Effect of Field and Experimentally-induced Cases of Frothy Bloat on Physical Examination, Rumen Fermentation Pattern and Blood Constituents in Baladi Egyptian Sheep

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Abstract

Rumen fermentation pattern of sheep is greatly affected by several factors. This research studied the effect of field and experimentally-induced cases of frothy bloat on physical examination, blood constituents and rumen fermentation efficiency in Baladi Egyptian sheep. Sixty-six native breed Baladi Egyptian sheep were classified according to clinical presentation into fifty-eight apparently healthy sheep and eight clinically diseased cases of frothy bloat divided into three field cases due to grazing on lush pasture of barseem and five experimental cases induced by ingestion of cabbage leaves. All animals were subjected to detailed case history, comprehensive clinical examination and sampling of blood and rumen liquor for analysis. Results revealed that field and experimentally-induced cases of rumen frothy bloat caused highly significant increase in pulse and respiratory rates with highly significant decrease in rumen motility. Field cases of frothy bloat caused highly significant increase in Holotricha % and monocytes % with highly significant decrease in TPC, Entodinium %, TVFAs, lactic acid, propionic acid, butyric acid, acetic acid, CH_4, lymphocytes %, albumin and A/G ratio. Experimentally-induced cases of frothy bloat caused highly significant increase in Hb and MCHC with highly significant decrease in TVFAs, lactic, butyric and acetic acids, A/P ratio, CH_4 and CH_4/TVFAs %. It could be concluded that barseem lush-pasture bloat has more dramatic effect on rumen fermentation efficiency than bloat due to ingestion of cabbage leaves. Frothy bloat is still field problem of concern despite awareness of sheep farmers. Further investigations are highly recommended from aspects of rumen methane, rumen enzymes and rumen ciliates for therapeutic and productive purposes.

Key words: Frothy Bloat, Rumen Fermentation, Blood Constituents, Sheep, Rumen Methane, Rumen Enzymes, Rumen Ciliates, Fermentation Efficiency

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Introduction

Ruminant animals carry an active population of micro-organisms; bacteria, fungi, and protozoa in the forestomach of their digestive system. Without these organisms, the animal would be unable to digest fibrous feeds, such as grasses and legumes. In the process of digesting these materials, the micro-organisms produce large quantities of gas that must be expelled (Majak *et al.*, 2003). The importance of digestive of diseases is underscored by the fact that forestomach digestion supplies the ruminants not only with energy but also with a balance of essential amino acids and most of the vitamins requirements. In addition, forestomach motility and digestion are secondarily affected by many diseases of other body systems, and an accurate assessment of such problems can be very important in arranging therapeutic measures that support an optimum recovery of normal function (Smith *et al.*, 1992). From an economical point of view, forestomach diseases result in great losses to the producers through deaths, wasted feed, delayed marketing, premature marketing such as repetitive bloaters, unthriftness of the recovered animals and extralabour coasts of therapeutic and preventive measures (Kimberling, 1988). Diagnosis of such group of rumen dysfunction diseases is difficult using only routine clinical methods of examination. So, in order to establish an objective diagnosis, we have to examine the rumen fluid adjacent to the blood analysis (Hofirek *et al.*, 1989). Bloat is a disease that has been described in agricultural writings since many years ago. Few livestock diseases have such a long and colorful history in addition to its complexity and difficulty to predict under field conditions. As a result, field observations have led to varied and conflicting theories about its causes (Majak *et al.*, 2003). Based on grazing behavior, it would be expected that sheep might bloat more severely than cattle because they selectively choose to eat leaves over stems and chew what they ingest more frequently than cattle. Furthermore, sheep appear to select legumes over grasses because the legumes can be eaten more rapidly (Colvin and Backus, 1988). Several national and international authors studied frothy bloat from aspects of field diagnosis including case history, clinical presentation, etiological theories and pathogenesis. Also, researchers focused on consequences of such a disease on rumen physical characters, rumen biochemical constituents and blood profile, however, effects of field and experimentally induced cases of frothy bloat on rumen fermentative methane production, rumen fermentation efficiency, rumen enzymes need more attention. So, the objective of the present investigation is evaluation the effect of field and experimentally-induced cases of frothy bloat on physical clinical examination, rumen fermentation efficiency and blood constituents of sheep to confirm field diagnosis.

Material and Methods

Animals

Total number of sixty-six native breed Baladi Egyptian sheep their ages ranged between 1 to 3 years belonged to different private farms in Giza government, farms of Faculty of Veterinary Medicine, Faculty of Agriculture, Cairo University and clinical cases in Teaching Hospital of Department of Medicine and Infectious Diseases, Faculty of Veterinary Medicine, Cairo University. These animals were divided into fifty-eight apparently healthy- of different sexes within different seasons under different feeding conditions- and eight clinically diseased cases of frothy bloat. Three field cases of frothy bloat (FFB) were caused by grazing on lush pasture of barseem diagnosed cautiously via complete case history and comprehensive clinical examination. Five experimentally-induced cases of frothy bloat (EFB) were induced by ingestion of ten kilograms of cabbage leaves to dry feed adapted female sheep. Regarding ethical approach, all animals in this study were subjected to minimal degree of stress through induction of stomach tube for obtaining rumen fluid samples. The five cases used for experimental induction of frothy bloat suffered from mild degree of stress through appearance of disease symptoms such as rapid respiration and abdominal distention. These five animals were subjected to treatment and relief of symptoms using paraffin oil orally after evacuation of rumen content and neostigmine injection as rumen tonic, so animals returned to normal physiological cycles of rumination and eructation.

Samples

Rumen Fluid Samples

A total number of sixty-six rumen fluid samples each of fifty ml were collected during the present investigation using a selected rubber stomach tube connected to a suction pump after introducing a mouth gag. Color, odor, consistency, pH and protozoal activity were examined immediately after sampling. Then each sample was sieved through 4 folds of gauze to obtain strained rumen liquor which divided into 4 portions. The first portion was 2 ml for determination of ammonia nitrogen level after preservation by adding 2 ml hydrochloric acid 0.1 N then centrifugation and taking supernatant. The second portion was 4 ml; 2 ml for TVFA and 2 ml for differentiation of volatile fatty acids after preservation by adding 2 ml orthophosphoric acid and 1 ml hydrochloric acid 0.1 N. The third portion was 2 ml for protozoal counting and identification after adding equal volume of methyl green formol saline (MFS) and keeping in dark

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place till examination by. The fourth portion was centrifuged for 15 minutes at 3000 rpm and the supernatant were collected for determination of biochemical constituents.

Blood Samples

A total number of sixty-six blood samples were collected from each animal during the present study by jugular venipuncture. Each sample was divided into two portions; the first was used for collection of a clear non haemolized serum after centrifugation for 10 minutes at 3000 rpm for determination of serum biochemical constituents, the second one was obtained in vials containing Ethylene Diamine Tetra Acetate (EDTA) as an anticoagulant for determination of blood cellular constituents. Diff 3's stained blood films were examined microscopically for differential leucosytic count.

Physical Clinical Examination

Each animal was subjected to physical clinical examination procedures including pulse rate, body temperature, respiratory rate, mucous membranes and rumen motility according to method described by Kelly (1984) , Radostits *et al.* (2000) and Radostits *et al.* (2007). Body condition score (BCS) was determined according to Pugh and Baird (2012).

Rumen Liquor Constituents

The rumen fluid pH, color, odor and consistency were determined according to Alonso (1979), Dirksen and Smith (1987) and Radostits *et al.* (2007). Rumen protozoal activity was determined according to method described by El-Saifi (1969) and Alonso (1979). TPC and ciliate proportions were determined using Fuchs-Rosenthal haemocytometer chamber according to method described by Ito *et al.* (1994). Total volatile fatty acids (TVFAs) was determined by steam distillation method as described by Eadie *et al.* (1967), VFAs concentrations were analyzed using Gas Chromatography according to the method described by Mathew *et al.* (1997). Fermentative methane (CH4) was calculated according to the equations of Wolin (1960) which has been validated recently by Blümmel *et al.* (1993). Fermentation efficiency (FE) was calculated on the basis of the equation worked out by Orskov (1975) and modified by Baran and Zitnan (2002). Rumen ammonia nitrogen (NH_3-N) was determined calorimetrically using specific kits produced by Egyptian Company for Biotechnology (SPECTRUM), Egypt, according to the method described by Chaney and Marbach (1962). Rumen lactic acid concentration was determined calorimetrically using specific kits produced by Egyptian Company for Biotechnology (SPECTRUM), Egypt. Activity of aspartate amino-transferase, (AST), alanine amino-transferase (ALT) and gamma glutamyl transferase (GGT) were determined using specific kits produced by STANBIO Laboratory, USA

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for AST and ALT and SPINREACT Company, Spain for GGT with specific spectrophotometer (Apple 302, USA). All kits were performed according to the manufacturer's recommendations.

Blood Cellular Constituents

Hemoglobin content (Hb), packed cell volume (PCV), red blood cell (RBCs) count, white blood cell (WBCs) count, differential leukocytic count were estimated using method described by Thrall *et al.* (2012). MCV was calculated by PCV / RBCs ×10, MCH was calculated by Hb / RBCs ×10 and MCHC was calculated by Hb /PCV × 100.

Serum Biochemical Constituents

Serum albumin, Blood urea nitrogen (BUN) were determined according to Young and Friedman (2001) and total protein was determined by the method described by King and Wootton (1959) using specific kits produced by Egyptian Company for Biotechnology (SPECTRUM), Egypt. Serum globulins were calculated by subtraction of serum albumin content from the total serum protein value. Albumin/globulin (A/G) ratio was calculated by dividing the albumin content by the globulin value.

Biochemical Constituents Measured In Both Serum and Strained Rumen Liquor

Magnesium level was determined according to Young and Friedman (2001) using specific kits produced by QCA Company, Spain. Inorganic phosphorus level was determined according to Young and Friedman (2001) using specific kits produced by Egyptian Company for Biotechnology (SPECTRUM), Egypt. Calcium level was determined according to Young and Friedman (2001). Using specific kits produced by SPINREACT Company, Spain.

Statistical Analysis

Statistical analysis of obtained data was carried out by SPSS program version 20 using independent samples T test of normally distributed data and Mann-Wittney U test for non-normally distributed data. Normality of distribution and equality of variances were checked using Shapiro-Wilk test and Leven's test respectively, according to method described by Nie *et al.* (1975) and obtained results were recorded as mean value ± stranded error of mean (SE)

Results

Clinical signs of experimentally-induced frothy bloat began to appear after 6 hours of induction; these signs included tachypnea, tachycardia and cessation of rumination and congested mucous membranes as showed in Figure 1. Examination of digestive tract revealed reduction in rumen motility and left-sided

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abdominal distention as showed in Figure 2. Results of statistical analysis of obtained data of physical clinical examination including body temperature, pulse rate, respiratory rate, BCS, mucous membranes and rumen motility of sheep suffering from field and experimentally-induced cases of frothy bloat were tabulated in Table 1. In comparison with control group, both FFB and EFB groups showed highly significant (P<0.001) increase in pulse and respiratory rates, while rumen motility decreased significantly (P<0.001).

Fig1: Congested Conjunctival Mucous Membrane in Baladi Sheep Suffering From Experimentally-Induced Rumen Frothy Bloat (Left) In Comparison With Faint Rosy Conjunctival Mucous Membrane of Clinically Healthy Control (Right)

Fig 2: Left-Sided Abdominal Distention in Baladi Sheep Suffering From Experimentally-Induced Rumen Frothy Bloat

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Table 1: Physical Clinical Examination of Sheep Suffering From Frothy Bloat (Mean ± SE)

Variables	Frothy Bloat		Clinically Healthy Control
	Field Cases	**Experimentally-induced**	
Temperature (°C)	38.50 ± 0.29 [c]	39.60 ± 0.07 [b]	39.06 ± 0.06
Pulse (/min.)	130.00 ± 2.89 [a]	114.00 ± 1.41 [a]	87.66 ± 0.73
Respiratory rate (/min.)	63.00 ± 1.73 [a]	61.00 ± 3.41 [a]	19.19 ± 0.46
Rumen motility (/2min)	0.00 ± 0.00 [a]	1.00 ± 0.00 [a]	3.03 ± 0.09
BCS	2.33 ± 0.17	2.50 ± 0.00 [c]	2.24 ± 0.04
Mucous membranes	Congested	Congested	Faint rosy

a: P value less than 0.001; b: P value less than 0.01; c: P value less than 0.05

Freshly collected rumen fluid samples were examined physically from aspects of color, odor, consistency, pH and protozoal activity of sheep suffering from field and experimentally-induced cases of frothy bloat and results were presented in Table 2 and presented in Figure 3.

Table 2: Physical Examination of Rumen Fluid of Sheep Suffering from Frothy Bloat (mean ± SE)

Variables	Frothy Bloat		Clinically Healthy Control
	Field Cases	**Experimentally-induced**	
Color	green	yellow	differs according to feed
Odor	slightly sour	slightly putrefied	aromatic
Consistency	watery	watery with frothiness	slimy
Protozoal activity	zero	zero	+++
pH	6.50 ± 0.06	7.03 ± 0.23 [c]	6.68 ± 0.04

a: P value less than 0.001 *b: P value less than 0.01* *c: P value less than 0.05*

FFB group showed green color, slightly sour odor, watery consistency, zero protozoal activity and slight decrease in rumen pH, while EFB group showed yellow color, slightly putrefied odor, watery consistency with frothiness, zero protozoal activity and significant increase in rumen pH. Results of statistical analysis of obtained data of rumen cellular constituents including TPC and protozoal proportions *Entodinium*, *Diplodinium*, *Epidinium* and *Holotricha* of sheep suffering from field and experimentally-induced cases of frothy bloat were tabulated in Table 3.

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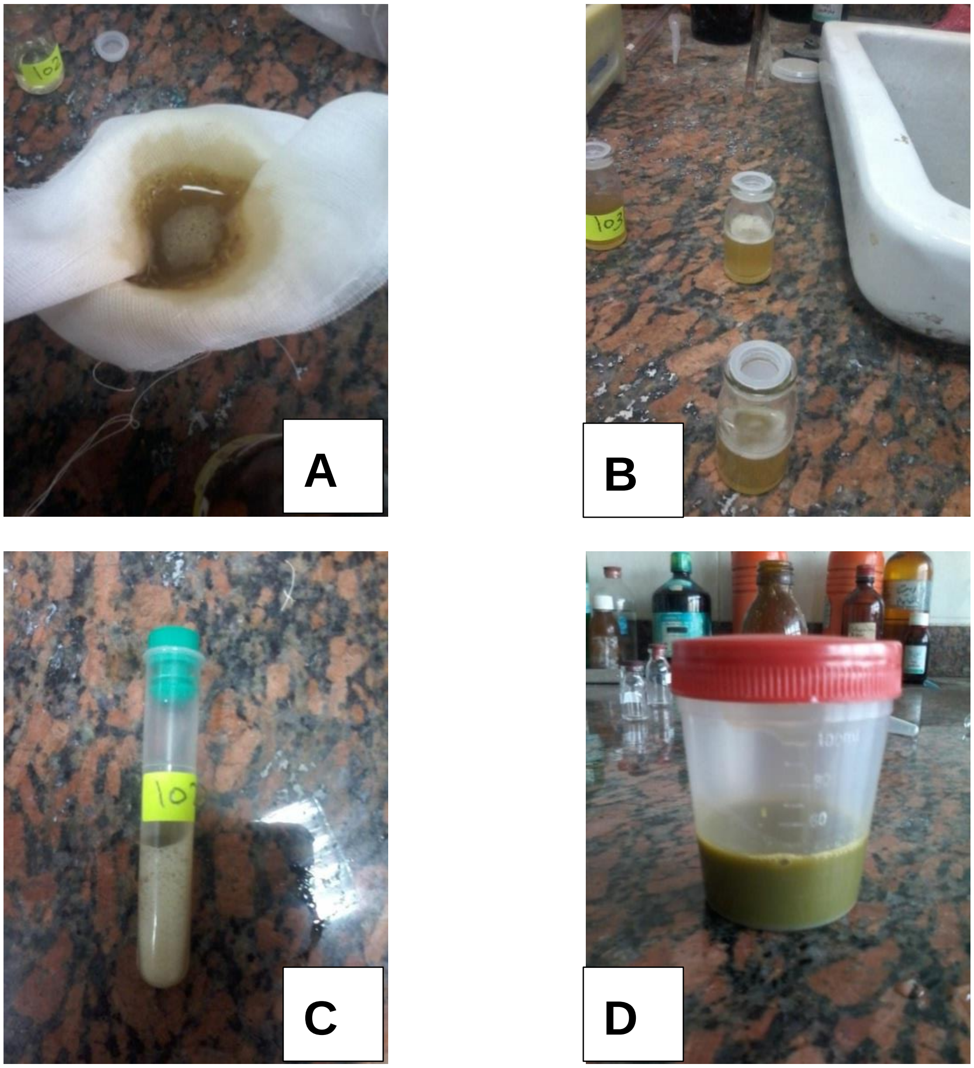

Fig 3: Frothy consistency of rumen liquor during different steps of preparation obtained from Baladi sheep suffering from experimentally-induced frothy bloat (A, B and C) in comparison with rumen fluid of clinically healthy control (D)

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Table 3: Rumen Cellular Constituents of Sheep Suffering From Frothy Bloat (Mean ± SE)

Variables	Frothy Bloat		Clinically Healthy Control
	Field Cases	**Experimentally-induced**	
TPC ($\times 10^4$/ml)	8.00 ± 1.15 [a]	43.63 ± 8.29	45.36 ± 3.24
Entodinium %	61.33 ± 2.03 [a]	80.00 ± 4.94	82.41 ± 1.15
Diplodinium %	3.00 ± 0.58	3.13 ± 0.59	3.09 ± 0.12
Epidinium %	12.00 ± 0.58 [b]	7.13 ± 1.75	6.14 ± 0.43
Holotricha %	23.67 ± 1.86 [a]	9.75 ± 3.00	8.35 ± 0.68

a: P value less than 0.001; b: P value less than 0.01; c: P value less than 0.05

In comparison with control group, rumen TPC and *Entodinium* in FFB group showed highly significant (P<0.001) decrease. Rumen *Epidinium* in FFB group showed significant (P<0.01) increase. Rumen *Holotricha* in FFB group showed highly significant (P<0.001) increase. Results of statistical analysis of obtained data of rumen fermentation characteristics including NH_3-N, TVFAs, lactic acid, acetic acid, propionic acid, butyric acid, acetic/propionic (A/P) ratio, fermentative CH4, CH4/TVFAs and FE of sheep suffering from field and experimentally-induced cases of frothy bloat were tabulated in Table 4. In comparison with control group, rumen NH_3-N in FFB group showed significant (P<0.05) increase. Rumen TVFAs and concentrations of acetic acid, propionic acid, butyric acid and lactic acid in both FFB and EFB groups showed highly significant (P<0.001) decrease. Rumen A/P ratio in EFB group showed highly significant (P<0.001) decrease, while FFB group was significantly (P<0.05) higher than control group. Rumen CH_4 in both FFB and EFB groups showed highly significant (P<0.001) decrease. Rumen CH_4/TVFAs in EFB group showed highly significant (P<0.001) decrease. Rumen FE % in FFB group was significantly (P<0.01) lower than control group. Results of statistical analysis of obtained data of rumen biochemical constituents including calcium level, inorganic phosphorus level, magnesium level and rumen enzyme activities of AST, ALT and GGT of sheep suffering from field and experimentally-induced cases of frothy bloat were tabulated in Table 5. Rumen AST and ALT activities in FFB group were significantly (P<0.01) lower than control group.

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Table 4: Rumen Fermentation Characteristics of Sheep Suffering From Frothy Bloat **(**Mean ± SE**)**

Variables	Frothy Bloat		Clinically Healthy Control
	Field cases	**Experimentally-induced**	
NH_3-N (mmol/L)	8.14 ± 0.56 [c]	6.85 ± 1.05	5.15 ± 0.32
TVFAs (mmol/L)	17.50 ± 1.15 [a]	27.10 ± 4.47 [a]	57.53 ± 1.46
Lactic acid (mmol/L)	0.06 ± 0.00 [a]	0.11 ± 0.06 [a]	0.58 ± 0.03
Propionic acid (mmol/L)	2.99 ± 0.10 [a]	8.60 ± 1.13	10.77 ± 0.51
Butyric acid (mmol/L)	2.15 ± 0.00 [a]	3.48 ± 0.38 [a]	12.00 ± 1.08
acetic acid (mmol/L)	12.36 ± 0.10 [a]	15.03 ± 1.34 [a]	35.15 ± 1.16
A/P ratio	4.14 ± 0.17 [c]	1.86 ± 0.41 [a]	3.35 ± 0.13
CH4 (mmol)	6.51 ± 0.08 [a]	7.10 ± 0.85 [a]	20.88 ± 0.69
CH4/TVFAs (%)	37.18 ± 0.43	26.22 ± 3.13 [a]	36.05 ± 0.54
FE %	72.87 ± 0.24 [b]	79.03 ± 1.80	74.85 ± 0.27

a: P value less than 0.001; b: P value less than 0.01; c: P value less than 0.05

Table 5: Rumen Biochemical Constituents of Sheep Suffering From Frothy Bloat **(**Mean ± SE)

Variables	Frothy Bloat		Clinically Healthy Control
	Field Cases	**Experimentally-induced**	
Calcium (mmol/L)	0.88 ± 0.01	1.21 ± 0.53	1.43 ± 0.24
Inorganic phosphorus (mmol/L)	7.83 ± 0.01	7.64 ± 0.08	6.71 ± 0.26
Magnesium (mmol/L)	1.46 ± 0.01	1.20 ± 0.42 [c]	0.62 ± 0.11
AST(Ukat/L)	0.04 ± 0.01 [b]	0.38 ± 0.11	0.22 ± 0.02
ALT (Ukat/L)	0.26 ± 0.01[c]	0.47 ± 0.14	0.51 ± 0.04
GGT (Ukat/L)	0.11 ± 0.00	0.11 ± 0.03	0.11 ± 0.01

a: P value less than 0.001 ;b: P value less than 0.01 ; c: P value less than 0.05

Results of statistical analysis of obtained data of hematological blood constituents including RBCs count, Hb concentration, PCV, blood indices; MCV, MCH and MCH, WBCS count and differential leukocytic count; neutrophils, eosinophils, basophils, lymphocyte and monocytes in sheep suffering from field and experimentally-induced cases of frothy bloat were summarized in Table 6.

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Table 6: Blood Cellular Constituents of Sheep Suffering From Frothy Bloat (Mean ± SE)

Variables	Frothy bloat		Clinically healthy control
	Field cases	**Experimentally-induced**	
RBCs count (10^{12}/L)	9.00 ± 0.26	14.50 ± 0.65 [c]	11.22 ± 0.38
Hb (g/L)	130.17 ± 1.06	180.54 ± 9.92 [a]	117.35 ± 4.08
PCV (L/L)	33.50 ± 0.58	35.20 ± 1.11	34.65 ± 0.72
MCV (fL)	37.25 ± 0.43	24.42 ± 1.10 [c]	33.51 ± 1.52
MCH (pg)	14.48 ± 0.30 [c]	12.52 ± 0.81	10.78 ± 0.34
MCHC (g/L)	388.68 ± 3.53	511.58 ± 14.57 [a]	347.74 ± 14.26
WBCs count (10^9/L)	13.40 ± 0.46 [c]	9.80 ± 0.78	9.38 ± 0.36
Neutrophils (%)	70.00 ± 1.15 [b]	49.80 ± 4.52	51.31 ± 1.12
Eosinophils (%)	0.67 ± 0.67 [a]	3.80 ± 1.02	4.33 ± 0.60
Basophils (%)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Lymphocytes (%)	16.00 ± 1.15 [a]	40.80 ± 4.50	40.02 ± 0.93
Monocytes (%)	13.33 ± 0.67 [a]	5.60 ± 1.60	4.29 ± 0.23

a: P value less than 0.001; b: P value less than 0.01 ; c: P value less than 0.05

RBCs count in EFB group was significantly (P<0.05) higher than control group. Hb concentration in EFB group showed highly significant (P<0.001) increase. MCH in FFB group showed significant (P<0.05) increase. MCHC in EFB group showed highly significant (P<0.001) increase. WBCs count in FFB group showed significant (P<0.05) increase. Neutrophils in FFB group showed significant increase (P<0.01). Lymphocytes of FFB group showed highly significant (P<0.001) decrease. Monocytes of FFB group showed highly significant (P<0.001) increase. Eosinophils of FFB group showed highly significant (P<0.001) decrease.Results of statistical analysis of obtained data of serum biochemical constituents including total protein level, albumin level, globulin level, albumin-globulin (A/G) ratio, BUN level, calcium level, inorganic phosphorus level and magnesium level of sheep suffering from frothy bloat were tabulated in Table 7. In comparison with control group, total protein of FFB group showed significant (P<0.05) increase. Albumin in FFB group showed highly significant (P<0.001) decrease, while EFB group showed significant (P<0.05) increase. Globulin of FFB group showed significant (P<0.05) increase. A/G ratio in FFB group showed highly significant (P<0.001) decrease. BUN in FFB group showed significant (P<0.01) increase. Magnesium in FFB group showed significant (P<0.05) decrease.

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Table 7: Serum Biochemical Constituents of Sheep Suffering From Frothy Bloat (Mean ± SE)

Variables	Frothy Bloat		Clinically Healthy Control
	Field Cases	**Experimentally-induced**	
Total protein (g/L)	80.56 ± 0.15 [c]	69.61 ± 5.62	63.24 ± 1.37
Albumin (g/L)	23.70 ± 0.04 [a]	32.93 ± 1.38 [c]	29.40 ± 0.38
Globulin (g/L)	56.86 ± 0.10 [c]	36.68 ± 6.68	33.84 ± 1.41
A/G ratio	0.42 ± 0.00 [a]	1.04 ± 0.20	0.96 ± 0.04
Urea N (mmol/L)	8.12 ± 0.11 [b]	3.32 ± 0.69	4.38 ± 0.29
Calcium (mmol/L)	2.51 ± 0.01	3.04 ± 0.11	2.64 ± 0.06
Magnesium (mmol/L)	1.16 ± 0.00 [c]	1.32 ± 0.07	1.53 ± 0.04
Inorganic phosphorus (mmol/L)	2.73 ± 0.01	2.08 ± 0.30	2.23 ± 0.11

a: P value less than 0.001; b: P value less than 0.01; c: P value less than 0.05

Discussion

Physical Clinical Examination of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

In comparison with control group, pulse and respiratory rates in FFB group and EFB group showed highly significant (P<0.001) increase and this finding was in complete agreement with Fouda (1995), Radostits *et al.* (2007), Anderson and Rings (2008), Smith (2014), Baraka *et al.* (2000) in camel, Chakrabarti (2001) in cattle and Mousa (2011) in cattle and this could be explained on basis of progressive increment of heart rate as diaphragm and lungs were compressed due to severe distention interfering with venous return to the heart and lung ventilation leading to elevation of pulse and respiratory rates (Anderson and Rings, 2008). Rumen motility of FFB group and EFB group showed highly significant (P<0.001) decrease and this observation agreed with Fouda (1995), Radostits *et al.* (2007) and Anderson and Rings (2008) and this could be explained on basis of activation of high-threshold tension receptors in reticulo-rumen increasing the inhibitory inputs to gastric center (Leek, 1969) and (Leek, 1983).

Physical Characters of Rumen Fluid of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

FFB group showed green color, slightly sour odor, watery consistency and (0) protozoal activity. Similar finding was reported by Radostits *et al.* (2007), and Anderson and Rings (2008), while Kubesy (1983) reported foul odor and frothy consistency. EFB group showed yellow color, slightly putrefied odor, watery consistency with frothiness and (0) protozoal activity and this finding agreed with Fouda (1995). In comparison with control group, rumen pH of FFB group showed slight decrease and this finding was in

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agreement with Kubesy (1983), Smith (2014), Baraka *et al.* (2000) in camel and Mousa (2011) in cattle, while Kamal (2008) reported highly significant decrease in camel. EFB showed significant increase and this pH value agreed with Fouda (1995).

Rumen Cellular Constituents of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

In comparison with control group, rumen TPC in FFB group showed highly significant (P<0.001) decrease, similar finding reported by Mousa (2011) in cattle and this could be attributed to low rumen pH as Baraka (2011) recorded highly inverse correlation between rumen pH and TPC in Buffaloes. EFB group showed slight decrease, similar observation was reported by Fouda (1995). Rumen *Entodinium* in FFB group showed highly significant (P<0.001) decrease and this finding was in agreement with Fouda (1995) in experimentally-induced frothy bloat, while EFB group showed slight decrease and this finding was in disagreement with Fouda (1995). Rumen *Diplodinium* in FFB group showed slight decrease, while EFB showed mild increase. Rumen *Epidinium* in FFB group showed significant (P<0.01) increase, while EFB group showed mild increase and this finding was reported by Fouda (1995). Rumen *Holotricha* in FFB group showed highly significant (P<0.001) increase and this could be explained on basis of positive correlation between feeding on fresh cut green grass or pasture and predominance of large holotrich protozoa in rumen (Leng *et al.*, 1986). EFB group showed mild increase and this finding was also reported by Fouda (1995).

Rumen Fermentation Characteristics of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

In comparison with control group, rumen NH_3-N in EFB group showed mild increase, while FFB group showed significant (P<0.05) increase and this observation disagreed with Baraka *et al.* (2000), Kamal (2008) in camel and Mousa (2011) in cattle who reported significant decrease, and the obtained observation could be referred to normal values of GGT enzyme activity in both groups as ammonia assimilation by rumen microbes depends on ruminal ammonia−assimilating enzyme activity Faixová *et al.* (2004). Rumen TVFAs in FFB group and EFB group showed highly significant (P<0.001) decrease, finding of FFB group disagreed with Baraka *et al.* (2000) in camel and Mousa (2011) in cattle who reported mild increase, while Kamal (2008) in camel reported mild decrease, finding of EFB group was also reported by Fouda (1995). Rumen lactic acid in FFB group and EFB group showed highly significant (P<0.001) decrease and this finding was in disagreement with Fouda (1995). Rumen acetic acid in FFB group and EFB group showed highly significant (P<0.001) decrease and this observation was also reported by Fouda (1995). Rumen propionic acid in FFB group showed highly significant (P<0.001)

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decrease, while EFB group showed mild decrease and this observation was in agreement with Fouda (1995). Rumen butyric acid in FFB group and EFB group showed highly significant (P<0.001) decrease and this observation of was in agreement with Fouda (1995). Rumen A/P ratio in EFB group showed highly significant (P<0.001) decrease, while FFB group was significantly (P<0.05) higher than control group. Rumen CH_4 in FFB group and EFB group showed highly significant (P<0.001) decrease. Rumen CH_4/TVFAs in EFB group showed highly significant (P<0.001) decrease, while FFB group showed mild increase. Rumen FE % in FFB group was significantly (P<0.01) lower than control group, while EFB group showed slight increase.

Rumen Biochemical Constituents of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

In comparison with control group, rumen calcium in FFB group and EFB group showed moderate decrease and this observation agreed with Baraka *et al.* (2000) and Kamal (2008) in camel, while Mousa (2011) reported insignificant increase in cattle, and the obtained finding could be explained on basis of mild elevation of rumen pH in EFB group leading to decreased concentration and solubility of calcium as (Van't Klooster, 1967) and (Huber, 1971) reported that decreased rumen pH caused increased concentration and solubility of calcium in rumen fluid. Rumen inorganic phosphorus in FFB group and EFB group showed mild increase and this finding was in agreement with Baraka *et al.* (2000) in camel and Mousa (2011) in cattle, while Kamal (2008) recorded insignificant decrease in camel. Rumen magnesium in FFB group showed mild increase, while EFB was significantly (P<0.05) higher than control group, this observation was in agreement with Mousa (2011) in cattle. Rumen AST activity in EFB group showed mild increase, while FFB group was significantly (P<0.01) lower than control group and this observation could be explained on basis of decreased TPC and reduced rumen organic matter (Ushida *et al.*, 1986). Rumen ALT activity in EFB group showed mild decrease, while FFB group was significantly (P<0.05) lower than control group and this observation could be explained on basis of decreased TPC and reduced rumen organic matter (Ushida *et al.*, 1986).

Blood Cellular Constituents of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

In comparison with control group, RBCs count in FFB group showed mild decrease which agreed with Kamal (2008) and Baraka *et al.* (2000) in camel, while EFB group was significantly (P<0.05) higher than control group and this finding agreed with Mousa (2011) in cattle suffering from ruminal tympany. Hb concentration in FFB group showed mild increase which agreed with Mousa (2011) in cattle, while EFB

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group showed highly significant (P<0.001) increase which agreed with Kamal (2008) and Baraka *et al.* (2000) in camel. PCV in FFB group showed mild decrease which agreed with Mohamed (1984) in cattle, Baraka *et al.* (2000) in camel and Kamal (2008) in camel and this could be referred to varied degrees of dehydration concurrently with the disease, while EFB group showed mild increase which agreed with Mousa (2011) in cattle. MCV and MCH in FFB group showed mild and significant (P<0.05) increase respectively and this observation agreed with Baraka *et al.* (2000) in camel and disagreed with Mohamed (1984) in cattle and Mousa (2011) in cattle, while MCHC showed mild increase which agreed with Mohamed (1984) in cattle and Mousa (2011) in cattle. EFB group showed highly significant increase (P<0.001) which agreed with and Kamal (2008) in camel suffering from frothy bloat. WBCs count in FFB group showed significant (P<0.05) increase which disagreed with Mohamed (1984) in cattle and Mousa (2011) in cattle, while EFB group showed mild increase which agreed with Baraka *et al.* (2000) in camel suffering from frothy bloat. Neutrophils in FFB group showed significant increase (P<0.01) which disagreed with Kamal (2008) in camel, while EFB group showed mild decrease which agreed with Baraka *et al.* (2000) in camel. Lymphocytes of FFB group showed highly significant (P<0.001) decrease, while EFB group showed mild increase. Monocytes of FFB group showed highly significant (P<0.001) increase which agreed with Kamal (2008) in camel, while EFB group showed mild increase which agreed with Baraka *et al.* (2000) in camel. Eosinophils of FFB group showed highly significant (P<0.001) decrease, while EFB group showed mild decrease which agreed with Baraka *et al.* (2000) and Kamal (2008) in camel suffering from frothy bloat.

Serum Biochemical Constituents of Baladi Egyptian Sheep under Effect of Field and Experimentally-Induced Cases of Frothy Bloat

In comparison with control group, total protein of FFB group showed significant (P<0.05) increase, meanwhile Baraka *et al.* (2000) in camel and Mousa (2011) in cattle reported insignificant decrease, while EFB group showed mild increase which agreed with Kamal (2008) in camel suffering from frothy bloat. Albumin in FFB group showed highly significant (P<0.001) decrease, while EFB group showed significant (P<0.05) increase however, Mousa (2011) in cattle reported insignificant increase and Kamal (2008) in camel recorded insignificant decrease. Globulin of FFB group showed significant (P<0.05) increase, while EFB group showed mild increase, on the other hand, Mousa (2011) in cattle and Kamal (2008) in camel recorded insignificant decrease. A/G ratio in FFB group showed highly significant (P<0.001) decrease, while EFB group showed mild increase which agreed with Mousa (2011) in cattle, on the other hand Kamal (2008) recorded insignificant decrease in camel. BUN in FFB group showed significant (P<0.01) increase and this could be explained on basis of reduced renal perfusion and hence

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decreased renal glomerular filtration (Smith *et al.*, 1992), while EFB group showed mild decrease, on the other hand, Mousa (2011) in cattle, Baraka *et al.* (2000) and Kamal (2008) in camel reported significant decrease. Calcium in FFB group showed mild decrease which agreed with Baraka *et al.* (2000) in camel, while Mohamed (1984), Mousa (2011) in cattle and Kamal (2008) in camel reported significant decrease which could be explained on basis of anorexia accompanied with the disease and disturbance in absorption and utilization of calcium (Mohamed, 1984), meanwhile EFB group showed mild increase. Inorganic phosphorus in FFB group showed mild increase which agreed with Baraka *et al.* (2000) in camel, while EFB group showed mild decrease. Magnesium in FFB group showed significant ($P<0.05$) decrease, while EFB group showed mild decrease, on the other hand Mohamed (1984) and Mousa (2011) reported insignificant increase in cattle suffering from frothy bloat.

Conclusion

Lush-pasture bloat has more dramatic effect on rumen fermentation efficiency than bloat due to ingestion of cabbage leaves in Baladi Egyptian sheep. Field cases of frothy bloat because of lush-pasture of barseem caused highly significant increase in *Holotricha* % and monocytes % with highly significant decrease in TPC, *Entodinium* %, TVFAs, lactic, propionic, butyric, acetic acids, CH_4, lymphocytes, albumin and A/G ratio. Experimentally-induced cases due to cabbage leaves led to highly significant increase in Hb and MCHC with highly significant decrease in TVFAs, lactic, butyric, acetic acids, A/P ratio, CH_4 and CH_4/TVFAs %. Frothy bloat is still field problem of concern despite awareness of sheep farmers. Further investigations are highly recommended from aspects of rumen methane, rumen enzymes and rumen ciliates for therapeutic and productive purposes.

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