The Hematological and Biochemical Profiles of Wonosobo Sheep Blood in Various Physiological Conditions

Sarmin*, Pudji Astuti, and Claude Mona Airin

Department of Physiology, Faculty of Veterinary Medicine, Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia

ABSTRACT

The study aimed at examining the hematological and biochemical profiles of Wonosobo sheep blood in various physiological conditions. There were 32 Wonosobo sheep in the various physiological conditions, including 17 ewe lamb of 1-2 months of age, 5 pregnant female sheep of 12-48 months of age at 3 months of pregnancy, 5 ewe of 12-48 months of age in second lactation period of 1-2 months and 5 ram of 12-48 months of age. Each of the sheep was put in individual sheepfold and given Pakchang-1 grass, dried kangkong, and concentrate. Drinking water was given ad libitum. Blood sample was drawn from jugular vein and put into tubes for blood hematological and biochemical analyses. The results of the study showed that total leukocyte and lymphocyte in high in young sheep, while neutrophils was high in pregnant female sheep (P<0.05). There was not any significant physiological impact on hemoglobin, MCV, MCH, MCHC, RDW, hematocrit, platelet, monocyte, eosinophil, and basophil (P>0.05). The highest ALP activity and Pi levels were found in the ewe lamb, while low creatinine was found in the ram (P<0.05). The parameter of the activities of SGPT, SGOT, LDH, calcium, kalium, chloride, sodium, magnesium, TIBC, UIBC, TS, globulin, albumin, total protein, BUN, creatinine, glucose, cholesterol, triglyceride, HDL and LDL was not affected by physiological conditions (P>0.05). It was concluded that the impact of the physiological conditions of the Wonosobo sheep caused high total leukocyte and lymphocyte in ewe lamb and high neutrophil in pregnant female sheep, the increase in the Pi level and ALP activity of the ewe lamb, and high creatinine in the ram.

Keywords: Ewe lamb, Hematology, Physiological conditions, Pregnant, Wonosobo sheep

Introduction

Wonosobo sheep have been established as Indonesian local livestock on the Decision Letter of the Minister of Agriculture Number 2915/Kpts/OT.140/6/2011 (Suswono, 2011). The sheep represented the crossbreed between Texel sheep and local sheep (Hakim et al., 2019), including thin tailed sheep and thick tailed sheep that are bred by local people of Wonosobo district of Central Java from generation to generation. The body weight of the Wonosobo sheep was up to 108±13.0 Kg (male) and 82.0±4.5 Kg (female) (Suswono, 2011). The first mating age of the sheep ranged from 10 to 12 months, the first breeding age ranged from 15 to 19 months, the number of ewe lamb in a birth was 1-2 sheep, the estrous cycle lasted for 17-19 days and the estrous period was 25-35 hours, while the motherhood characteristics were good (Suswono, 2011), birth weight was 2.81 Kg and the post-weaning weight was 31.20 Kg (Hakim et al., 2018).

The Wonosobo sheep had uniform physiology and genetic composition and good adaptability to environmental limitation, typical characteristics that were different from those of other endemic sheep or other local sheep and represented Indonesian local livestock genetic resource (Suswono, 2011). However, there have not been any hematological and biochemical parameters of the blood of the sheep. The blood hematological and biochemical parameters played an important role in establishing livestock health. The hematological and biochemical parameters contained in reference book (Jackson and Cockcroft, 2002; Kramer, 2000; Feldman et al., 2002; Jain, 1986) could not accommodate the hematological and biochemical data of the blood of the Wonosobo sheep because of the difference in sheep race, geographic area, climate, time, method, instrument, and environment and also forages. Each race of sheep had hematological characteristics (Azimzadeh and Javadi, 2020). It was also the case of goat race (Al-Bulushi et al., 2017). It has been reported that other causal
factors of the hematological and biochemical variation were age (Alonso et al., 1997; Antunovic et al., 2012; Börnez et al., 2009), physiological condition (Antunovic et al., 2011), pregnancy status, post-partum period, lactation period and dry period (Piccione et al., 2009), and also sex (Bhat et al., 2014).

Based on the aforementioned background, the hematological and biochemical parameters of the blood of the Wonosobo sheep based on the variation of the physiological conditions were very important as indicators of sheep health and metabolic status (de Souza et al., 2020). Additionally, the data were also important in making comparative diagnosis of livestock diseases (Russell and Roussel, 2007). Therefore, the study aimed at examining the hematological and biochemical parameters of the blood of the Wonosobo sheep in various physiological conditions.

**Materials and Methods**

All the methods used in the study have been accepted by the Ethical Clearance Committee of the Integrated Laboratory Study and Testing of Gadjah Mada University for preclinical study (No 0004/04/LPPT/VII/2019).

**The location and the time of study**

The study was conducted in Griya Ternak Farm, Kemiri, Wringinanom, Kertek subdistrict, Wonosobo district, Central Java, 7.22°S, 109.55°E, at 743 m above sea level. It lasted from May 2019 to August 2019, while sample was drawn in July 2019.

**Experimental animals and treatment management**

All the experimental animals were under the supervision of veterinarians and considered to be healthy and without any physical defect and any medication such as hormone, antibiotics, and electrolyte and glucose solution infuse. The recording of the data of livestock was managed by animal nurses. Each of the animals was regularly examined, including possible infection by microbes, ectoparasite and endoparasite infestation, while physical examination included temperature, pulse, respiration, eye mucus, appetite, fecal consistency and clinical laboratory examination. The animals during the study was prevented by regularly eradicating ectoparasites once in three weeks, while anthelminitic was given before the study.

Each of the sheep was put in individual wooden raised platform sheepfold, except young sheep that were raised along with their mothers. There were 32 Wonosobo sheep in various physiological conditions sampled out randomly, including 17 ewe lamb of 1-2 months of age, 5 pregnant female sheep of 12-48 months of age at 3 months of pregnancy, 5 ewe in second lactation period of 1-2 months and 5 ram of 12-48 months of age.

The sheep were given drinking water ad libitum. Each of the sheep was put in individual sheepfold and given forage of Pakchong-1 grass, dried kangkong, and concentrate. The ingredient of the feed were summarized in Table 1. The ewe lamb got milk directly from their mothers and ate along with their mother in a sheepfold.

| Ingredient          | Percentages |
|---------------------|-------------|
| Pakchong-1 grass    | 35          |
| Dried kangkong      | 35          |
| Concentrate         | 30          |
| Total (%)           | 100         |

**Blood sampling and analysis**

Blood sample (10 mL) was drawn from jugular vein at 06:00-07:00 a.m. before the sheep were given forage in the morning and they have been fasted for several hours before blood sampling. Five mL of blood was put into Vacuhab® Onemed tubes (PT Jayamas Medica Industri, Sidoarjo, Indonesia) containing ethylenediaminetetraacetic acid (EDTA). Hematological analysis included hemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red distribution width (RDW), hematocrit, platelet, total leukocyte, lymphocyte, monocyte, eusinophil, basofil and neutrophil and was made using Sysmex KX-21 hematology analyzer (Sysmex Corporation, Japan).

The remaining 5 mL of the blood was put into plain tube Vacuhab® Onemed (PT Jayamas Medica Industri, Sidoarjo, Indonesia) and then centrifuged at 3000 rpm for 15 min. The resulting serum was kept at -20°C for blood biochemical analysis. The serums included glutamic pyruvic transaminase (GPT), glutamic oxaloacetic transaminase (GOT), alkaline phosphatase (ALP), lactate dehydrogenase (LDH), phosphor inorganic (Pi), calcium, kalium, chloride, sodium, magnesium, ferrum, unbound iron-binding capacity (UIBC), globulin, albumin, blood urea nitrogen (BUN), creatinine, total protein, glucose, cholesterol, triglyceride, High-density lipoprotein (HDL), and low-density lipoprotein (LDL) were analyzed using a kit supplied by Roche Diagnostics in Roche/Hitachi Cobas c systems Cobas c 502 (Japan). The level of total iron-binding capacity (TIBC) = Ferrum + UIBC (Demir et al., 2020; Weiss and Wardrop, 2010). Transferrin saturation (TS) resulted from Ferrum/TIBC x 100.

**Statistical analysis**

The blood hematological and biochemical parameters were analyzed using general linear model of ANOVA and the impact of the physiological conditions on the blood hematology and biochemistry was analyzed using Duncan’s multiple range test at the significance of P=0.05. The data of the parameters were expressed in standard deviation of various physiological conditions.
Results and Discussion

Table 2 summarized the hematological data of the Wonosobo sheep in various physiological conditions. It was found that the physiological conditions had significant impact on total leukocyte and resulted in the low total leukocyte of pregnant female sheep, the high lymphocyte percentage of ram and ewe lamb and the low neutrophil of ewe lamb and ram (P<0.05), while there was not any significant impact of the physiological conditions on hemoglobin, hematocrit, MCV, MCH, platelet, RDW, monocyte, eosinophil and basophil (P>0.05).

The resulting hemoglobin in the study was consistent with the reference parameter (Kramer, 2000; Feldman et al., 2002). The hemoglobin level was that of the Iraqi Awassi sheep, which was 11.00±0.7 pg (Badawi and AL-Hadithy, 2014). The resulting hemoglobin in the study was still in the range of the reference parameter (Feldman et al., 2002) and of the Iraqi fat-tailed sheep, which was 33.30±0.16% (Ahmadi-hamedani et al., 2016), that of Merino sheep, which was 36.10±15.2% (Lepherd et al., 2009), that of Iraqi Awassi sheep, which was 32.9±0.19% (Badawi and AL-Hadithy, 2014). It was indicative of the accuracy of red blood cell index so that its increase would cause anemia because of ferrous deficiency (Polizopoulos, 2010).

The hematocrit of the Wonosobo sheep in all the physiological conditions was consistent with the reference parameter (Feldman et al., 2002; Jackson and Cockcroft, 2002). It was higher in young sheep than adult Baruwal sheep (Barsila et al., 2020) and the hematocrit reported by Elnageeb and Abdelatif (2013) because of the impact of growth (Singh et al., 2018).

The physiological status did not have any significant impact on platelet (P>0.05) as reported in Sokoto sheep and Sahel goats (Okonkwo et al., 2021). On the contrary, Habibu et al. (2017) reported that the platelet in pregnant goat was higher than that in non-pregnant goat. It was reported that the platelet level in pregnant goat was higher than that in non-pregnant goat. It was also higher than the reference parameter (Feldman et al., 2002; Jackson and Cockcroft, 2002). The resulting total leukocyte in the study was still in the range of the reference parameter (Kramer, 2000). The total leukocyte was used to monitor inflammation status (Feldman et al., 2002), physiological mechanism in the adaptation to environment and defense system against infectious agents (Pizetti et al., 2021) and the progress of sheep health (Daramola et al., 2005). The lymphocyte level of the Wonosobo sheep was still in the range of 40-55% of the reference of 40-75% according to Kramer (2000); it was also the case of Etiopian sheep, which was 49.07±0.76% (Tibbo et al., 2005) and Indonesian fat-tailed sheep, which was 77.57±4.04% (Sarin et al., 2021b). The resulting monocyte in the study was still in the range of the reference parameter of 0-6 (Kramer, 2000; Feldman et al., 2002), physiological mechanism in the adaptation to environment and defense system against infectious agents (Pizetti et al., 2021) and the progress of sheep health (Daramola et al., 2005). The resulting monocyte in the study was still in the range of the reference parameter of 0-10% (Kramer, 2000; Feldman et al., 2002), and Etiopian sheep, which was 2.08±0.10% (Tibbo et al., 2005), and Iranian red sheep, which was 2.52±0.68% (Azimzadeh and Javadi, 2020). The resulting eosinophil in the study was still in the range of the reference parameter of 0-10% (Kramer, 2000; Feldman et al., 2002), and Etiopian sheep, which was 3.69±0.18% (Tibbo et al., 2005). The increase and the decrease in the eosinophil level related to immune response to hematode parasitic conditions (ewe lamb, pregnant female sheep, lactating female sheep and ram).
infestation (Pernthaner et al., 2005; Buddle et al., 1992). Basophil related to eosinophil (Jain, 1986). The resulting basophil level in the study was consistent with the reference parameter of 0-3 (Kramer, 2000; Feldman et al., 2002), and that of Etiopian sheep, which was 0.53±0.07% (Tibbo et al., 2005). The resulting neutrophil level in the study was still in the range of the reference parameter of 10-50% (Kramer, 2000; Feldman et al., 2002). The normal neutrophil level indicated that the sheep were not infected by any infectious agents (Antunovic et al., 2011).

The biochemistry of the Wonosobo sheep blood

Table 3 summarized the biochemical parameters of the Wonosobo sheep blood in various physiological conditions. The biochemical conditions did not have any significant impact on the resulting GPT activity of the thick-tailed sheep in the study (P>0.05) as reported by Sarmin et al. (2021a). It was reported that the GPT of Tsigai lactating sheep was high because of the increase in hepatic metabolic activity (Antunovic et al., 2011). The same result has been reported in Rasa Aragonesa sheep (Ramos et al., 1994). The GPT activity of the Wonosobo sheep was in the range of the reference parameter (Jackson and Cockcroft, 2002). The normal GPT activity was indicative of the deficit of protein and fat supply in hepatic metabolism and in normal physical activity (Antunovic et al., 2004).

The physiological conditions did not have any significant impact on the GOT activity (P>0.05) and it was consistent with the report of the fat-tailed sheep (Sarmin et al., 2021a). On the contrary, the GOT activity was higher in pregnant Tsigai sheep than in the lactating sheep (Antunovic et al., 2004). It indicated that the hepatic metabolic activity of the Wonosobo sheep was normal.

The physiological conditions had significant impact on the ALP (P<0.05) and the parameter was as high as that in Tsigai sheep (Antunovic et al., 2004). On the contrary, the physiological condition did not have any significant impact (Sarmin et al., 2021a). The ALP activity was found to be high in Bighorn sheep (Borjesson et al., 2000). In the Wonosobo sheep, it was still in the range of the reference parameter (Jackson and Cockcroft, 2002).

The physiological conditions did not have any significant impact on the resulting LDH activity in the study (P>0.05), as reported in Tsigai sheep (Antunovic et al., 2004). The LDH activity of the Wonosobo sheep was higher than the reference parameter (Jackson and Cockcroft, 2002) and that of Bighorn sheep, which was 409–788 U/L (Borjesson et al., 2000).

The physiological conditions had significant impact on the resulting Pi level in the study. The highest Pi level was found in ewe lamb, while the lowest one was found in pregnant sheep (P<0.05). Meanwhile, it was reported that among the fat-tailed sheep the highest Pi level was found in ram (Sarmin et al., 2021a). Low Pi level was found in adult Merinolandschaf sheep (Antunovic et al., 2004). The resulting Pi level in the study was consistent with the reference parameter (Jackson and Cockcroft, 2002).

The physiological conditions did not have any significant impact on the resulting calcium level in the study (P>0.05) as reported in the fat-tailed sheep (Sarmin et al., 2021a) though other study showed high calcium in the sheep of a year of age (Antunovic et al., 2004). The resulting calcium level in the study was still in the range of the reference parameter (Jackson and Cockcroft, 2002).

The physiological conditions did not have any significant impact on the resulting kalam level in the study (P>0.05) as reported in the fat-tailed sheep (Sarmin et al., 2021a; Azimzadeh and Javadi, 2020; Mostaghni et al., 2005) though Antunovic et al. (2011) suggested that the kalam of pregnant sheep was higher than that of lactating sheep. It was also reported that there did not have any significant impact on the kalam of sheep (Antunovic et al., 2004). The resulting kalam level in the study was in the range of the
The Hematological and Biochemical Profiles of Wonosobo Sheep Blood

| Variables | Units | Values |
|-----------|-------|--------|
| GPT | U/L | 140.59±19.90<sup>a</sup>, 122.05±23.71<sup>b</sup> |
| GOT | U/L | 17.65±3.22<sup>a</sup>, 16.20±2.08<sup>b</sup> |
| ALP | U/L | 246.35±38.55<sup>a</sup>, 122.60±13.63<sup>b</sup> |
| LDH | U/L | 1197.59±68.19<sup>a</sup>, 1208.59±187.97<sup>b</sup> |
| Pi | mg/dL | 7.06±0.54<sup>a</sup>, 4.88±0.43<sup>b</sup> |
| Calcium | 10<sup>2</sup>/L | 2.27±0.06<sup>a</sup>, 2.37±0.14<sup>b</sup> |
| Kallium | mmol/L | 4.82±0.15<sup>a</sup>, 4.68±0.18<sup>b</sup> |
| Chloride | µmol/L | 105.88±0.81<sup>a</sup>, 106.80±1.62<sup>b</sup> |
| Sodium | mmol/L | 148.29±1.24<sup>a</sup>, 148.20±1.88<sup>b</sup> |
| Magnesium | mg/dL | 3.14±0.23<sup>a</sup>, 3.16±0.11<sup>b</sup> |
| Ferrum | µg/dL | 176.29±13.16<sup>a</sup>, 186.40±19.24<sup>b</sup> |
| TIBC | µg/dL | 336.12±11.34<sup>a</sup>, 360.80±20.34<sup>b</sup> |
| Albumin | mg/dL | 3.29±0.10<sup>a</sup>, 3.60±0.17<sup>b</sup> |
| Total protein | mg/dL | 6.21±0.15<sup>a</sup>, 6.64±0.19<sup>b</sup> |
| BUN | mg/dL | 19.45±0.87<sup>a</sup>, 21.30±2.08<sup>b</sup> |
| Creatinine | mg/dL | 0.85±0.03<sup>a</sup>, 0.72±0.06<sup>b</sup> |
| Glucose | mg/dL | 42.84±0.99<sup>a</sup>, 30.80±1.68<sup>b</sup> |
| Cholesterol | µmol/L | 66.00±3.05<sup>a</sup>, 81.20±3.92<sup>b</sup> |
| Triglyceride | mg/dL | 31.82±3.51<sup>a</sup>, 25.60±7.69<sup>b</sup> |
| HDL | mg/dL | 39.47±3.29<sup>a</sup>, 45.80±1.98<sup>b</sup> |
| LDL | mg/dL | 21.24±3.32<sup>a</sup>, 30.80±9.53<sup>b</sup> |

**<sup>a</sup>** The same superscripts in a row were indicative of significant difference (P<0.05).

**GPT:** glutamic pyruvic transaminase; **GOT:** glutamic oxaloacetic transaminase.

**ALP:** alkaline phosphatase; **LDH:** lactate dehydrogenase; **Pi:** phosphor inorganic; **TIBC:** total iron-binding capacity; **UIBC:** unbound iron-binding capacity; **TS:** transferrin saturation; **BUN:** blood urea nitrogen; **HDL:** high-density lipoprotein; **LDL:** low-density lipoprotein.

The physiological conditions did not have any significant impact on the resulting ferrum level in the study (P>0.05) and it was consistent with the reference parameter (Jackson and Cockcroft, 2002) of Turkish sheep, which was 183.10±10.10 (µg/dL) (Cihan et al., 2016) and Akkaraman sheep, which was 117.80±4.20 (Kozat et al., 2006). The physiological condition did not have any significant impact on the resulting TIBC level in the study (P>0.05) that was concordance with 466.50±11.70 (µg/dL) in Turkish sheep (Cihan et al., 2016). The physiological conditions did not have any significant impact on the resulting UIBC level in the study (P>0.05) that was concordance with 317.00±35.29 (µg/dL) in Turkish sheep (Cihan et al., 2016). The TS level of the sheep was higher than that of Turkish Akkaraman sheep, which was 38.60±1.6% (Kozat et al., 2006).

The physiological conditions did not have any significant impact on the resulting globulin level in the study (P>0.05), while high globulin level was found in the lactating fat-tailed sheep (Armut et al., 2021a). In cows, higher globulin level was found in calves of 5 days of age as compared to calves of 30 days of age (Nagy et al., 2014). The resulting globulin level in the study was consistent with the reference parameter of 3.5–5.7 g/dL (Kaneko et al., 2008). The physiological conditions did not have any significant impact on the resulting albumin level in the study (P>0.05), while on the contrary, the physiological condition had significant impact on the albumin level of the fat-tailed sheep (Armut et al., 2021a). It was reported that high albumin level was found in calves of a month of age (Nagy et al., 2014). Also, albumin level was higher in lactating sheep than that of pregnant and non-

reference parameter (Jackson and Cockcroft, 2002). The variation of the kalium levels depended on forage, renal and intestinal elimination (Carlson, 1997) and rumen absorption (Dias et al., 2010).

The physiological conditions did not have any significant impact on the resulting chloride level in the study (P>0.05) as reported in the fat-tailed sheep (Armut et al., 2021a) though Antunovic et al. (2011) suggested that the chloride level of lactating sheep was higher than that of pregnant and non-pregnant sheep. The resulting chloride level in the study was in the range of the chloride reference parameter (Jackson and Cockcroft, 2002).

The physiological conditions did not have any significant impact on the resulting sodium level in the study (P>0.05) as reported in the fat-tailed sheep (Armut et al., 2021a). Also, age did not have any significant impact on the sodium level (Antunovic et al., 2004). The resulting sodium level in the study was consistent with the reference parameter (Jackson and Cockcroft, 2002).

The physiological conditions did not have any significant impact on the resulting magnesium level in the study (P>0.05) as reported in the fat-tailed sheep (Armut et al., 2021a). It was higher than the reference parameter (Jackson and Cockcroft, 2002). It was found in skeletal tissues and played an important role in cellular biological function as co-factor (Chaney, 1997), while its level in serum depended on the magnesium content of forage and the growing stages of sheep and the production of milk in lactating sheep (Mohammed et al., 2017).

The physiological conditions did not have any significant impact on the resulting ferrum level in the study (P>0.05) and it was consistent with the reference parameter (Jackson and Cockcroft, 2002) of Turkish sheep, which was 183.10±10.10 (µg/dL) (Cihan et al., 2016) and Akkaraman sheep, which was 117.80±4.20 (Kozat et al., 2006). The physiological condition did not have any significant impact on the resulting TIBC level in the study (P>0.05) that was concordance with 466.50±11.70 (µg/dL) in Turkish sheep (Cihan et al., 2016). The physiological conditions did not have any significant impact on the resulting UIBC level in the study (P>0.05) that was concordance with 317.00±35.29 (µg/dL) in Turkish sheep (Cihan et al., 2016). The TS level of the sheep was higher than that of Turkish Akkaraman sheep, which was 38.60±1.6% (Kozat et al., 2006).

The physiological conditions did not have any significant impact on the resulting globulin level in the study (P>0.05), while high globulin level was found in the lactating fat-tailed sheep (Armut et al., 2021a). In cows, higher globulin level was found in calves of 5 days of age as compared to calves of 30 days of age (Nagy et al., 2014). The resulting globulin level in the study was consistent with the reference parameter of 3.5–5.7 g/dL (Kaneko et al., 2008). The physiological conditions did not have any significant impact on the resulting albumin level in the study (P>0.05), while on the contrary, the physiological condition had significant impact on the albumin level of the fat-tailed sheep (Armut et al., 2021a). It was reported that high albumin level was found in calves of a month of age (Nagy et al., 2014). Also, albumin level was higher in lactating sheep than that of pregnant and non-

**<sup>a</sup>** The same superscripts in a row were indicative of significant difference (P<0.05).

**GPT:** glutamic pyruvic transaminase; **GOT:** glutamic oxaloacetic transaminase.

**ALP:** alkaline phosphatase; **LDH:** lactate dehydrogenase; **Pi:** phosphor inorganic; **TIBC:** total iron-binding capacity; **UIBC:** unbound iron-binding capacity; **TS:** transferrin saturation; **BUN:** blood urea nitrogen; **HDL:** high-density lipoprotein; **LDL:** low-density lipoprotein.
pregnant sheep (Antunović et al., 2004). The resulting albumin level in the study was in the range of the chloride of the reference parameter (Jackson and Cockcroft, 2002).

The physiological conditions did not have any significant impact on the resulting total protein in the study (P>0.05) as reported in the fat-tailed sheep (Sarmin et al., 2021a). It was reported that among Banglades sheeex sheep the total protein was higher in young sheep than adult sheep and it related to protein intake (Rahman et al., 2018). The resulting total protein level in the study was in the range of 6.61±1.20 mg/dL as reported in Banglades sheep (Rahman et al., 2018) and in the range of the reference parameter (Jackson and Cockcroft, 2002; Kaneko et al., 2008).

The physiological conditions did not have any significant impact on the resulting BUN level in the study (P>0.05) as reported in the fat-tailed sheep (Sarmin et al., 2021a) though the BUN level of Barki sheep increased in a month after weaning (Abdel-Fattah et al., 2013), while it was low in the male Bighorn sheep (Kock et al., 1987). The resulting BUN level in the study was consistent with the reference parameter (Jackson and Cockcroft, 2002).

The physiological condition had significant impact on the resulting creatinine level in the study (P<0.05) and the lowest level was found in the ram as reported in the fat-tailed sheep (Sarmin et al., 2021a). High creatinine level was found in non-pregnant Tsigai sheep (Antunović et al., 2004). The resulting creatinine level in the study was in the range of the reference parameter (Kaneko et al., 2008). The creatinine served as the main marker of glomerular filtration rate in ruminants (Russell and Roussel, 2007) and was not significantly influenced by external factors (de Souza et al., 2020).

The physiological conditions did not have any significant impact on the resulting glucose level in the study (P>0.05) though the glucose level of lactating and pregnant Ossimi sheep was reported to be low (Soliman, 2014). The glucose level was lower than the reference parameter (Jackson and Cockcroft, 2002; Kaneko et al., 2008). The glucose level of ruminants was not influenced by forage, but by hormonal homeostatic mechanism to maintain glucose level (de Souza et al., 2020).

The physiological conditions did not have any significant impact on the resulting cholesterol level in the study (P>0.05), while high cholesterol level was found in the young fat-tailed sheep (Sarmin et al., 2021a), the pregnant Tsigai sheep (Antunović et al., 2004), young suckling Suffolk and it decreased after weaning (Fernandes et al., 2012) and pure and cross-bred Rambouillet sheep (Cavender et al., 1995). The resulting cholesterol level in the study was in the range of the reference parameter (Jackson and Cockcroft, 2002; Kaneko et al., 2008).

The physiological conditions did not have any significant impact on the resulting triglyceride level in the study (P>0.05), while on the contrary, high triglyceride level was found in the male and young fat-tailed sheep (Sarmin et al., 2021a) and low triglyceride level was found in the ewe lamb of 30 days of age (Cruz et al., 2017; de Souza et al., 2020) and also in Dorper sheep of 5 days and 121 days of age (Cruz et al., 2017) because milk intake began to decrease, while hepatic maturation and lipid metabolic capacity increased (de Souza et al., 2020). The triglyceride level was still in the range of that of cross-bred White Dorper x Suffolk sheep at the levels of 26.45±9.27 mg/dL (de Souza et al., 2020) and 23.70±5.30 mg/dL for Bangladesh male sheep and 24.80±7.10 mg/dL in Bangladesh female sheep (Rahman et al., 2018).

The physiological conditions did not have any significant impact on the resulting HDL level in the study (P>0.05) and the HDL level was different from that of the fat-tailed sheep (Sarmin et al., 2021a) and Mouflon sheep and Iranian thick-tailed sheep (Ahlad and Javadi, 2020). Lower HDL level was reported in Iranian fat-tailed sheep of 2 years of age than that of the sheep of more than 2 years of age (Azimzadeh and Javadi, 2020). The resulting HDL level in the study was higher than 14.49±5.68 mg/dL for young Mouflon sheep and 13.84±9.05 mg/dL for adult Mouflon sheep (Pošiváková et al., 2019). Physiological condition did not have any significant impact on the resulting LDL level in the study (P>0.05) as reported in the fat-tailed sheep (Sarmin et al., 2021a). It was reported that among Mouflon sheep age did not have any significant impact on LDL level (Pošiváková et al., 2019). High LDL level was found in young Suffolk sheep before weaning (Fernandes et al., 2012). Lower LDL level was reported in Iranian fat-tailed sheep of 2 years of age than that of the sheep of more than 2 years of age (Azimzadeh and Javadi, 2020). The resulting LDL level in the study was higher than that of young Mouflon sheep, which was 5.75±5.87 mg/dL and that of adult Mouflon sheep, which was 5.95±3.20 mg/dL (Pošiváková et al., 2019).

The results of the study showed that it was necessary to consider the factor of the variation of the physiological conditions of the Wonsosobo sheep in interpreting the hematology and the biochemistry of the sheep.

Conclusions

It was concluded that the impact of the physiological conditions of the Wonsosobo sheep caused high total leukocyte and lymphocyte in ewe lamb and high neutrophil in pregnant female sheep, the increase in the Pi level and ALP activity of the ewe lamb, and high creatinine in the ram.

Acknowledgement

Authors thank the Faculty of Veterinary of Gadjah Mada University for the grant Number: 984/J01.1.22/HK4/2019. We also thank drh. Rizal Aidi, M.Sc and drh. Nur Adrianto, M.Sc for their
help in animal health monitoring and in sampling and drh. Akhmad Abror As Siddiqi for his help in analyzing data.

References

Abdel-Fattah, M. S., A. L. S. Hashem, Y. M. Shaker, A. M. Ellamei, and H. Z. Amer. 2013. Effect of weaning age on productive performance and some plasma biochemical parameters of Barki lambs in Siwa Oasis, Egypt. Glob. Vet. 10: 189–202. https://doi.org/10.5829/idosi.gv.2013.10.2.104

Ahmadi-hamedani, M., K. Ghazvinian, N. Atyabi, P. Khanalizadeh, M. A. Masoum, and M. S. Ghodrati. 2016. Hematological reference values of healthy adult Sangaari sheep (Iranian fat-tailed sheep) estimated by Reference Value Advisor. Comp. Clin. Path. 25: 459–464. https://doi.org/10.1007/s00058-015-2211-z

Al-Bulushi, S., T. Shawaf, and A. Al-Hasani. 2017. Some hematological and biochemical parameters of different goat breeds in Sultanate of Oman “A preliminary study.” Vet. World 10: 461–466. https://doi.org/10.14202/vetworld.2017.461-466

Alonso, A. J., R. Teresa, M. García, J. R. González, and M. Valero. 1997. The Effects of age and reproductive status on serum and blood parameters in Merino breed sheep. J. Vet. Med. A 44: 223–231. https://doi.org/10.1111/j.1439-0442.1997.tb01104.x

Antunovic, Z., J. Novoselec, H. Sauerwein, M. Šperanda, and M. Vegara. 2011. Blood metabolic profile and some of hormones concentration in ewes during different physiological status. Bulgarian Journal of Agricultural Science 17: 687–695.

Antunovic, Z., M. Šperanda, D. Senčić, J. Novoselec, Z. Steiner, and M. Djidara. 2012. Influence of age on some blood parameters of lambs in organic production. Maced. J. Anim. Sci. 1: 11–15.

Antunovic, Z., M. Šperanda, and Z. Steiner. 2004. The influence of age and the reproductive status to the blood indicators of the ewes. Arch. Anim. Breed. 47: 265–273. https://doi.org/10.5194/aab-47-265-2004

Ashour, G., Neama, A. Ashmawy, S. M. Dessouki, and O. H. Shihab. 2015. Blood hematology, metabolites and hormones in newborn sheep and goat from birth to weaning. Int. J. Adv. Res. 3: 1377–1386.

Azimzadeh, K., and A. Javadi. 2020. Serum biochemical and haematology of Iranian Red Sheep (Ovis orientalis gmelini) in Sorkhabad Protected Area, Zanjan, Iran: Comparison with age and sex. Iran. J. Vet. Med. 14: 76–84. https://doi.org/10.22059/ijvm.2019.239317.1004840

Badawi, N. and H. Al-Hadithy. 2014. The Hematological parameters in clinically healthy Iraqi Awassi sheep. World’s Vet. J. 6: 01. https://doi.org/10.5455/wvj.20140237

Barsila, S. R., K. Bhatt, B. Devkota, and N. R. Devkota. 2020. Haematological changes in transhumant Baruwal sheep (Ovis aries) grazing in the western Himalayan mountains in Nepal. Pastoralism 10: 1–10. https://doi.org/10.1186/s13570-019-0156-6

Bhat, S., M. Mir, A. Reshi, S. Ahmad, I. Husain, S. Bashir, and M. Khan. 2014. Impact of age and gender on some blood biochemical parameters of apparently healthy small ruminants of sheep and goats in Kashmir valley India. International Journal of Agricultural Sciences and Veterinary Medicine 2: 22–27.

Borjesson, D. L., M. M. Christopher, and W. M. Boyce. 2000. Biochemical and hematologic reference intervals for free-ranging desert bighorn sheep. J. Wildl. Dis. 36: 294–300. https://doi.org/10.7589/0090-3558-36.2.294

Börnæz, R., M. B. Linares, and H. Vergara. 2009. Haematological, hormonal and biochemical blood parameters in lamb: Effect of age and blood sampling time. Livest. Sci. 121: 200–206. https://doi.org/10.1016/j.livsci.2008.06.009

Buddle, B. M., G. Jowett, R. S. Green, P. G. C. Douch, and P. L. Risdon. 1992. Association of blood eosinophilia with the expression of resistance in Romney lambs to nematodes. Int. J. Parasitol. 22: 955–960. https://doi.org/10.1016/0090-7519(92)90053-N

Cavender, C. P., S. D. Turley, and J. M. Dietschy. 1995. Sterol metabolism in fetal, newborn, and suckled lambs and their response to cholesterol after weaning. Am. J. Physiol. Endocrinol. Metab. 269: E331–E340. https://doi.org/10.1152/ajpendo.1995.269.2.E331

Carlson, G. P. 1997. Fluid, electrolyte, and acidbase balance. In: Clinical biochemistry of domestic animals. Kaneko, J. J. Harvey, J. W. Bruss, M. L. (Eds). 5th edn. San Diego: Academic. pp. 485-516.

Chaney, S. G. 1997. Principles of nutrition II: Micronutrients. In: Textbook of biochemistry with clinical correlations. 4 edn. Devlin, T. M. (Ed). Wiley Liss, Inc., New York, p.1107-1136.

Cihan, H., E. M. Temizel, Z. Yilmaz, and Y. Ozarda. 2016. Koyunlarda doğum öncesi ve sonrası serum demir durumu ve hematolojik endekslerle ilişkisi. Kafkas Üniversitesi Veteriner Fakültesi Dergisi. https://doi.org/10.9775/kvd.2016.15103

Cruz, R. E. S. da, F. M. Rocha, C. V. B. Sena, P. G.Noleto, E. C. Guimarães, J. A. Galo, and A. V. Mundim. 2017. Effects of age and
Mazzullo, G., C. Rifci, G. Caccamo, Rizzo, M. and G. Piccione. 2014. Effect of different environmental conditions on some haematological parameters in cow. Annals Anim. Sci. 14: 947–954. https://doi.org/10.2478/aoas-2014-0049

Mohammed, A., A. Khan, I. Pargass, P. Bridgemohan, A. E. Edwards, H. S. Stewart, F. G. Youssef, and S. Sieuchand. 2017. Serum mineral levels in goats of various physiological stages in the dry and wet seasons in central trinidad. Microelements в Medicine 18: 18–27.

Mostaghni, K., K. Badiei, and M. Emadi 2005. Haematology and serum biochemistry of captive wild sheep (Ovis orientalis esphahanica) in Iran. Comp. Clin. Path. 13: 155–161. https://doi.org/10.1007/s00580-004-0526-2

Murphy, W. G. 2014. The sex difference in haemoglobin levels in adults-Mechanisms, causes, and consequences. Blood Rev. 28: 41–47. https://doi.org/10.1016/j.bire.2013.12.003

Nagy, O., C. Tóthová, and G. Kováč. 2014. Age-related changes in the concentrations of serum proteins in calves. J. Appl. Anim. Res. 42: 451–458. https://doi.org/10.1080/09712119.2013.875918

Okonkwo, J., I. Okonkwo, and G. Ebuh. 2011. Effect of breed, sex and source within breed on the haematological parameters of the nigerian goats. J. Anim. Feed Res. 1: 8–13.

Pernthaner, A., Cole, S. A. Morrison, L. and W. R. Hein. 2005. Increased Expression of Interleukin-5 (IL-5), IL-13, and tumor necrosis factor alpha genes in intestinal lymph cells of sheep selected for enhanced resistance to nematodes during Infection with Trichostrongylus colubriformis. Infect. Immun. 73: 2175–2183.2005

Piccione, G., Caola, G. Giannetto, C. Grasso, F., Runzo, S. C. Zumbo, A. and P. Pennis 2009. Selected biochemical serum parameters in ewes during pregnancy, post-parturition, lactation and dry period. Anim. Sci. Pap. Reports 27: 321-220

Pizetti, A. J. M, R. O. Sarmiento, L. A. Pintos, G. B. Trova, J. A. Binda, and O. S. Negrette. 2021. Haematological and protein profile of goat rodeo in extensive productions of different regions in the province of Salta, Argentina. J. Appl. Anim. Res. 49: 239–246. https://doi.org/10.1080/09712119.2021.1938580

Polizopoulos, Z. S. 2010. Haematological tests in sheep health management. Small Rumin. Res. 92: 88–91. https://doi.org/10.1016/j.smallrumres.2010.04.015

Pošiváková, T., J. Švajlenka, J. Pošiváková, J. Pokorádi, R. Hromada, P. Korim, and L. Molnár. 2019. The influence of age on the activity of selected biochemical parameters of the mouflon (Ovis musimon L.). Animals 9: 242. https://doi.org/10.3390/ani9050242

Rahman, Md. K., S. Islam, J. Ferdous, Md. H. Uddin, M. B. Hassain, M. M.Hassan, and A. Islam. 2018. Determination of hematological and serum biochemical reference values for indigenous sheep (Ovis aries) in Dhaka and Chittagong Districts of Bangladesh. Vet. World 11: 1089–1093. https://doi.org/10.14202/vetworld.2018.1089-1093

Ramos, J. J., M. T. Verde, M. C. Marca, and A. Fernández, 1994. Clinical chemical Anim. and variations in Rasa Aragonesas ewes and lambs. Small Rumin. Res. 13: 133–139. https://doi.org/10.1016/0921-4488(94)90088-4

Ribeiro, N. L., R. G. Costa., E. C. P. Filho, M. N. Ribeiro, and R. Bozzi. 2018. Effects of the dry and the rainy season on endocrine and physiologic profiles of goats in the Brazilian semi-arid region. Ital. J. Anim. Sci. 17: 454–461. https://doi.org/10.1080/1828051X.2017.1393320

Russell, K. E. and A. J. Roussel.2007. Evaluation of the ruminant serum chemistry profile. Vet. Clin. North Am. Food Anim. Pract. 23: 403–426. https://doi.org/10.1016/j.cvfa.2007.07.003

Salvagno, G. L., F. Sanchis-Gomar, A. Picanza, and G. Lippi. 2015. Red blood cell distribution width: A simple parameter with multiple clinical applications. Crit. Rev. Clin. Lab. Sci. 52: 86–105. https://doi.org/10.3109/10408363.2014.992604

Sarmin, S., Winarsh, A., Hana, P., Astuti, and C. M. Airin. 2021a. Parameters of blood biochemistry in different physiological status of fat-tailed sheep. AIP Conference Proceedings 2353, 030070. https://doi.org/10.1063/5.0052634

Sarmin, S., Winarsh, A., Hana, P. Astuti, and C. M. Airin. 2021b. Haematological profiles of Indonesian fat-tailed sheep under different physiological conditions. Trop. Anim. Health Prod. 53: 523. https://doi.org/10.1007/s11250-021-02961-3

Soliman, E. B. 2014. Effect of physiological status on some hematological and biochemical parameters of ossimi sheep. Egyptian Journal of Sheep & Goat Sciences 9: 33–42.

Suswono. 2011. Keputusan Menteri Pertanian Nomor 2915/Kpts/OT.140/6/2011 tentang Penetapan Rumpun Domba Wonosobo.
Tibbo, M., K. Aragaw, F. Abunna, M. Woldemeskel, A. Deressa, M. L. Dechassa, and J. E. O. Rege. 2005. Factors affecting haematological profiles in three indigenous Ethiopian sheep breeds. Comp. Clin. Path. 13: 119–127. https://doi.org/10.1007/s00580-004-0525-3

Weiss, D. and K. Wardrop 2010. Schalms Veterinary Haematology 6th edn. Wiley-Blackwell, Ammes, Iowa USA.

Zúriá Žaja, I., Vince, S. N. P. Milas, I. R. A. Lobpreis, B. Špoljarič, A. S. Vugrovečki, S. Milinković-Tur, M. Šimpraga, L. Pajurin, T. Mikuš, K. Vlahović, M. Popović, and D. Špoljarič. 2019. A new method of assessing sheep red blood cell types from their morphology. Animals 9: 1130. https://doi.org/10.3390/ani9121130.