should be taken with caution, since only four replications in each group were made and the sex ratio in groups was not equalized.

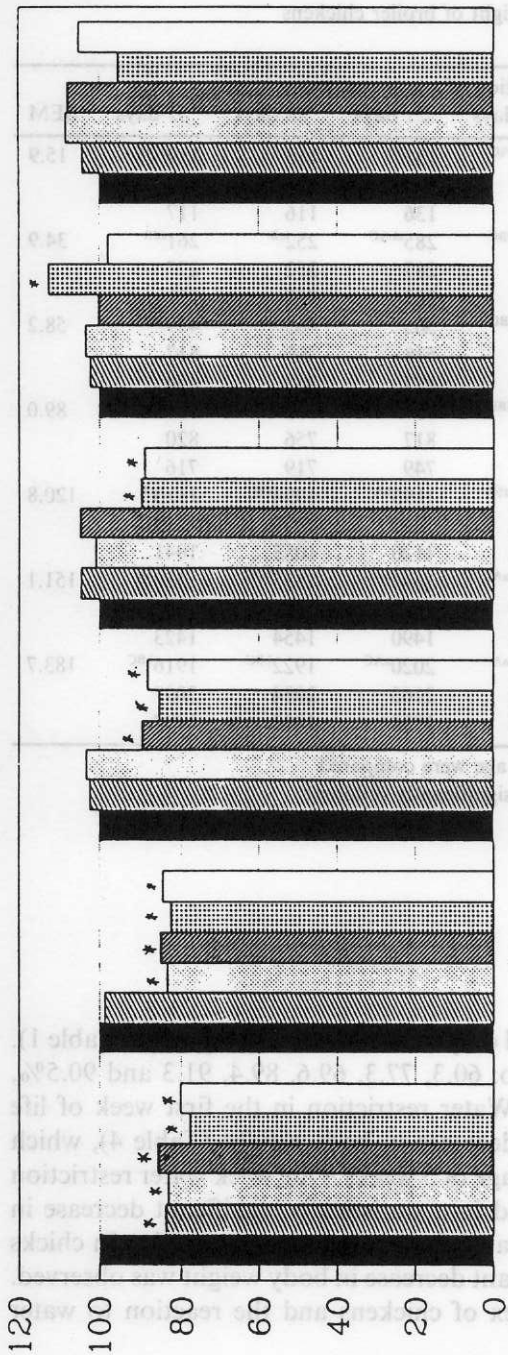

Figure 1. Experiment 1. Relative body weight gain of broilers (BWG of control as 100 %)
Significantly different from control group * $P \leq 0.01$

TABLE 3

Effect of water restriction on average body weight of broiler chickens (Experiment 1)

Body weight, g		Duration of water restriction: Control	7 days	14 days	21 days	28 days	35 days	SEM
Day 7	♂ ♀	120^{aAC}	126^{abAB}	125^{acAC}	135^{bB}	115^{cC}	119^{acAC}	15.9
	♂	124	128	125	133	114	122	
	♀	119	122	125	136	116	117	
Day 14	♂ ♀	297^{aA}	273^{bdBC}	271^{bdBC}	285^{abAC}	252^{cB}	261^{cdB}	34.9
	♂	319	279	278	287	252	277	
	♀	284	264	266	283	253	251	
Day 21	♂ ♀	554^{aA}	527^{bcA}	486^{cdBD}	505^{bdBC}	465^{cD}	479^{cdBD}	58.2
	♂	611	549	503	518	469	517	
	♀	521	496	471	487	462	454	
Day 28	♂ ♀	870^{aA}	851^{adAD}	812^{bdBD}	787^{bcBC}	735^{cC}	757^{cC}	89.0
	♂	967	893	864	817	756	820	
	♀	814	789	767	749	719	716	
Day 35	♂ ♀	1266^{aA}	1255^{aA}	1212^{abA}	1193^{bA}	1094^{cB}	1110^{cB}	120.8
	♂	1437	1335	1308	1250	1149	1212	
	♀	1168	1137	1130	1120	1053	1041	
Day 42	♂ ♀	1677^{aA}	1674^{aA}	1636^{aAC}	1604^{acAC}	1555^{bcBC}	1510^{bB}	151.1
	♂	1913	1790	1779	1692	1692	1642	
	♀	1540	1504	1513	1490	1454	1423	
Day 49	♂ ♀	2062^{aA}	2075^{aA}	2053^{aA}	2020^{aAC}	1922^{bBC}	1916^{bBC}	183.7
	♂	2340	2242	2274	2163	2084	2097	
	♀	1901	1830	1864	1834	1803	1794	

average body weights of chickens at the same age were compared
means not sharing a common superscript are significantly different
a, b – $P<0.05$
A, B – $P<0.01$

Experiment 2

Water intake in birds was restricted only for one week in all groups (Table 1). In consecutive groups it amounted to: 60.3, 77.3, 69.6, 89.4, 91.3 and 90.5%, respectively, of control bird intake. Water restriction in the first week of life resulted in a statistically significant decrease in body weight (Table 4), which was compensated for as late as at the age of 5 weeks. One week water restriction in chicks aged 1-3 weeks also resulted in a statistically significant decrease in body weight (Table 4) to be compensated for in the following weeks. In chicks aged 3-6 weeks no statistically significant decrease in body weight was observed. There was no interaction between sex of chickens and the reaction to water restriction.

TABLE 4

Effect of water restriction lasting one week on average body weight of broiler chickens (Experiment 2)

Body weight, g		Age at beginning of restriction: Control	5 days	7 days	14 days	21 days	28 days	35 days	SEM
Day 7	♂ ♀	120^{aA}	98^{bB}	126^{acA}	126^{acA}	121^{aA}	129^{cA}	129^{cA}	15.0
	♂	124	101	128	126	122	130	125	
	♀	119	96	122	126	119	128	131	
Day 14	♂ ♀	297^{A}	261^{B}	273^{B}	302^{A}	299^{A}	313^{A}	308^{A}	36.4
	♂	319	268	279	306	306	317	307	
	♀	284	250	264	299	288	310	308	
Day 21	♂ ♀	554^{acAB}	517^{bA}	527^{abAB}	519^{bA}	563^{cdBC}	587^{dC}	565^{cdBC}	59.7
	♂	611	543	549	531	578	610	571	
	♀	521	481	496	505	535	565	562	
Day 28	♂ ♀	870^{aAA}	823^{bA}	851^{abAC}	852^{abAC}	840^{abAC}	914^{cB}	883^{acBC}	92.4
	♂	967	871	893	883	866	965	914	
	♀	814	757	789	817	794	866	863	
Day 35	♂ ♀	1267^{ab}	1215^{a}	1255^{ab}	1245^{ab}	1236^{ab}	1287^{b}	1261^{ab}	124.9
	♂	1437	1296	1335	1298	1278	1366	1317	
	♀	1168	1101	1137	1184	1156	1213	1225	
Day 42	♂ ♀	1677^{AB}	1651^{AB}	1674^{AB}	1655^{AB}	1676^{AB}	1730^{A}	1614^{B}	165.7
	♂	1913	1779	1790	1730	1746	1849	1700	
	♀	1540	1471	1504	1570	1546	1618	1558	
Day 49	♂ ♀	2062^{AB}	2028^{AB}	2075^{AB}	2029^{AB}	2054^{AB}	2123^{A}	1982^{B}	207.3
	♂	2340	2189	2242	2127	2170	2279	2111	
	♀	1901	1802	1830	1916	1841	1975	1900	

average body weights of chickens at the same age were compared
a, b, A, B – as in Table 3

Water restriction beginning with 2-day-old chickens (group 2) had the most adverse effect on feed intake. The lower feed intake in this group was maintained even after the withdrawal of water restriction. Also in groups 3, 4, and 5 a significant decrease in feed intake during the period of water restriction was found. One week water restriction in chicks older than 5 weeks did not decrease feed intake significantly. Cumulative feed intake as well as feed efficiency for 7 weeks were slightly better in all restricted groups but the differences were not statistically significant.

DISCUSSION

Water intake by control birds was similar to that reported by Marks (1980) and slightly higher than that found by Kapkowska (1980). It was recognized

that many factors might affect water intake, among others the genetic origin of the chickens, their growth rate, source and concentration of dietary protein, physical form of diet and ambient temperature (Kapkowska, 1980; Marks, 1980; Marks and Brody, 1984).

No statistically significant effect of water restriction on body weight was found in 3-6 week-old chicks. The results of Gerry (1980) indicate that between the fifth to eighth week of age the time of water availability could be reduced to 15 min per hour without adverse effect on performance of broilers in cages.

Compensatory growth in broilers is a complex and still not fully understood phenomenon, producing varied responses to different restriction programs. A primary objective of this study was to define the extent of compensatory growth under conditions of water restriction which consequently caused reduced feed intake. Pinchasov et al. (1987) found a high positive correlation between water and feed intake. In the experiment of Proudman and Opel (1981) feed restriction and water restriction were equally effective in limiting the growth of young turkey poults. There have been several studies on the effect of restricted length of feeding time on the growth of broilers and feed consumption. McCartney and Brown (1977) reported that growth in broiler males was not adversely affected by limiting the feeding time by as much as 15 min each two hours, however, the same feeding time in each three or four hours did result in a significant decrease in body weight.

In our experiment, if the water restriction period lasted for 1-3 weeks beginning with one-week-old birds, chickens could compensate for the decrease in body weight up to 49 days of age. This also applies to chicks up to three weeks of age, water-restricted for one week only. These findings are in agreement with those of Plavnik and Hurwitz (1988, 1989, 1991), Plavnik et al. (1986), Jones and Farrell (1992 a,b), Zubair and Lesson (1994), who reported compensatory growth in broilers following early feed restriction. Other investigators (Mollison et al., 1984; Pinchasov and Jansen, 1989) have observed significantly lower body weights but improved feed efficiency in feed restricted broilers when compared with *ad libitum* controls at various market ages.

With water restriction lasting for 4-5 weeks the broilers did not compensate fully for body mass losses, which indicates that a period of 2-3 weeks of unrestricted water supply at the end of the fattening periods is too short for full body weight recovery.

In both experiments broiler males were more sensitive than females to water restriction and they displayed slower compensatory growth. Ślósarz and Kapkowska (1988) have observed a similar phenomenon with respect to feed restriction in broilers.

In summary, feed restriction in broilers is worth recommending, but should be started at an early age in order to leave the birds enough recovery period for

TABLE 5

Effect of duration of water restriction on average feed intake (g/week) (Experiment 1)

Group	Duration of water restriction, days	Weeks of age								g feed per g BW
		1	2	3	4	5	6	7	0-7	
Control		94	248	401	554	748	1101	931	4075	2.26
2	7	99	206	377	579	696	1079	927	3964	1.96
3	14	100	205	337^{xx}	548	717	1071	913	3890	1.93
4	21	107	217	346^{x}	481^{xx}	719	1084	951	3905	1.98
5	28	87	207	334^{xx}	476^{xx}	649^{x}	1082	953	3789^{x}	2.02
6	35	94	196^{xx}	326^{xx}	479^{xx}	625^{xx}	1035	919	3698^{xx}	1.96

x – $P<0.05$
xx – $P<0.01$, statistically different from control group

TABLE 6

Effect of water restriction imposed at various age on average feed intake (g/week) (Experiment 2)

Group	Age at beginning of water restriction, days	Weeks of age								g feed per g BW
		1	2	3	4	5	6	7	0-7	
Control		94	248	401	554	748	1101	931	4075	2.26
2	2	77^{xx}	211^{xx}	382	498^{x}	719	1097	912	3920	1.96
3	7	99	206^{xx}	377	579	696	1079	927	3964	1.96
4	14	98	234	345^{xx}	566	768	1119	943	4071	2.05
5	21	94	235	410	499^{x}	710	1103	951	4001	1.98
6	28	98	247	422	582	697	1130	976	4084	1.96
7	35	97^{x}	242	412	551	698	1055	949	4004	2.04

x – $P<0.05$
xx – $P<0.01$, statistically different from control group

manifesting compensatory growth, which is in agreement with observations of Plavnik and Hurwitz (1991) and Jones and Farrell (1992a). Feed restriction can be induced through water restriction but this requires much more caution.

The metabolic changes that permit compensatory growth are not fully understood. In the experiment of Proudman and Opel (1981) both feed and water restriction of growing turkeys resulted in an increase of plasma growth hormone (GH) level which remained elevated above control levels after returning to *ad libitum* intake. This may partially explain the compensatory growth phenomenon.

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STRESZCZENIE

Wzrost kompensacyjny u brojlerów w warunkach ograniczenia dostępu do wody

Badano wpływ terminu rozpoczęcia ograniczania wody (od 2 dnia życia do 6 tygodnia) i czasu trwania ograniczenia (1-5 tygodni) na zjawisko wzrostu kompensacyjnego u brojlerów. W grupach doświadczalnych dostęp do poideł był ograniczony do trzech 15-minutowych okresów w ciągu dnia o 7:00, 12:00 i 17:00. W przypadku ograniczania dostępu do wody od 1 do 3 tygodni kurczęta kompensowały straty masy ciała. Nie stwierdzono pełnej kompensacji wzrostu w przypadku ograniczenia dostępu do wody przez 4 lub 5 tygodni. Ograniczenie dostępu do wody przez 1 tydzień w ciągu pierwszych 3 tygodni życia powodowało obniżenie masy ciała, ale ptaki straty te kompensowały przed końcem tuczu; taki sam okres ograniczenia dostępu do wody u kurcząt starszych nie wpływał na przyrost masy ciała.