한국가금학회지 제 29권 제 4호, 259~263(2002)
Korean J. Poult. Sci. Vol. 29, No. 4, 259~263(2002)

Effects of Cecal Ligation and Colostomy on Food and Water Intake and Water Excretion in Chickens Fed Restrictedly and Freely

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닭에 있어서 사료섭취의 자유 및 제한급여시킬 때의 사료섭취량, 음수량 및 수분 배설량에 미치는 맹장결찰 및 인공항문 수술의 효과

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ABSTRACT : It was examined whether the ceca and the back-flow of urine into the lower intestine are involved in water intake and excretion in chickens and food intake affects those. Colostomy significantly increased water intake, total water excretion and the ratio of the water intake to food intake in the ceca-ligated chickens under restrict and *ad libitum* feeding conditions ($P<0.05$), but the increases were much larger in chickens fed ad libitum than in those fed restrictedly. Cecal ligation increased water intake, total water excretion and the ratio of water intake to food intake in the colostomised chickens which were fed freely ($P<0.05$), but not in those fed restrictedly. None of colostomy and cecal ligation affected the resultant water balances in chickens under both feeding conditions. Colostomy increased food intake in the ceca-ligated chickens ($P<0.05$), but no increase by cecal ligation was observed in colostomised chickens. It is concluded that the lower intestine takes a very important role in water recovery from urine to maintain water balance in chickens.

(Key words: cecal ligation, colostomy, water balance, ratio of water intake to food intake, chickens)

INTRODUCTION

The digestive tract of chickens contains a pair of outpocketing that project from the proximal colon at its junction with the small intestine (Clark, 1978). One very likely role that the lower intestine (coprodeum, colon and ceca) plays is that of water absorption. In the chicken ureteral urine drains into a posterior compartment of the cloaca, usually the urodeum, then moves into the coprodeum, colon and, to a certain extent, into the ceca and even the ileum. This retrograde, antiperistaltic movement has been demonstrated in chickens, using radiography (Akester et al., 1967) and in cecostomised chickens (Son et al., 2002).

Previously, we have reported that the lower intestine of the chicken may play an important role in the reabsorption of water when fed a low protein diet with or without urea (Son and Karasawa, 2000). The ceca are filled by two routs, the first is the small particles of ingesta from small intestine (Clemens et al., 1975; Björnhag and Sperber, 1977; Skadhauge, 1981), and the other is the urinary and digestive fluids from the cloaca through the colon (Akester et al., 1967; Fena and Boag, 1974; Björnhag, 1989). Many studies reviewed solute and water absorption and transport by the organs of the avian lower intestine. However, there is little information on relationship between food intake and water absorption at the lower intestine of chickens.

The aims of this study were to clarify whether the ceca and the back-flow of urine into the lower intestine are involved in water intake, excretion and economy in chickens and food intake affects those.

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MATERIALS AND METHODS

Twelve-month-old Single Comb White Leghorn cockerels, weighing 2.17±0.02 (mean±SEM) kg body weight, were used. The birds were individually housed in metabolism cages in a room light-controlled (14 L and 10 D) and maintained at 20±1.5℃. The control chickens were sham-operated. Surgeries for cecal ligation and colostomy were performed according to the method of Son et al. (1996) and Son and Nahm (1998), respectively. Prior to surgery birds were fasted for 12 h and anaesthetized with sodium pentobarbital (25 mg/kg body weight) via the wing vein. The ceca were ligated with a nylon thread (Gin-rin, No. 1.5, 0.205 mm) as near as possible to the cecal origin and an artificial anus was made in the colon. A small amount of Sulfisomidinum[1)] was sprinkled into the abdominal cavity of the chicken, and the body wall closed in three layers; muscular, subcuticular and skin. Two months after each operation, the chickens were used for experiments. Post-mortem inspections were done on all the ceca-ligated chickens to ascertain the completeness of the ligation.

All experimental chickens were fed a commercially available ration (mash type, a main ingredient is corn; 140 g/kg of crude protein, 25.0 g/kg of crude fat, 60.0 g/kg of crude fiber, 7.0 g/kg of calcium, 4.5 g/kg of phosphorus, 11.3 MJ/kg of metabolizable energy). In experiment 1, the experimental chickens were fed once daily 35.0 g per kg body weight per day (08:30), and given water *ad libitum*. In experiment 2, chickens had free access to the food and water. Water and food were provided by separate plastic troughs attached to the exterior of the cage. Water and food consumption and water evaporation from the troughs were determined daily. The consumption of water was corrected for the evaporated water loss (less than 3ml a day). The feces and urine were collected for the 12 day of each experimental period, using a polyethylene bag attached to the cloaca and the artificial anus, respectively. The collected excreta were immediately weighed then dried in a forced-air oven at 55℃ for 48 h.

Statistical differences were determined by an analysis of variance with mean separations performed by Duncan's new multiple range test using general linear model procedures of SAS (SAS Inst Inc. Cary, N. C. USA, 1998).

RESULTS

No significant changes in body weight by colostomy and caecal ligation were observed in chickens fed ad libitum and restrictedly. Table 1 shows the effects of cecal ligation and colostomisation on water intake and excretion when food supply was restricted. The water intake and total water excretion were

Table 1. Effects of cecal ligation and colostomy on water intake and excretion in chicken when fed with a restricted diet (g/ kg body weight/day, values are means of 5 chickens)

	Control	Ceca-Ligated	Colostomised	Colostomised plus Ligated	SEM
Water intake	70.1^a	78.4^a	94.8^b	101.8^b	7.1
Water excretion					
Feces			8.9^a	16.3^b	1.5
Urine			37.6	36.0	1.4
Total	31.7^a	32.9^a	46.5^b	52.3^b	2.6
Water balance	38.4	45.5	48.3	49.5	6.8
Water intake/food intake	2.00^a	2.24^a	2.71^b	2.91^b	0.13

^{a,b}Values with different letters in the same row are significantly different at $P<0.05$.

Water balance: (water intake) − (water excretion + evaporative water).

[1)] Iwaki Pharmaceutical Co., Tokyo

Table 2. Effects of cecal ligation and colostomy on water and food intake and water excretion in chicken when fed with a free access to diet (g/kg body weight/day, values are means of 5 chickens)

	Control	Ceca-Ligated	Colostomised	Colostomised plus Ligated	SEM
Food intake	42.1[a]	46.1[a]	61.5[b]	64.4[b]	2.7
Water intake	70.9[a]	106.6[b]	210.6[c]	335.0[d]	7.8
Water excretion					
Feces			10.7[a]	17.1[b]	0.4
Urine			151.6[a]	270.0[b]	17.2
Total	32.9[a]	60.1[b]	162.3[c]	287.1[d]	13.1
Water balance	38.0	46.5	48.3	47.9	12.5
Water intake/ food intake	1.68[a]	2.31[b]	3.32[c]	5.17[d]	0.15

[a~d]Values with different letters in the same row are significantly different at $P<0.05$.
Water balance: (water intake) − (water excretion + evaporative water).

significantly increased by colostomy in the ceca-ligated chickens ($P<0.05$), and the resultant water balances were not significantly different in these birds. The colostomy also increased the ratio of water intake to food intake in control and ceca-ligated chickens ($P<0.05$). However, cecal ligation did not change water intake, total water excretion and the ratio of water intake to food intake in colostomised chickens. Water excretion through feces was significantly increased by the cecal ligation in the colostomised chicken ($P<0.05$).

The effects of colostomy and cecal ligation when food was ad libitum fed to chickens were shown in Table 2. The water intake, total water excretion and the ratio of water intake to food intake were significantly increased by the colostomy in the ceca-ligated chickens and by the cecal ligation in the colostomised chickens ($P<0.05$). However, the resultant water balances were not significantly different in these chickens (Table 2). On the contrary of the results in restrict feeding experiment, the cecal ligation significantly increased water intake, total water excretion and the ratio of water intake to food intake in the colostomised chickens ($P<0.05$). Water excretion through feces was also increased by the cecal ligation in the colostomised chicken which was fed freely ($P<0.05$). The colostomy also increased food intake in the ceca-ligated chickens ($P<0.05$), but the cecal ligation did not affect it in the colostomised birds.

The increases in water intake, total water excretion and the ratio of water intake to food intake by the colostomy were much larger in the ceca-ligated chickens fed ad libitum than in those fed restrictedly.

DISCUSSION

A back-flow of urine from the cloaca through the colon into the ceca is known in chickens (Koike and McFarland, 1966; Akester et al., 1967; Skadhauge, 1968) and shown to be involved in the recovery of water from urine (Skadhauge, 1968). Colostomy prevents the back-flow and consequently the reabsorption of urinary water at the rectum and colon. In the present experiment the colostomy augmented water excretion and water intake, but not water balance. Therefore, the inhibition of recovery of urinary water by the colostomy might increase urinary water excretion and stimulate water intake to maintain water balance in the body.

It has been reported that the ratio of water intake to food intake is 2.06 in a normal chicken and food intake is closely correlated with water intake (Kampen, 1981). However, the ratio in the present experiment was significantly increased by colostomy in the ceca-ligated chickens to which the same amount of diet was fed. In addition, the ratios were 3.32 and 5.17 when food intake was increased by colostomy in the ceca-ligated chickens having free access to food. These results suggest that an increase in water intake is primarily regulated by the extent of reabsorption of urinary and intestinal fluid at the lower intestine more than by the amount of dry matter intake.

Control and ceca-ligated chickens having free access to food responded to a colostomy treatment with larger increases in water intake, total water excretion and the ratio of water intake to food intake as compared with those fed restrictedly. Cecal ligation increased water intake, total water excretion and the ratio of water intake to food intake in the colostomised chickens under ad libitum feeding condition, although caused no effect on those in chickens fed restrictedly. These findings indicate an involvement of food availability in water metabolism.

The ceca are filled by two routs, the first is the small particles of ingesta from the small intestine (Clemens et al., 1975; Björnhag and Sperber, 1977; Skadhauge, 1981), and the other is the urinary and digestive fluids from the cloaca through the colon (Akester et al., 1967; Fena and Boag, 1974; Björnhag, 1989). In the present experiment total water, fecal water and urinary water excretion were observed to be increased by cecal ligation in the colostomised chickens fed *ad libitum.* The data suggest that not only the back-flow of cloacal urine into the ceca is involved in water recovery but also is the entry of ingesta from the small intestine when food is always available. The present experiment further suggests that water from cloacal urine accounts for 95% of the water recovery at the ceca in ad libitum-fed chickens, because the increased amount of urinary water by cecal ligation in the colostomised chickens was about 20 times as much as that of fecal water.

Previously, we have reported that the lower intestine of the chicken may play an important role in the reabsorption of water when fed a low protein diet with or without urea (Son and Karasawa, 2000). The present experiment also indicated that the lower intestine plays a similar role in water intake and excretion in chickens fed a commercial diet ad libitum. It is therefore, concluded that the lower intestine takes a very important role in water recovery from urine to maintain water balance in chickens under various feeding conditions.

적 요

본 연구는 닭에 있어서 맹장을 포함한 하부소화관으로 요(尿)의 역류가 음수량 및 수분 배설량에 어떠한 영향을 미칠지를 또한 사료의 섭취량이 요 (尿)의 역류량에 어떤 영향을 미칠지를 시험하였다. 급여사료를 제한 및 무제한 급여의 양 조건에서 사육된 대조구 닭과 맹장이 결찰된 닭에 인공항문 수술을 실시하면 음수량, 총 수분배설량 및 음수량/사료섭취량이 유의하게 증가(P<0.05)하였으며 이 증가량은 사료섭취량을 무제한 급여하였을 때가 제한 급여하였을 때보다 더 크게 나타났다. 사료의 섭취량을 무제한으로 하였을 때에 대조구 닭과 인공항문이 장착된 닭에 맹장결찰 수술을 실시하면 음수량, 총 수분 배설량 및 음수량/사료섭취량이 유의하게 증가(P<0.05)하였지만, 제한급여 조건에서는 나타나지 않았다. 제한 급여 및 무제한 급여의 양 조건에서 수분균형은 인공항문 수술 및 맹장결찰 수술에 따른 변화는 나타나지 않았다. 대조구 닭과 맹장이 결찰된 닭에서의 인공항문 수술은 사료섭취량을 증가(P<0.05)시켰지만, 대조구 닭과 인공항문이 장착된 닭에서의 맹장결찰 수술은 사료섭취량에 영향을 미치지 않았다. 이상의 결과 닭에 있어서 맹장을 포함한 하부소화관은 수분균형을 유지하기 위해서 요 (尿)로부터 수분을 재 흡수하는 매우 중요한 역할을 하고 있다고 결론을 내린다.

(색인어: 맹장결찰, 인공항문수술, 수분배설량, 수분섭취량:사료섭취량, 닭)

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