Effect of Caecectomy on Body Weight Gain, Intestinal Characteristics and Enteric Gas Production in Goslings

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ABSTRACT : Two experiments of four-week duration were conducted to investigate the effect of caecectomy on the intestinal characteristics, body weight gain and gas production in the caeca of White Roman goslings. In experiment I, forty eight 2-wk-old female goslings with similar body weight were randomly divided into four treatments: sham (SHAM), left side caecum removed (LSCR), right side caecum removed (RSCR) and both caeca removed (CAECECTOMY). Smimilarly, experiment II was conducted with twelve 5-wk-old male goslings in two treatments: SHAM and CAECECTOMY. Free choice water with *ad libitum* feed was provided during experiment. At the end of experiment I, goslings were sacrificed and gut length and weight were determined. At 7 and 9 wks of age, birds in experiment II were subjected to respiration calorimetry studies. In both experiments, final body weights were not affected by caecectomy. Results of experiment I indicated that caecectomy did not significantly affect the relative weight (g/100 g BW) of gizzard, small intestine, rectum and colon ($p>0.05$); however, the relative length of colon and rectum did increase ($p<0.05$). The remaining caecum did not show compensatory growth in both LSCR and RSCR treatments. In experiment II, results indicated that the average enteric methane production from the caecetomised goslings was significantly lower than that from the bird in SHAM goslings ($p<0.05$). In comparison with SHAM goslings, calorific loss from entric methane in caecetomised birds was lower ($p<0.05$). There was no effect of age on methane production. The enteric nitrous oxide production in caeca of goslings was very low with no significantly different between two treatments. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 7 : 1030-1034)***

Key Words : Goslings, Caecectomy, Methane, Nitrous Oxide

INTRODUCTION

The caecum is the major organ for dietary fiber digestion in the poultry intestine and is considered to be the major fermentation site (Annison et al., 1968; Clemens et al., 1975; McBee, 1969) and also called as the "fermentation vat" (Gasaway, 1976a). Three groups of bacteria including fermentative bacteria, acetogenic bacteria, and methanogenic bacteria, are involved in the complete anaerobic degradation of organic matter leading to CO2 and CH4 production (Maynard et al., 1979; Smith and Bryant, 1979). Certain species of bacteria in the gut derive energy by reducing the waste CO2 with H2 to form methane (CH_4) (Hungate, 1966). Geese have a pair of well developed caeca and possess fine villi structure (Chen et al., 2002a). The goose caecum is rich in anaerobic bacteria that degrade cellulose. There are 2.7×10^9 *Peptostreptococci*, 1.7×10^8 *Clostridia*, 2.0×10^7 *Streptococci*, 9.0×10^4 *Bacteroides* and 2.3×10^4 *Lactobacilli*/g wet content in caeca of goslings (Mattocks, 1971). The two main role of caecum were acetogenesis (Clemens et al., 1975) and methane formation in birds (Tsukahara and Ushida, 2000) and acetogenesis is affected by age (Annison et al., 1968). Tsukahara and Ushida (2000) indicated that the cecal content of chicks during in vitro fermentation produced methane gas. However, little information is available concerning gas production in the caeca of goslings. Moreover, it is necessary to process caecum ligation or caecectomy when we study caecum functions in poultry and caecetomy provide a tool to study the role of caecum in metabolism. No information is available on the effect of caecum removed on the intestinal characteristics and enteric gas production in goslings. The purpose of this study was to investigate the effect of caecectomy on the intestinal characteristics, body weight gain, and gas production in the caeca of goslings. The energy lost in the air as methane due to fermentation was also calculated.

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MATERIALS AND METHODS

Animals and management

Experiment 1 : Sixty 1-day-old female White Roman goslings were obtained from the Taiwan Livestock Research Institute, Changhua Animal Propagation Station. Goslings were brooded in an electric brooder from 0 to 2 wks of age. Forty-eight 2-wk-old goslings with similar body weight were randomly divided into four treatments, including sham (SHAM), left side caecum removed (LSCR), right side caecum removed (RSCR) and both caeca removed (CACECTOMY). Goslings of each treatment were

Table 1. Composition of experimental diets (experiment 1)

Ingredients	Period	
	Starter (0-4 wk, %)	Grower (5-6 wk, %)
Yellow corn	51.60	54.55
Wheat bran	3.00	6.00
Soybean meal, 44%	29.10	20.20
Fish meal, 60%	3.00	3.00
Alfalfa meal, 17%	7.00	11.00
Tallow	3.50	2.90
Dicalcium phosphate	1.32	1.02
Calcium carbonate, pulverized	0.50	0.35
Salt	0.40	0.40
L-Lysine	-	-
DL-Methionine	0.20	0.20
Choline chloride, 50%	0.08	0.08
Premix*	0.30	0.30
Total	100	100
Caculated composition		
Crude protein, %	20.60	18.07
Crude fat, %	6.55	6.43
Crude fiber, %	5.39	6.22
ME, kcal/kg	2,826	2,800
Calcium, %	0.83	0.73
Available phosphorus, %	0.45	0.38

*Supplied per kilogram of diet: vitamin A, 15,000 IU; vitamin D_3, 3,000 IU; vitamin E, 30 mg; vitamin K_3, 4 mg; vitamin B_2, 8 mg; vitamin B_6, 5 mg; vitamin B_{12}, 25 mcg; Ca-pantothenate 19 mg; niacin 50 mg; folic acid 1.5 mg; biotin 60 mcg; Fe, 153 mg; Mn, 200 mg; Cu, 17.64 mg; Mg, 25.3 mg; Se, 0.25 mg; Zn,105.8 mg; Co, 0.4 mg.

allocated to three cages (90 cm×56 cm×60 cm) of 4 goslings each. Caecectomy was conducted according to the method of Chen et al. (2002b). The diets used at 0-4 wks of age and 5-6 wks of age were pelletted diets containing CP(%)/ME (kcal/kg) as 20.6/2826 and 18.07/2800, respectively (Table 1). Feed and water were supplied *ad libitum* and average room temperature was 18.7°C for a 4-wk experimental period (3-6 wks of age).

Experiment 2 : Twelve 5-wk-old goslings with similar body weight were randomly divided into two treatments, including SHAM and CAECECTOMY. Goslings of each treatment were allocated to four cages of 3 goslings each. Caecectomy was conducted as in experiment 1. Goslings were fed pellet commercial diets containing 22.5% crude protein, 6% crude fiber, and 3,150 kcal/kg metabolizable energy at 0-4 wks of age, and 16.0% crude protein, 7% crude fiber, and 3,240 kcal/kg metabolizable energy at 5-9 wks of age. The experiment lasted for 4 wks (6-9 wks age). Feed and water were supplied *ad libitum*.

Sampling and analytical procedure

Experiment 1 : Body weight of individual gosling and total feed intake of each cage were measured once a week throughout the experiment. At 6 wks of age, all goslings were weighed individually and sacrificed by neck vein bleeding. Gizzard, small intestine, caecum, colon and rectum were dissected individually to determine weight and length.

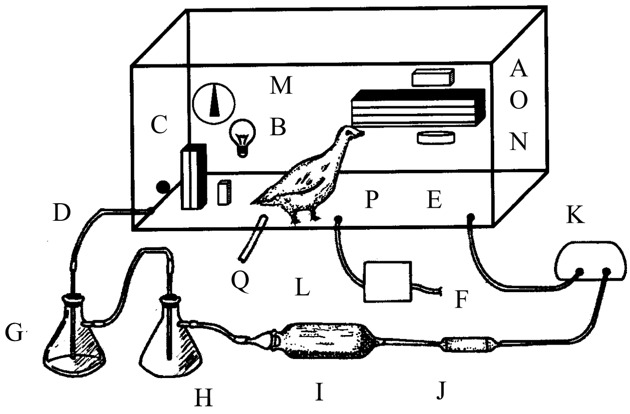

Figure 1. The respiration chamber and accessory equipment. A. fan, B. light globe, C. sample outlet, D. circulation outlet, E. circulation inlet, F. connected to oxygen tank, G. water trap (with desiccant), H. flask containing KOH, I. Water trap, J. filtration train, K. pump, L. timer and pressure valve, M. thermometer, N. hygrometer, O. radiator, P. inlet for oxygen, Q. power supply.

Experiment 2 : After the caecectomy operation, each gosling was weighed once a week. At 7 and 9 wks of age, two birds from each treatment were put into one closed respiratory chamber (90 cm×60 cm×60 cm) (Figure 1) as a unit of measurement. The air was circulated with a pump; CO_2 and vapor were absorbed to 10 N KOH and calcium chloride, respectively. The chamber temperature was maintained at 25 °C and was equipped with an oxygen tank, and oxygen was supplemented when the pressure gauge detected a drop of pressure below atmospheric pressure. The gas released from enteric fermentation in the goslings accumulated in the chamber were collected and analyzed for methane and nitrous oxide production. The gas samples were collected using a 35 ml syringe via the sample outlet at 0 hour and 4 h of the experiment. Samples were injected into a 15 ml serum bottle previously filled with N_2 using a replacing method. Five samples were collected at each sampling time and stored at room temperature for CH_4 and N_2O analysis. Methane was analyzed using gas chromatography (Shimadzu 14B) with a flame ionization detector (FID) using a Propark Q (0.32 mm×3 m) column and N_2 as the carrier gas. N_2O was analyzed with an electron capture detector (ECD) using a Propark Q (0.32 mm×3 m) column and P-10 (90% Ar+10% CH_4) as carrier gas. The calorific value of the methane was calculated as follows:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \quad \Delta H = -210.8 \text{ kcal/mol}$$

(Czerkawski, 1986)

Table 2. Effect of caecectomy on body weight gain, feed intake and feed efficiency in White Roman goslings (experiment 1)

Items	Treatments			
	SHAM	LSCR	RSCR	CAECECTOMY
Body weight gain	----g/ bird/day ----			
2-4 wks of age	82.0±4.3	78.2±10.0	80.4±9.0	76.6±14.3
4-6 wks of age	85.4±7.1	76.7±13.0	82.5±13.1	82.5±20.0
2-6 wks of age	83.7±4.6	77.4±9.0	81.4±8.7	79.5±15.2
Feed intake	----g/bird/day ----			
2-4 wks of age	183.7±5.5	175.8±8.9	181.1±3.8	173.3±11.2
4-6 wks of age	262.4±4.1	249.8±5.9	259.9±11.2	262.6±13.0
2-6 wks of age	223.0±4.8	212.7±2.6	220.5±0.8	217.9±10.6
Feed efficiency	----gain/feed----			
2-4 wks of age	0.447±0.018	0.445±0.015	0.444±0.005	0.441±0.022
4-6 wks of age	0.325±0.002	0.307±0.016	0.317±0.009	0.314±0.018
2-6 wks of age	0.386±0.010	0.376±0.014	0.381±0.003	0.378±0.017

SHAM: sham; LSCR: left side caecum removed; RSCR: right side caecum removed; CAECECTOMY: both side caecum removed.

Table 3. Effect of caecectomy on body weight and intestinal organ weight or length in White Roman goslings at 6 wks of age (experiment 1)

Items	Treatments			
	SHAM[1]	LSCR	RSCR	CAECECTOMY
	-------------------------------- g -------------------------------			
Body weight	3,593±166	3,399±303	3,472±471	3,421±542
	------ Relative weight with content (g/100 g BW) ------			
Gizzard	3.60±0.22	3.81±0.37	4.26±1.53	4.06±1.59
Small intestine	3.63±0.58	3.88±0.77	4.01±0.87	3.88±1.01
Colon and rectum	0.30±0.08	0.32±0.05	0.36±0.12	0.34±0.09
	------ Relative weight without content (g/100 g BW) ------			
Gizzard	3.48±0.27	3.68±0.34	4.14±1.55	3.95±1.54
Small intestine	1.86±0.26	1.82±0.13	1.78±0.20	1.89±0.14
Colon and rectum	0.23±0.02	0.26±0.04	0.25±0.04	0.25±0.03
	------------- Relative length (cm/100 g BW) ----------------			
Small intestine	6.75±0.37	6.87±0.71	6.71±0.45	6.77±0.73
Colon and rectum	0.47±0.04[a]	0.50±0.04[ab]	0.50±0.09[ab]	0.53±0.08[b]

[a-b] Means within the same row with the different superscripts differ significantly (p<0.05). [1] Same as Table 2.

Statistical analysis

All data were subjected to analysis of variance using the General Linear Model (GLM) of SAS (Statistical Analysis System, 1996). The Least Squares Means were used to compare and estimate the differences among treatments.

RESULTS

Experiment 1 : There were 2 birds dead after operation for 2 days in LSCR treatment, and the other birds were healthy during experimental period in this experiment. There were no significant differences (p>0.05) in body weight gain (g/bird/day), feed intake (g/bird/day) and feed efficiency (gain/feed) among the treatments in the entire experimental period (Table 2). However, SHAM goslings had a higher average daily gain than that in the CAECECTOMY treatment from 2 to 3 wks of age (67.7 vs. 54.4 g/bird/day, p<0.05; not show in Table 2).

The caecectomy effect on body weight and intestinal organ weight or length in the goslings at 6 wks of age are shown in Table 3. No significant differences were found in the gosling body weight among treatments. The relative weight (g/100 g BW) of the gizzard, small intestine, colon and rectum with or without content showed no significant differences among treatments (p>0.05). The relative length (g/100g BW) of the small intestine was not significantly different among treatments (p>0.05). However, the relative length of the colon and rectum in the CAECECTOMY treatment was longer than that in SHAM treatment (p<0.05).

Effect of one side caecum removal on the other side caecum weight and length in goslings at 6 wks of age are shown in Table 4. The relative weight with or without content and relative length of the left and right caecum in goslings at 6 wks of age from different treatments were not significantly different (p>0.05).

Experiment 2 : The effect of caecectomy on the average body weight gain and methane production in goslings are shown in Table 5. In this experiment, all birds were healthy during experiment period. Results indicated that SHAM goslings had higher average daily gain from 5 to 7 wks of age (p<0.05). However, there were no significant differences from 7 to 9 wks of age and the entire

Table 4. Effect of one side caecum removal on the other side caecum weight and length in White Roman goslings at 6 wks of age (experiment 1)

Items	Treatments		
	SHAM [1]	LSCR	RSCR
	-- Relative weight with content (g/100 g BW)--		
Left caecum	0.33±0.11	-	0.28±0.09 -
Right caecum	0.32±0.10	0.27±0.12	- -
	-- Relative weight without content (g/100 g BW) --		
Left caecum	0.11±0.03	-	0.12±0.02 -
Right caecum	0.12±0.03	0.12±0.01	-
	-- Relative length (cm/100 g BW) --		
Left caecum	0.87±0.12	-	0.79±0.09
Right caecum	0.89±0.12	0.82±0.10	-

[a-b] Means within the same row with the different superscripts differ significantly ($p<0.05$). [1] Same as Table 2.

experimental period ($p>0.05$). The average methane productions in SHAM goslings expressed as per bird basis or as per kg body weight basis were both significantly higher than that in the CAECECTOMY birds ($p<0.05$). Although methane production on a per bird basis increased with age, the age effect was not significantly different in both treatments ($p>0.05$). The calorific values of methane production on a per bird basis and per kg body weight in the SHAM goslings were significantly higher than that in the caectomised birds ($p<0.05$).

The enteric nitrous oxide production per bird or per kg body weight in goslings were both very low at 7 and 9 wks of age (Table 6), and there were no significant differences between the two treatments ($p>0.05$). Nitrous oxide production increased with age, but there were no significant differences between 7 and 9 wks of age in each treatment ($p>0.05$).

DISCUSSION

Experiment 1

The SHAM goslings had higher body weight gain than caectomised goslings at 2-3 wks of age. However, the body weight gain in the entire experimental period was not affected by removing one or both caeca. This implies that CAECECTOMY might cause stress and temporarily decrease nutrient absorption after operation and that the goslings have compensatory growth afterwards. In the same manner, resecting one caecum did not change the length or relative weight of the other caecum in goslings at 6 wks of age, that is to say, resecting one caecum did not result in compensatory growth in the other caecum. The relative length of the colon and rectum in the caectomised birds

Table 5. Effect of caecetomy on average body weight gain, methane production and calorific loss in goslings (experiment 2)

Items	Treatments	
	SHAM [1]	CAECECTOMY
Average weight gain	------ g/bird/day ------	
5-7 wk	87±12 ^{b}	70±13 ^{a}
7-9 wk	79±15	96±22
5-9 wk	82±11	86±17
Methane production	------ mg/bird/day ------	
7 wk	35.8±18.6^{b}	3.6±1.9^{a}
9 wk	45.9±20.3 ^{b}	3.8±1.4^{a}
Average	40.8±18.3 ^{b}	3.7 ±1.5^{a}
	------ mg/kg BW/day ------	
7 wk	20.1±10.9^{b}	2.2±1.3 ^{a}
9 wk	15.2±7.3 ^{b}	1.2±0.4 ^{a}
Average	17.6±8.7 ^{b}	1.7±1.0 ^{a}

[a-b] Means within the same row with the different superscripts differ significantly ($p<0.05$). [1] Same as Table 2.

were significantly longer compared with the SHAM treatment group. This might be due to the antiperistalsis characteristic of the colon and rectum in poultry (Bjornhag and Seperber, 1977). It is well known that the colon and rectum content could enter the caeca. Therefore, caeca removal would force the intestinal content to accumulate in the colon and rectum, leading to an increase in the length of the colon and rectum. However, further investigation is needed for a thorough explanation.

Experiment 2

In experiment 2, the SHAM goslings had higher average daily gain from 5 to 7 wks of age. However, no evidence was found in the 7 to 9 wks of age and in the entire experimental period. This result was same as the result of experiment 1. Results also showed that age did not affect methane production in both treatments. This finding was different from the results of Annison et al.（1968）who indicated that the fermentation matter, volatile fatty acids, in the caeca content in chickens increase with age from 2 to 16 wks of age. The reason might be that the caeca in goslings used in this experiment, were well developed at 7 wks of age, since the length of caeca in goslings at 6 weeks of age were same as those at 9 wks of age (Chen et al.,

Table 6. Effect of caecectomy on nitrous oxide production in goslings (experiment 2)

Age	Treatments	
	SHAM [1]	CAECECTOMY
	------ mg/bird/day ------	
7 wk	0.46±0.00	0.77±1.03
9 wk	1.88±0.33	1.75±0.84
Average	1.17±0.76	1.26±1.00
	------ mg/kg BW/day ------	
7 wk	0.30±0.00	0.41±0.53
9 wk	0.60±0.15	0.58±0.31
Average	0.45±0.19	0.50±0.40

[1] Same as Table 2.

1992). On the other hand, the anaerobic bacteria (colonies per ml basis) in the caeca did not increase with age (Chang, 1998). As a consequence, it is reasonable to find no effect of age on the methane production in the caeca of goslings. The methane production (per day) in SHAM treatment at 7 and 9 weeks of age was greater than that in caecectomised birds in this study. Basing on the per kg body weight basis, the methane production by goslings in the SHAM treatment at 7 (9.14 mg/day/kg) and 9 (11.11 mg/day/kg; not show in Table 5) wks of age was greater than that in no operation broilers (0.108-0.145 mg/day/kg) derived from regression equation provided by Huang and Wang (2000). Geese have a well-developed pair of caeca (Chen et al., 1992) and probably the fermentation in these may be of more magnitude than that in broilers. It is obvious that the caeca in goslings is the main fermentation area since caecectomy resulted in a 90-92% reduction of methane production. The average calorific methane production value per goslings in the SHAM treatment group was 2.25 MJ/day greater than the 0.67 MJ/day value in the rock ptarmigan (Gasaway, 1976b). The calorific value of methane production in SHAM goslings was equivalent to 0.09% of their metabolizable energy less than the 0.2-0.4% value in the rock ptarmigan. In this study, the enteric nitrous oxide production per bird or per kg body weight basis in goslings was low. However, this was greater than the 0.39-1.10 μg/bird/day value in broilers (Huang and Wang, 2000). Basing on methane production, it is suggested that goslings have more fermentation capacity than other birds, e.g. broiler or rock ptarmigan. Therefore, the energy loss in air as methane due to fermentation in goslings is larger than that of rock ptarmigan base on per bird basis or broiler base on the per kg body weight basis. However, comparison on the basis of metabolizable energy, the energy loss in the Sham goslings is less than the rock ptarmigan.

CONCLUSION

Caecectomy did not affect relative weights of gizzard, small intestine, colon and rectum in goslings. However, the relative length of the colon and rectum increased after caecectomy. Removal of caecum on one side did not result in the compensatory growth of caecum on other side. Caecectomy decreased average daily gain in goslings, but this phenomenon was temporary. Average per bird methane production deceased when both caeca were removed in goslings. The nitrous oxide production in goslings was very low and not affected by caecectomy.

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