

# Study on the Therapeutic Effect of Modified Yujin Powder on *E. coli* in the *Procapra przewalskii*

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## ABSTRACT

This experiment was to study the therapeutic effect of modified Yujin powder on *E. coli* in the *P. przewalskii*. Twenty the *Procapra przewalskii* with the *E. coli* were selected from the Wildlife Rescue Center of the Qinghai Lake National Nature Reserve and randomly divided into low-dose group, high-dose group, gentamicin sulfate group and control group with 5 *Procapra przewalskii* in each group. The *P. przewalskii* in modified Yujin powder group were given Yujing powder once every morning and evening, 3, 4 mL/ (kg·BW) for the low-dose group and high-dose group, respectively. The *P. przewalskii* were injected with gentamicin sulfate intramuscularly, once every morning and evening. The *P. przewalskii* in control group were fed normally and no medicine was given. After 7 d, the clinical symptoms of the *P. przewalskii* were observed, and the blood routine, serum biochemical parameter, serum immune and antioxidant indices were measured. The results showed that the *P. przewalskii* were sensitive reaction, increased appetite, and no diarrhea in the modified Yujin powder group. The healing rates were 75%, 85%, and 60% in low-dose group, high-dose group, gentamicin sulfate group, respectively. The effects of modified Yujin powder was better than gentamicin sulfate. The contents of blood urea nitrogen (BUN), malondialdehyde (MDA), and the number of white blood cell (WBC) in 3 drug delivery groups were extremely significantly lower ( $P < 0.01$ ) than the control group, and the contents of potassium (K), total protein (TP), albumin (ALB), globulin (GLB), and total antioxidant capacity (T-AOC) in the 3 drug delivery groups were extremely significantly higher ( $P < 0.01$ ) than that of control group, but there were no remarkable differences between the 3 drug delivery groups. The serum catalase (CAT) activity in the high-dose group was extremely significantly higher ( $P < 0.01$ ) than that in the low-dose group, gentamicin sulfate group, and control group. Consequently, modified Yujin powder had a good therapeutic effect on the *E. coli* in *P. przewalskii*, and the effect of the high-dose group was better.

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## Authors' Contribution

CJS collected material, compiled the results and writing of manuscript. CJS and SQG performed the experiments. XYS reviewed the manuscript.

## Key words

The *E. coli*, The *P. przewalskii*, Modified Yujin powder, Gentamicin sulfate, Blood parameter

## INTRODUCTION

The Przewalski's gazelle (*Procapra przewalskii*) is endemic to the Qinghai-Tibetan Plateau, China, and has been widely distributed throughout the Inner Mongolia, Ningxia, Gansu, Qinghai, Xinjiang, and Tibet regions (Hu and Jiang, 2011; Ping et al., 2018). In recent years, the distribution range of the *P. przewalskii* has been gradually shrinking because of human population growth, grassland degradation, and habitat fragmentation (Shen et al., 2018; Chi et al., 2020; Jiang, 2004). Currently, only the Qinghai Lake basin remains preserved as a habitat for the *P. przewalskii*

(Yang et al., 2006). According to the survey results in recent years, only the *P. przewalskii* populations comprising about 300 animals inhabit the Qinghai Lake area (Zhang et al., 2018). Therefore, the *P. przewalskii* has become the least populous species among the endemic mammals in China (Shen et al., 2009, 2019; Jiang and Wang, 2000). In 2008, the *P. przewalskii* was recategorized on the International Union for Conservation of Nature (IUCN) Red List from "critically endangered" to "endangered" (Li et al., 2012).

The colibacillary (*Escherichia coli*) is an acute bacterial infection caused by infection with pathogenic *E. coli* (Fernando et al., 2019; Wu, 2014). It is characterized by depression, loss of appetite, abnormal growth and development, diarrhea, and high mortality (Fit et al., 2019; Mainil, 2013). The main characteristics of affected animals are to excrete the feces with foul smell and gray color (Ma, 2017). The disease will not only

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cause dehydration and debilitation, but also increase the mortality of *P. przewalskii*. At present, the treatment of *E. coli* is mainly based on antibiotics, but there are problems such as drug residues and drug resistance (Su *et al.*, 2019). In recent years, the research and development of Chinese herbal medicine antibacterial and antiviral drugs has become a research hot spot at domestic and abroad (Tong *et al.*, 2014). Traditional Chinese medicine can not only directly kill bacteria, but also exert antibacterial effect by enhancing the organism immunity. Traditional Chinese medicine has the dual functions of medicinal and nutrient in clinical practice, which is environmentally friendly, safe and resistant to drug resistance (Ning *et al.*, 2015; Ho *et al.*, 2013). Chinese herbal medicines have small side effects, low prices, and wide sources, which can also reduce the cost of breeding (Tong *et al.*, 2014; Meng *et al.*, 2015).

According to the Chinese veterinary syndrome theory, *E. coli* is caused by damp-heat hoarding of the intestinal tract, which should be heat-clearing and detoxifying, eliminating dampness and relieving diarrhea (Li, 2017). Yujin powder is the prescription in “Yuan Heng Liao Ma Ji” (Commission of Chinese veterinary pharmacopoeia, 2011). It has the effects of heat-clearing and detoxifying, dispersing phlegm and stopping diarrhea (Liao *et al.*, 1990). This experiment adds 4 Chinese herbal medicines of *Atractylodes macrocephala*, *Glycyrrhiza uralensis*, *Common vladimiria* and *Pulsatilla chinensis* on the basis of Yujin powder, and subtracts *Scutellaria baicalensis*, *Phellodendron amurense*, *Gardenia jasminoides* and *Rheum palmatum*. Take Yujin to promote and normalize the flow of qi as a principle drug. *Atractylodes macrocephala*, *Glycyrrhiza uralensis*, and *Common vladimiria* can regulate qi for invigorating spleen, as an adjuvant drug. *Coptis chinensis* and *Pulsatilla chinensis* can clear heat, eliminating dampness, and removing toxicity, as an assistant drug. *Terminalia chebula* relieving diarrhea with astringents. *Cynanchum otophyllum* retaining yin with astringent and harmonizing method (Li, 2002). The combination of various drugs has the effects of clearing away heat and detoxifying, relieving diarrhea with astringents. By studying the therapy of modified Yujin powder on *E. coli* in *P. przewalskii*, it aims to provide a reference for clinical treatment of such bacterium, and also provides new ideas for the protection of the *P. przewalskii*.

## MATERIALS AND METHODS

### *Preparation of traditional Chinese medicine and gentamicin sulfate*

Modified Yujin powder is composed of tulip, *S. baicalensis* and *G. uralensis*, each 25 g. *A. macrocephala*, *C. vladimiria*, *P. chinensis*, and *C. otophyllum*, each 20

g, and *T. chebula* 15 g. Soak for 30 min with water, boil quickly with a fire, then use a simmer to cook. The drug juice was filtered, and the filtered drug residue and the appropriate amount of water were further boiled for 30 min, and then filtered, and the filtrate was combined and concentrated to contain 1 g of crude drug per 1 mL of the drug solution.

### *Experimental animals*

The experimental animals were selected from the Wildlife Rescue Center of the Qinghai Lake National Nature Reserve. *E. coli* antibody test was carried out on *P. przewalskii*, and twenty animals (1.5-year-old) with negative antibody detection and clinical symptoms were selected. Nutrition level of grassland types in the habitat of *P. przewalskii* as shown in Table I.

**Table I. Nutrition level in main grassland types of *P. przewalskii* (%).**

Category	CP	EE	CF	NFE
<i>Artemisia desertorum</i> shrubland	11.36	3.86	30.88	33.94
<i>Agropyron cristatum</i> grassland	9.16	2.36	35.63	45.99
<i>Iris lacteal</i> grassland	12.10	2.81	29.00	33.70
<i>Achnatherum splendens</i> grassland	10.96	2.94	26.06	49.18
<i>Potentilla discolor</i> grassland	14.89	3.06	18.17	47.53
<i>Stipa purpursa</i> grassland	13.10	3.00	27.89	42.52
<i>Elymus nutans</i> grassland	9.90	2.73	28.37	48.65
<i>Carex rigescens</i> grassland	11.44	2.80	28.35	45.27
<i>Orinus kokonorica</i> grassland	14.98	4.07	21.05	41.17
<i>Stipa breviflora</i> grassland	13.80	3.61	28.28	38.36

CP, crude protein; EE, ether extract; CF, crude fiber; NFE, nitrogen free extract.

### *Experimental design*

Twenty *P. przewalskii* with *E. coli* were randomly divided into 4 groups. Modified Yujin powder were low-dose group and high-dose group. According to the low (3 mL/kg, BW), high (4 mL/kg, BW) dose of intragastric administration, each morning and evening, dosing for 7 d. The gentamicin sulfate group intramuscular injection of 10 mL gentamicin sulfate 0.1-0.2 mL/kg, twice a day, for 7 d. The control group was fed normally and was not administered. The test period was 14 days, and the drug was administered for 7 d, observe for 7 d.

Judgment of drug effect: After healing, the clinical symptoms of the affected animals completely disappeared, the affected animals were react quickly, with a strong appetite, no diarrhea, and no recurrence within 7 d after stopping the drug. Effective is that the main clinical

symptoms of the affected animals, has a good mental state, increased appetite, and reduced diarrhea, but relapsed within 7 d after stopping the drug. Invalidation is that the clinical symptoms of the affected animals were not alleviated after treatment, and there was a tendency to increase.

#### Sample collection

At the end of the experiment, blood samples from 20 affected animals were collected from the jugular, placed in a heparin sodium vacuum tube for 60 min, centrifuged at 4 °C, 3500 r/min for 10 min, and stored at -80°C for testing.

#### Physiological and biochemical indicators

Hemoglobin (Hb), erythrocyte count (RBC), packed cell volume (PCV), corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and white blood cell count (WBC) were determined by automatic blood cell analyzer (SF-3000, Sysmex-Toa Medical Electronics, Kobe, Japan). Biochemical analyses, which included blood urea nitrogen (BUN), aspartate aminotransferase (AST), alanine transaminase (ALT), superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSH-Px), malondialdehyde (MDA), total antioxidant capacity (T-AOC), potassium (K), magnesium (Mn), and phosphorus (P) were determined by automatic biochemical analyzer (SF-1, Shanghai Medical Apparatus and Instruments Factory, Shanghai, China). Total protein (TP), albumin (ALB), globulin (GLB) were determined by electrophoresis (WH-300-LCD, Shanghai Shuangqi Biotechnology Co., Ltd., China).

#### Statistical analyses

Data were analyzed using the Statistical Package for the Social Sciences (SPSS, version 22.0, Inc., Chicago, IL, USA) and presented in the form of mean±standard error (SE). The differences were assessed by Student's *t*-test and were extremely significant at  $P<0.01$ .

## RESULTS

The incubation period is 1-2 d, mostly occurs in 6-week-old *P. przewalskii*. At the beginning, the body temperature of the juvenile *P. przewalskii* increased to above 41°C, conjunctiva became red and congested, and some of the affected juvenile *P. przewalskii* had neurological symptoms, stiffness of juncture, molars and dyskinesia. There are diarrhea symptoms. First, the yellow and white atheroma loose stool is discharged, and then the yellow and white watery loose stool is discharged. The undigested clot, exfoliated intestinal mucosa and blood silk are often mixed in the stool, and there are a lot of bubbles

in the stool. Most of them died within 4-12 h after the onset of the disease, with a mortality rate of 80%. Affected *P. przewalskii* have abdominal pain symptoms, cannot stand, because of long-term diarrhea, and hindquarters were fecal pollution. Adult *P. przewalskii* have different symptoms, some of which are not obvious, some of which are mental depression, anorexia, diarrhea and almost no death. The pathological changes were mainly concentrated in gastrointestinal tract, presenting acute enteritis and systemic anemia. In the stomach, there are a lot of milk clots digested by the stomach, and the gastric mucosa is highly congested and edematous. The contents are in the form of blood and water. Some of the gastric mucosa falls off, the mesenteric lymph nodes are highly congested and swollen, the section is juicy, and the color of the kidney and liver is lighter. There are a lot of bleeding points under the renal capsule and the liver capsule, and the gallbladder is full. There is a large amount of hemorrhage in the endocardium. The whole blood is thin and cannot coagulate normally, and the spleen is significantly enlarged.

As shown in Figure 1, the cure rates of the low-dose and high-dose groups were 75% and 85%, respectively, and the cure rate of the gentamicin sulfate group was 60%. The effects of modified Yujin powder was better than gentamicin sulfate, however, the clinical symptoms of the *P. przewalskii* were still obvious.

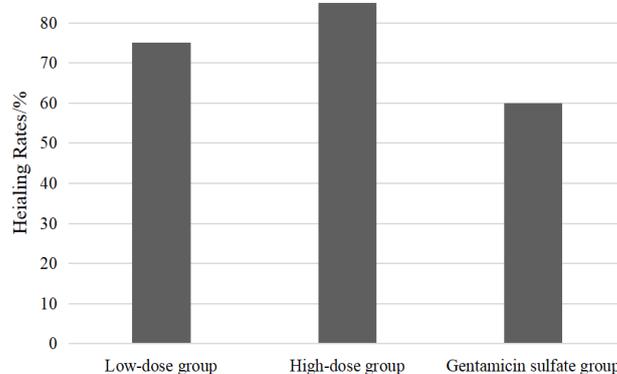


Fig. 1. Analysis of total curative effect.

As shown in Table II, the number of WBC in the low-dose group, the high-dose group, and the gentamicin sulfate group were extremely significantly lower ( $P<0.01$ ) than those in the control group, but the difference between the experimental groups were not significant. There were no significant differences in other blood parameters between groups.

As shown in Table III, BUN and MDA contents in the low-dose group, the high-dose group, and the gentamicin

**Table II. Hematological values of *P. przewalskii*.**

Items	Low-dose group	High-dose group	Gentamicin sulfate group	Control group
Hb (g/L)	232.56±12.72	231.52±11.33	232.56±12.43	235.63±12.53
WBC ( $\times 10^9$ /L)	11.87±0.47 <sup>B</sup>	14.69±0.66 <sup>B</sup>	11.08±0.64 <sup>B</sup>	28.02±3.65 <sup>A</sup>
RBC ( $\times 10^{12}$ /L)	12.88±0.63	12.82±0.55	13.73±0.74	13.76±0.88
PCV (%)	61.86±3.36	62.75±3.36	61.26±3.86	61.83±3.86
MCV (fL)	45.86±0.73	45.88±0.39	45.27±0.74	44.29±0.92
MCH (pg)	16.25±0.35	15.53±0.24	16.43±0.35	15.25±0.54
MCHC (g/L)	344.37±7.69	345.38±7.53	344.57±6.59	343.95±7.85

Hb, hemoglobin; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, corpuscular volume; PCV, packed cell volume; RBC, erythrocyte count; WBC, white blood cell count. Different capital letter superscripts indicate extremely significant differences at  $P < 0.01$  level.

**Table III. Serum biochemical indices of *P. przewalskii*.**

Items	Low-dose group	High-dose group	Gentamicin sulfate group	Control group
BUN (mmol/L)	1.79±0.33 <sup>B</sup>	1.83±0.42 <sup>B</sup>	1.87±0.34 <sup>B</sup>	6.89±0.46 <sup>A</sup>
AST (U/L)	89.87±8.47	89.75±8.32	89.08±8.64	88.52±8.65
ALT (U/L)	44.64±4.74	44.53±4.75	44.58±4.74	43.84±4.75
GSH-Px (U/mL)	114.64±21.35	113.64±21.36	113.64±21.85	112.64±21.86
SOD (U/mL)	94.43±9.24	95.75±9.74	94.73±9.62	94.84±7.63
CAT (U/mL)	16.64±1.43 <sup>B</sup>	18.64±1.86 <sup>A</sup>	16.63±1.24 <sup>B</sup>	14.32±1.54 <sup>C</sup>
MDA (nmol/L)	20.64±2.54 <sup>B</sup>	24.53±2.32 <sup>B</sup>	21.53±2.51 <sup>B</sup>	33.64±2.25 <sup>A</sup>
T-AOC (U/mL)	3.42±0.22 <sup>A</sup>	4.95±0.32 <sup>A</sup>	3.64±0.12 <sup>A</sup>	2.52±0.21 <sup>B</sup>
K (mmol/L)	3.51±0.22 <sup>A</sup>	3.52±0.22 <sup>A</sup>	3.55±0.20 <sup>A</sup>	2.41±0.12 <sup>B</sup>
Mn (mmol/L)	0.30±0.067	0.29±0.015	0.29±0.058	0.29±0.067
P (mmol/L)	2.85±0.43	2.83±0.34	2.84±0.25	2.82±0.54

BUN, blood urea nitrogen; AST, aspartate aminotransferase; ALT, alanine transaminase; GSH-Px, glutathione peroxidase; SOD, superoxide dismutase; CAT, catalase; MDA, malondialdehyde; T-AOC, total antioxidant capacity; K, potassium; Mn, magnesium; P, phosphorus. Different capital letter superscripts indicate extremely significant differences at  $P < 0.01$  level.

**Table IV. Serum immunologic parameters of *P. przewalskii*.**

Items	Low-dose group	High-dose group	Gentamicin sulfate group	Control group
TP (g/L)	56.76±5.78 <sup>A</sup>	57.62±5.66 <sup>A</sup>	56.53±4.64 <sup>A</sup>	36.20±3.78 <sup>B</sup>
ALB (g/L)	31.82±2.56 <sup>A</sup>	31.52±3.65 <sup>A</sup>	30.62±3.64 <sup>A</sup>	23.78±3.99 <sup>B</sup>
GLB (g/L)	24.67±2.71 <sup>A</sup>	24.41±2.52 <sup>A</sup>	23.51±2.53 <sup>A</sup>	14.42±2.23 <sup>B</sup>
A/G	1.29±0.16	1.29±0.25	1.30±0.19	1.64±0.23

TP, total protein; ALB, albumin; GLB, globulin; A/G, albumin/globulin. Different capital letter superscripts indicate extremely significant differences at  $P < 0.01$  level.

sulfate group were extremely significantly lower ( $P < 0.01$ ) than those in the control group, while K content and T-AOC level were greatly significantly higher ( $P < 0.01$ ) than those in the control group. There was no significant difference between the experimental groups. The activity of CAT in the high-dose group was extremely significantly higher ( $P < 0.01$ ) than that in the low-dose group, the gentamicin sulfate group, and the control group. The activity of CAT in the low-dose group and the gentamicin sulfate group was greatly significantly higher ( $P < 0.01$ ) than that in the control group. The difference between the low-dose group and the gentamicin sulfate group was not significant.

There were no significant differences in other biochemical indicators between groups.

As shown in [Table IV](#), TP, ALB, and GLB contents in the low-dose group, the high-dose group, and the gentamicin sulfate group were extremely significantly higher ( $P < 0.01$ ) than those in the control group, but the difference between the experimental groups was not significant.

## DISCUSSION

[Yang et al. \(2004\)](#) study shows that Yujin has a

protective effect on the gastrointestinal tract. Yujin also has the effect of relieving cold diarrhea, and compatibility with *P. chinensis* can reduce the adverse stimulation of the cold of the *P. przewalskii* (Lu *et al.*, 2017). Shi *et al.* (2007) study shows that *A. macrocephala* has the effect of regulate qi-flowing for strengthening spleen, eliminating dampness and diuresis, and can improve the organism immune function. Shao *et al.* (2005) showed that *C. vladimiria* has an effect of promoting bile flow. *C. vladimiria* is warm in nature, and it has the effect of relieving pain and regulating the stagnation. It can be used in combination with *A. macrocephala* to treat “qi” deficiency of spleen and stomach, transport weakness, and vomite and eat less. Studies have shown that *T. chebula* and *C. chinensis* have anti-inflammatory effects (Cui *et al.*, 2015; Li *et al.*, 2015). Therefore, modern pharmacology believes that *C. chinensis* and *T. chebula* have a good inhibitory effect on *E. coli*, they have the functions of clearing heat and removing toxicity, and astringent. *C. otophyllum* can supplement blood, and *G. uralensis* can enhance palatability.

Animal blood physiological and biochemical indicators can not only reflect the physiological and health status of animals, but also can be used as one of the indicators to reflect the organism metabolic status (Chuku and Uwakwe, 2012; Saban, 2019; Allam *et al.*, 2020; Fasaie *et al.*, 2015). The number of WBC in blood of the case greatly significantly increased, which may cause damage to the immune system of the organism. BUN is the final product of protein breakdown, which can more accurately reflect the balance between protein metabolism and amino acids in animals (Huo *et al.*, 2020; Akhtar *et al.*, 2020; Scott *et al.*, 1982). In addition, the organism can maintain the balance of organism fluids through the kidneys and maintain the internal environment stability, and the changes in the organism fluids during abnormal renal function (Wang *et al.*, 2014; Meng *et al.*, 2019), such as vomiting, diarrhea, gastrointestinal drainage, can cause excessive potassium loss in the gastrointestinal tract. Modified Yujin powder can greatly significantly reduced BUN content and WBC, and extremely significantly increased K content. The levels of TP, ALB and GLB in serum can reflect the immune status of the animal's organism (Ryabchenko *et al.*, 2018). The results showed that modified Yujin powder can extremely significantly increased the contents of TP, ALB, and GLB. Therefore, modified Yujin powder can reduce the immune function of the *P. przewalskii*. The activities of GSH-Px, SOD, and CAT in serum reflect the organism antioxidant properties and ability to scavenge free radicals (Sinan *et al.*, 2017; Song *et al.*, 2020). Serum T-AOC level represents the total antioxidant capacity of the organism (Liu *et al.*, 2019a,

b). Serum MDA is a product of excessive oxidative free radicals attacking the rich unsaturated fatty acids in biofilms (Mahfuz *et al.*, 2020; Iqra *et al.*, 2019). It is a sensitive and reliable marker reflecting oxidative damage of tissues and cells caused by reactive oxygen species in organisms (Zeng *et al.*, 2020; Allam *et al.*, 2019). The study showed that the high-dose group can highly significantly increased the CAT activity, and was extremely significantly higher than the low-dose group and the gentamicin sulfate group. Compared with the control group, the high-dose group can extremely significantly reduced the MDA content, and greatly significantly increased the T-AOC. It indicated that the high-dose group can improve the scavenging ability of free radicals, reduce the damage of free radicals to cells, and effectively improve the antioxidant capacity of the *P. przewalskii*.

## CONCLUSION

Modified Yujin powder had a good therapeutic effect on the *E. coli* in *P. przewalskii*, and the effect of the high-dose group was better. Modified Yujin powder can effectively enhance the immune and antioxidant functions of *P. przewalskii*, but the research on the active ingredients between Chinese medicine has yet to be further developed.

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### Statement of conflict of interest

The authors have declared no conflict of interest.

## REFERENCES

- Akhtar, M.U., Qayum, A., Shan, A., Chou, S., Jo, H., Shah, S.W.A. and Muhammad, I., 2020. Influence of different dietary rumen degradable protein concentrations on nutrient intake, nutrient digestibility, nitrogen balance, blood urea nitrogen and milk yield of lactating beetal goats. *Pakistan J. Zool.*, **52**: 213-221. <https://doi.org/10.17582/journal.pjz/2020.52.1.213.221>
- Allam, S.M., El-Bedawy, T.M., Bakr, M.H. and Mahmoud, A.E.M., 2020. Effect of feeding dried orange pulp to lactating dairy cows on nutrients digestibility, blood constituents, plasma antioxidant biomarker, and pathogenic fecal bacteria. *Pakistan J. Zool.*, **52**: 79-86. <https://doi.org/10.17582/journal.pjz/2020.52.1.79.86>

- Chi, Y.K., Huo, B. and Shen, X.Y., 2020. Distribution characteristics of selenium nutrition on the natural habitat of Przewalski's gazelle. *Pol. J. environ. Stud.*, **29**: 67-77. <https://doi.org/10.15244/pjoes/104661>
- Chuku, L.C. and Uwakwe, A.A., 2012. Haematological and biochemical studies on some ruminants. *J. appl. Sci. Environ. Manage.*, **2**: 217-221.
- Commission of Chinese Veterinary Pharmacopoeia. 2011. *People's Republic of China veterinary pharmacopoeia*. 2010 Edition. Beijing: China Agric. Press.
- Cui, E.H., Zhi, X.Y. and Chen, Y., 2015. Coptis chinensis and myrobalan can synergistically inhibit inflammatory response *in vitro* and *in vivo*. *Evid.-Based Comp. Alt. Med.*, **22**: 39-40.
- Fasae, O.A., Amos, A.O., Owodunni, A. and Yusuf, A.O., 2015. Performance, haematological parameters and faecal egg count of semi-intensively managed West African dwarf sheep to varying levels of cassava leaves and peels supplementation. *Pertanika J. trop. agric. Sci.*, **38**: 1-12.
- Fernando, N.G., Fernando, R.P., Ángel, C. and Mariano, L., 2019. Type VI secretion system in pathogenic escherichia coli: Structure, role in virulence, and acquisition. *Front. Microbiol.*, **10**: 1965. <https://doi.org/10.3389/fmicb.2019.01965>
- Fit, N.I., Novac, C., Pasca, C., Matei, I.A.B., Chirila, F. and Andrei, S., 2019. Alternative treatment with natural products on *E. coli* strains isolated from animals. *J. Biotechnol.*, **305**: 80. <https://doi.org/10.1016/j.jbiotec.2019.05.278>
- Ho, T.Y., Lo, H.Y., Li, C.C., Chen, J.C. and Hsiang, C.Y., 2013. *In vitro* and *in vivo* bioluminescent imaging to evaluate anti-*Escherichia coli* activity of *Galla chinensis*. *Biol. Med.*, **3**: 160-166. <https://doi.org/10.1016/j.biomed.2013.04.003>
- Hu, J. and Jiang, Z., 2011. Climate change hastens the conservation urgency of an endangered ungulate. *PLoS One*, **6**: e22873. <https://doi.org/10.1371/journal.pone.0022873>
- Huo, B., Wu, T., Song, C.J. and Shen, X.Y., 2020. Studies of selenium deficiency in the Wumeng semi-fine wool sheep. *Biol. Trace Elem. Res.*, **194**: 152-158. <https://doi.org/10.1007/s12011-019-01751-1>
- Iqra, B., Moolchand, M., Pershotam, K., Saeed, A.S. and Hira, S., 2019. Effect of dietary selenium yeast supplementation on morphology and antioxidant status in testes of young goat. *Pakistan J. Zool.*, **51**: 979-988. <https://doi.org/10.17582/journal.pjz/2019.51.3.979.988>
- Jiang, Z.G., 2004. *China's Przewalski's gazelle*. China Forestry Publishing House, Beijing.
- Jiang, Z.G. and Wang, S., 2000. *Antelopes*. Glob. Surv. Reg. Action Plan. IUCN. Gland.
- Li, B., Li, X. and Fan, Y., 2015. Research progress on pharmacological action of Terminalia chebula Retz. *J. Pharm. Res.*, **34**: 591-595.
- Li, C.L., Jiang, Z.G., Ping, X.G., Cai, J., You, Z.Q. and Li, C.W., 2012. Current status and conservation of the endangered *Procapra przewalskii*, endemic to the Qinghai-Tibetan Plateau, China. *Oryx*, **46**: 145-153. <https://doi.org/10.1017/S0030605310001134>
- Li, W.Y., 2017. *Preparation of compound Jinxiong oral liquid and its effect on the prevention and treatment of chicken colibacillosis*. Nanjing Agric. Univ.
- Li, Z.W., 2002. *China traditional Chinese medicine* press, Beijing.
- Liao, S.B. and Li, Y.X., 1990. YuJin powder clinical application. *Chin. J. Tradit. Vet. Sci.*, **1**: 11-12.
- Liu, K.Y., Liu, H.L., Zhang, T., Mu, L.L., Liu, X.Q. and Li, G.Y., 2019a. Effects of vitamin E and selenium on growth performance, antioxidant capacity and metabolic parameters in growing furring blue foxes (*Alopex lagopus*). *Biol. Trace Elem. Res.*, **192**: 183-195. <https://doi.org/10.1007/s12011-019-1655-4>
- Liu, L.N., Chen, F., Qin, S.Y., Ma, J.F., Li, L., Jin, T.M. and Zhao, R.L., 2019b. Effects of selenium-enriched yeast improved aflatoxin B1-induced changes in growth performance, antioxidation capacity, IL-2 and IFN- $\gamma$  contents, and gene expression in mice. *Biol. Trace Elem. Res.*, **191**: 183-188. <https://doi.org/10.1007/s12011-018-1607-4>
- Lu, E.H., Zong, S.Y. and Liu, Q.C., 2017. Study on warm and cold nature of *Curcuma aromatica* based on excess-cold syndrome rats model. *J. Math. Med.*, **30**: 223-225.
- Ma, B.L., 2017. Diagnosis and prevention measures of lamb colibacillosis. *China Anim. Hlth.*, **19**: 29-30.
- Mahfuz, S., Wang, S.Y., Chen, M., Zao, F., Zhen, D., Liu, Z.J. and Song, H., 2020. Effects of mushroom stem waste (*Flammulina velutipes*) on laying performance, egg quality and serum biochemical indices. *Pakistan J. Zool.*, **52**: 255-262. <https://doi.org/10.17582/journal.pjz/2020.52.1.255.262>
- Mainil, J., 2013. *Escherichia coli* virulence factors. *Vet. Immunol. Immunopathol.*, **152**: 2-12. <https://doi.org/10.1016/j.vetimm.2012.09.032>
- Meng, T.T., Liu, Y.L. and Xie, C.Y., 2019. Effects of different selenium sources on laying performance, egg selenium concentration, and antioxidant capacity in laying hens. *Biol. Trace Elem. Res.*, **189**: 548-555. <https://doi.org/10.1007/s12011-018-1490-z>

- Meng, X.F., Xu, F. and Chen, L.H., 2015. Combining traditional Chinese and western medicine treatment of piglet contagion enterogastritis etc experiment research. *Modern J. Anim. Husb. Vet. Med.*, **8**: 41-45.
- Ning, G.B., Niu, Y.R. and Zhang, D., 2015. Analysis of drug resistance of *Escherichia coli* from chicken source and study on the effect of traditional Chinese medicine on the elimination of *Escherichia coli* resistance. *China J. Anim. Vet. Med.*, **46**: 1018-1025.
- Ping, X.G., Li, C.W., Li, C.L., Tang, S.H., Fang, H.X., Cui, S.P., Chen, J., Wang, E.G., He, Y.B., Ping, C.P., Zhang, Y., Wu, Y.L. and Jiang, Z.G., 2018. The distribution, population and conservation status of Przewalski's gazelle (*Procapra przewalskii*). *Biodivers. Sci.*, **26**: 177-184. <https://doi.org/10.17520/biods.2017152>
- Ryabchenko, N.I., Dzikovskaya, L.A., Izmet'eva, O.S. and Zhavoronkov, L.P., 2018. Effects of exposure of animals to oxygen atmosphere at low pressure on lipid peroxidation and antioxidant defense. *B. exp. Biol. Med.*, **165**: 640-643. <https://doi.org/10.1007/s10517-018-4231-6>
- Saban, C., 2019. Effect of dietary vitamin E, selenium and their combination on concentration of selenium, MDA, and antioxidant enzyme activities in some tissues of laying hens. *Pakistan J. Zool.*, **51**: 1155-1161. <https://doi.org/10.17582/journal.pjz/2019.51.3.1155.1161>
- Scott, M.L., Nesheim, M.C. and Yuong, R.J., 1982. *Nutrition of the chicken*. 3<sup>rd</sup> Edition. Cornell University, Ithaca, US.
- Shao, Y., Huang, F. and Wang, Q., 2005. Anti-inflammatory and cholagogic effects of aucklandiae. *Jiangsu Pharm. Clin. Res.*, **13**: 5-6.
- Shen, X.Y., 2009. Forage strategy of Przewalski's gazelle under selenium stress. *Acta Ecol. Sin.*, **29**: 2775-2781.
- Shen, X.Y., Huo, B., Wu, T., Song, C.J. and Chi, Y.K., 2019. iTRAQ-based proteomic analysis to identify molecular mechanisms of the selenium deficiency response in the Przewalski's gazelle. *J. Proteomics*, **203**: 103389. <https://doi.org/10.1016/j.jprot.2019.103389>
- Shen, X.Y., Huo, B., Min, X.Y., Wu, T., Liao, J.J., Cai, P., Zhang, Y., He, Y.B., Sun, J.Q. and Wu, Y.L., 2018. Assessment of mineral nutrition of forage in the natural habitat of Przewalski's gazelle (*Procapra przewalskii*). *Acta Pratacul. Sin.*, **27**: 108-115.
- Shi, W.R., Liu, Y. and Chen, L., 2007. Experimental study on the effect of drying dampness and diuresis of atracylodes macrocephala. *J. Fujian Coll. Tradit Chin. Med.*, **17**: 29-31.
- Sinan, A.M., Mehmet, K.F., Akin, K., Basak, H. and Akif, A.M., 2017. Evaluation of oxidative stress in sheep infected with *Psoroptes ovis* using total antioxidant capacity, total oxidant status and malondialdehyde level. *J. Vet. Res.*, **61**: 197-201. <https://doi.org/10.1515/jvetres-2017-0025>
- Song, C.J. and Shen, X.Y., 2020. Effects of environmental zinc deficiency on antioxidant system function in Wumeng semi-fine wool sheep. *Biol. Trace Elem. Res.*, **195**: 110-116. <https://doi.org/10.1007/s12011-020-02085-z>
- Su, Z.Q., Ma, K.Q., Tong, P.P., Wang, D., Gao, J.J., Sun, X., Chen, R.L. and Yao, G., 2019. Isolation, identification and phylogenetic group of a strain of multidrug-resistant pathogenic *Escherichia coli*. *China Anim. Husb. Vet. Med.*, **46**: 1127-1134.
- Tong, H.F., Tong, Y.L. and Xue, J., 2014. Multi-residual pesticide monitoring in commercial Chinese herbal medicines by gas chromatography-triple quadrupole tandem mass spectrometry. *Fd. Anal. Meth.*, **7**: 135-145. <https://doi.org/10.1007/s12161-013-9609-5>
- Wang, D.S., Zhang, S.D. and Li, H.S., 2014. Effects of *Escherichia coli* infection on blood biochemical indexes in pigs. *Jiangsu agric. Sci.*, **42**: 172-174.
- Wu, Y.P., 2014. Prevention and treatment measures for lamb colibacillosis. *China Livest. Poult. Breed.*, **9**: 98.
- Yang, J. and Wang, X.D., 2006. Proteomics in organ dysfunction today: A new way to understand the disease. *J. Organ. Dysfunct.*, **2**: 66-67. <https://doi.org/10.1080/17471060600782633>
- Yang, S.J., Zheng, T.Z. and Qu, S.Y., 2004. Effect of Yujin on contractile activity of isolated gastric muscle strips in rabbits. *J. Ningbo Univ.*, **17**: 228-229.
- Zeng, R., Muhammad, U.F., Zhang, G. and Tang, Z.C., 2020. Dissecting the potential of selenoproteins extracted from selenium-enriched rice on physiological, biochemical and anti-ageing effects in vivo. *Biol. Trace Elem. Res.*, **196**: 119-130. <https://doi.org/10.1007/s12011-019-01896-z>
- Zhang, L., Liu, J.Z., Wang, D.J., Wang, H., Wu, Y.L. and Lv, Z., 2018. Fencing for conservation? The impacts of fencing on grasslands and the endangered Przewalski's gazelle on the Tibetan Plateau. *Sci. China (Life Sci.)*, **61**: 145-147. <https://doi.org/10.1007/s11427-016-5096-4>