

## Original Research Article

### **Influence of Pregnancy Stages on Thyroid Status and Blood Metabolites in Desert Ewes Raised under Range Conditions in West Kordufan State, Sudan**

#### **ABSTRACT:**

**-Background and Objective:** This study aimed to evaluate the influence of the stages of pregnancy in two ecotypes of sheep, located in different grazing areas on thyroid status and certain blood metabolites. **Materials and Methods:** Eighty clinically healthy ewes (40 Hamari and 40 Kabashi ecotype), aged 2-5 years, were used in the study. For each ecotype, the ewes were divided into four groups according to the reproductive status. Group (A): 10 ewes non-pregnant non-lactating (empty dry) served as a the control. Group (B): 10 ewes in the early stage of pregnancy (successful insemination to 50 days first trimester). Group (C): 10 ewes in mid-stage of pregnancy (51-100 days second trimester). Group (D): 10 ewes in the late stage of pregnancy (about 101-150 days third trimester). Blood samples were used to measure serum levels of thyroid stimulating hormone (TSH), thyroxine (T<sub>4</sub>), triiodothyronine (T<sub>3</sub>), plasma glucose concentration and serum triglyceride levels. **Results:** The results showed that in both ecotypes, the serum TSH levels were significantly ( $P<0.05$ ) higher (insert value) during the early stage of pregnancy, then, it decreased (insert value) ~~numerically with the advance of~~ as the pregnancy advanced. While serum T<sub>4</sub> levels were ~~numerically~~ higher (insert value) during the early stage of pregnancy, then it decreased (insert value) significantly ( $P<0.01$ ) during the late pregnancy. Serum T<sub>3</sub> level was significantly ( $P<0.001$ ) higher (insert value) in both ecotype during early and mid-pregnancy, then declined to the lowest value (insert value) during the late stage. The plasma glucose level was significantly ( $P<0.001$ ) lower (insert value) during mid and late pregnancy in both ecotypes. There was a significant ( $P<0.05$ ) decrease (insert value) in serum triglyceride level with the advance of pregnancy in both ecotypes. Kabashi ecotype showed significantly higher serum triglyceride levels (insert value) in the control group ( $P<0.001$ ) during early pregnancy stage ( $P<0.01$ ) and mid pregnancy stage ( $P<0.05$ ) compared to the values (insert value) of serum triglyceride levels in Hamari ecotypes. **Conclusions:** This study indicated that pregnancy ~~induces variable~~ altered ~~ations in~~ thyroid status in Kabashi? or

Comment [Repent!1]: Recast

~~Hamari? Then conclude based on TSH, T3, T4, Glucose level ecotype differences associated with some changes in certain relevant blood metabolites. Therefore, supplementation with minerals during pregnancy might enhance the metabolic profile of the studied ecotypes.~~

**Comment [Reprint2]:** Was this part of the study? If yes, provide result before concluding. If no, expunge and conclude based of the scope of the study.

**Keywords:** ~~Please choose words not captured in the title -Pregnancy Stages. Thyroid Status. Blood Metabolites. Desert Ewes.~~

## Introduction

Sudan is one of the largest countries in Africa, characterized by a great number of livestock, vast areas of range and cultivated land. Sheep are multiple purpose animals, providing meat, milk and skin. They are raised under nomadic condition with traditional methods of management and natural grazing [1]. ~~The~~ sheep populations ~~is are~~ estimated at 41 million ~~head~~, which represent over 36% of the livestock in the country. Most are ~~D~~desert sheep distributed across the low rainfall Savannah, semi-desert and desert zones [2]. The ~~D~~desert sheep production in the marginal area in Kordufan constitutes an important source of income for the nomadic tribes. There are many ecotypes of ~~D~~desert sheep in Kordufan State; ~~however~~ the major ecotypes are Hamari and Kabashi sheep [3].

About 90% of sheep are owned by the traditional producers who mainly depend on the natural grazing to raise their animals [4]. The nutritional limitation, low nutritive value of the forages, high ambient temperature, scarcity of feed and water have a great effect on sheep production [5], which could be associated with the activity of the thyroid gland.

Thyroid hormones (TH) influence most cells of the body and regulate growth rate chemical reactions [6]. The fundamental role of thyroid hormone in the body is attributed to the stimulation of metabolic activity by increasing the circulating hormones, particularly T<sub>3</sub> and T<sub>4</sub> plasma concentrations to sustain and improve animal nutrition and production. However, thyroid dysfunctions are considered important endocrinopathies in both human and animals [7, 8]. Pregnancy is a dynamic process characterized by dramatic physiological changes [9]. During pregnancy, thyroid activity is reported to be changed in most of ~~the~~ mammalian species

investigated [\(insert references\)](#). Serum biochemical metabolites might be altered by pregnancy; changes in the concentrations of serum biochemical profiles in different physiological conditions have been investigated in animal [10]. During pregnancy, several metabolic changes and adaptations take place [11]. Despite the importance of thyroid dysfunction, no data is available on sheep in Sudan, probably; there were no obvious clinical signs (goiter). However, studies have showed subclinical changes in thyroid activity, which could affect productivity in animals [12]. On [the](#) other hand, studies in West Kordufan state showed clinical and subclinical colloid goiter in camels [13]. The prevalence of thyroid disorder was also, high in humans in North Kordufan [14]. The aim of the present study was to evaluate the influence of stage of pregnancy in two different ecotypes of desert sheep (Hamari and Khabashi), located in different grazing areas, on thyroid status and certain blood metabolites.

## MATERIALS AND METHODS

### Study area

The present study was conducted in West Kordufan State, that is located in Southwestern part of the region of Kordufan, Sudan, between latitude [11-20 North and 32.22-30.27 East](#), and lies between the South Kordufan, North Kordufan and East Darfur state [15]. The Southern part of the state is characterized by heavy rainfall, vegetation, trees and heavy clay soils. The Northern part is a medium-range rain and sandy soil [15]. [For the present study, samples were collected from two different locations: Qubaiesh and Alnuhod.](#)

Comment [Reprint!3]: Recast 11° 20' N and ...

Comment [Reprint!4]: Recast

### ~~Animals and~~ Experimental plan

Eighty clinically healthy ewes (40 Hamari and 40 Kabashi ecotype) aged 2-5 years were used in the study. For each ecotype, the ewes were divided into four groups according to the reproductive statuses. Group (A): 10 ewes non-pregnant non-lactating ([empty dry](#)) ewes served as a control. Group (B): 10 ewes in early stage of pregnancy ([first trimester](#)~~about successful insemination to 50 days~~). Group (C): 10 ewes in mid stage of pregnancy ([second trimester](#)~~about 51-100 days~~). Group (D): 10 ewes in late stage of pregnancy ([third trimester](#)~~about 101-150 days~~). Pregnancy was diagnosed by palpation [according to \(insert reference\)](#) and the information obtained from the owners.

### **Grazing and Management of animals**

Animals were maintained on natural pasture grazing. However, Hamari ecotype was supplied salt and minerals block during watering by its owners. While in the area of Kabashi ecotype there was a shortage ~~in~~<sup>of</sup> water, dry matter and poor management. During the summer season, the flocks spent ~~ed~~ more time near the watering point and the animals were watered 2-3 times per week.

### **Blood samples collection**

Blood samples were collected by jugular venipuncture once at 8:00 a.m. Ten (10) ml of blood was collected and immediately 2 ml of blood was transferred to a test tube containing sodium fluoride as anticoagulant for of determination plasma glucose concentration. The rest of blood samples were allowed to stay at room temperature for 3 hours and then centrifuged at 3000 r.p.m. for 15 min. Hemolysis-free serum samples were separated and transferred to clean plastic vials, and immediately frozen at -20C° for TSH, T4, T3, total protein and triglycerides measurement according to...refernces. Thyroid function tests were carried out by measuring serum levels of TSH, thyroxin (T4) and triiodothyronine (T3) using microplate immune-enzymetic assay Kit-Antrim OIS available from (Fortress Company). Plasma glucose concentration was determined by the enzymatic method using a kit (Biosystem-Spain), as described by Rognoni and Ronchini [16]. The serum total proteins concentration was determined by the Biuret methods as described by King and Wootton [17]. Serum creatinine concentration was measured by spectrophotometer described by Fabian and Ertingshausen [18].

### **Statistical Analysis**

Data were analyzed using SPSS version 21. ANOVA test and t-test were used to assess the significant difference among the groups. While not use Chi square to compare Hamari and Kabashi for better clarity?

## RESULTS

The results showed that in both ecotypes, serum TSH level increased significantly ( $P < 0.05$ ) during early stage of pregnancy, afterwards it decreased ~~numerically~~ with advance of pregnancy. However, there was no significant difference in serum TSH values (insert values) between Hamari and Kabashi ecotypes. Serum  $T_4$  levels increased (insert values) ~~numerically~~ during early stage of pregnancy in both ecotypes, then the serum levels of  $T_4$  decreased (insert values) significantly ( $P < 0.01$ ) during the late stage of pregnancy in both ecotypes. Serum  $T_3$  level increased (insert values) significantly ( $P < 0.001$ ) in Hamari ecotype and ~~numerically in~~ Kabashi ecotype during the early and mid-stages of pregnancy, then the serum  $T_3$  levels declined to lowest value (insert values) during late stage in both ecotypes. Interestingly, the highest values (insert values) of serum  $T_3$  were observed only in Hamari ecotype in the control group ( $P < 0.01$ ) as well as during the early stage of pregnancy ~~( $P < 0.001$ ) ( $P < 0.001$ )~~. In both ecotypes, the Plasma glucose level decreased (insert values) significantly ( $P < 0.001$ ) in mid and late stage of pregnancy. Hamari ecotype showed significant ( $P < 0.001$ ) increase (insert values) in serum total protein levels during early stage of pregnancy, then it declined (insert values) significantly ( $P < 0.001$ ) in mid and late stage of pregnancy. However, there was no significant difference in plasma glucose level between Hamari and Kabashi ecotypes. Regarding, total protein Kabashi ecotype showed significantly ( $P < 0.001$ ) lower value (insert values) of serum total protein during early, mid and late stage of pregnancy compared to values of control group. However, Hamari ecotype showed significantly ( $P < 0.001$ ) higher value (insert values) of serum total protein during early stage of pregnancy compared to values of control group. Among the two ecotypes, Kabashi ecotype showed significantly ( $P < 0.001$ ) lower value (insert values) of serum total proteins during the early and mid-stages compared to values of Hamari ecotype

Comment [Reprint!5]: Not clear

## DISCUSSION

During pregnancy, thyroid activity was reported to be changed in sheep [19]. In the present study, the results indicated that thyroid status influenced by pregnancy and ecotype in desert ewes (Hamari and Kabashi) raised under range conditions. The data indicated that there was a significant increase in serum TSH concentration with advancing pregnancy, then the value of serum TSH declined during the late pregnancy in both ecotypes (Fig. 1, Table 1). This pattern

Comment [Reprint!6]: This is still results so delete and discuss appropriately

of response could be attributed to the elevated estrogen concentration, which could influence the liver activity to increase the serum thyroxin binding globulin (TBG) concentration, elevated TBG concentration leads to a decrease in free T<sub>4</sub> concentration, which results in increased TSH secretion by the pituitary gland [20]. An increase in concentration of TSH leads to increase in serum T<sub>4</sub> and T<sub>3</sub> values ultimately decrease TSH concentration by the negative feedback [21]. Similar pattern was observed in human [22, 23, 24] and in goats [25]. Noteworthy, a study in camels do not show a significant difference in TSH concentration between pregnant and non-pregnant dromedary camels [26].

Serum T<sub>4</sub> concentration increased numerically in early and mid-stages of pregnancy, then the value of T<sub>4</sub> decreased significantly during the late pregnancy in both ecotypes. This decrease is probably due to the growth foetus which plays a competitive role higher thyroid activity, iodine affinity and uptake than maternal ones [27]. Furthermore, the decrease in serum T<sub>4</sub> may be attributed to an increase in T<sub>4</sub> deionization by deiodinase type 2 in the placenta, which plays a critical role in delivery of T<sub>4</sub> to the fetus [28]. The current observations are in agreements with previous studies in ewes [29, 30, 31]. Similar studies indicated a decrease in the maternal serum T<sub>4</sub> concentration during late pregnancy in goats [27,32] and crossbreed dairy cows [33]. However, earlier studies did not show significant change in thyroid activity in ewes during different stages of pregnancy [34, 35]. ~~Regarding the ecotype, the present study revealed that during late pregnancy, Hamari ecotype showed higher value of T<sub>4</sub> compared to respective value of Kabashi ecotype (Fig. 2, Table 2).~~ The higher serum T<sub>4</sub> in Hamari ecotype could be due to mineral supplementation offered to Hamari ecotype. Serum T<sub>3</sub> showed the same pattern ~~of with~~ serum T<sub>4</sub> during different stages of pregnancy in both ecotypes, ~~probably due to ...but the change in hormone value was numerical and not significant in Kabashi ecotype (Fig. 3, Table 3).~~ The decrease in serum T<sub>3</sub> values during late pregnancy is probably attributed to the negative energy balance [19]. The current results are in line with previous studies in ewes [19, 30]. Studies on goat and in crossbreed dairy cow also indicated a decrease in the maternal serum T<sub>3</sub> concentration with advancing pregnancy [27, 32, 33]. Other investigations did not show any significant effect in the T<sub>3</sub> value in ewes among different stages of pregnancy [34, 35]. In the current study, the mean plasma glucose concentration decreased ~~significantly (P<0.001) with advance of pregnancy in both ecotypes (Fig. 4, Table 4).~~ The decrease could be attributed to mobilization of maternal glucose into foetal circulation through an active transport process

Comment [Reprint!7]: This is still results so delete and discuss appropriately

Comment [Reprint!8]: Be consistent with spelling

Comment [Reprint!9]: Provide results OR leave it as a mere error/bias in study plan

Comment [Reprint!10]: This is what I mean that it may not be due to the salt lick and minerals provided.

Comment [Reprint!11]: Be consistent with spelling

across the placenta. A decrease in glucose level with advance of pregnancy was also reported by Jacob and Vadodaria [36], who attributed ~~it that~~ to pregnancy glucose requirements for both the dam and the foetus. The reduction in glucose concentration during late pregnancy was observed in several studies in ewes [37, 38, 39] and in goats [25]. In contrast, other studies reported an increase in glucose concentration with the advance of pregnancy [40].

Comment [Repept!12]: Be consistent with spelling

~~The results obtained indicated a significant decrease in serum triglycerides concentration in late pregnancy in both ecotypes (Fig. 5, Table 5).~~ Previous studies indicated decrease in insulin concentration during late pregnancy combined with lower sensitivity of adipose tissue to insulin and increase in somatotropin may reduce the synthesis of triglycerides in the adipose tissues and favor their mobilization during this period [41, 42]. This result may indicate that the plasma lipids content is sensitive and it is affected by many factors. Study by Christie [43] confirmed that the amount and composition of the plasma circulating lipids of dairy cows were dependent upon number of physiological variables, includes the nature of the diet, time since feeding, age, ecotype, pregnancy and stage of lactation. ~~In the present study,~~ many factors could influence the triglycerides concentration in the body especially, feed intakes and feeding regimes. Previous studies confirmed decline in triglycerides concentration with advance of pregnancy [39, 44]. On the other hand, some researchers showed a gradual increase in serum triglycerides concentrations with the advance of pregnancy [37, 41]. In the current study, the lower mean values of serum triglycerides concentration in Kabashi compared to Hammari is probably due to poor handling and management for Kabashi ecotype.

Comment [Repept!13]: Please list the factors

~~It was concluded that pregnancy induces variable alterations in thyroid status associated with change in certain relevant blood metabolites. Supplementation with minerals might enhance the response of the ecotypes during pregnancy.~~

Please conclude based on the scope of the study: TSH in Hammari/Kabashi

T3 in Hammari/Kabashi

T4 in Hammari/Kabashi

Glucose concentration ...etc

#### COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly used products in ~~the our~~ area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

Comment [Reprint!14]: Specify the products

#### References

- 1- **Degen A.** Sheep and goat milk in pastoral societies. *Small Rumin. Research.* **2007**; 68: 7-19. <https://www.sciencedirect.com/science/article/abs/pii/S0921448806002616>.
- 2- **Ministry of Animal Wealth and Fisheries.** Department of statistic and information, Annual Report. **2017**; Khartoum, Sudan
- 3- **Bakhiet A.** An investigation on the Chemo-genetics characteristics of Roselle seed (Hibiscus sabdariffa) as an alternative source of proteins influencing fattening performance of Sudanese desert Sheep. **2016.** Ph.D. Thesis, Sudan University of Science and Technology. <http://repository.sustech.edu/handle/123456789/14834>.
- 4- **Steinfeld H, Gerber P, Wassenaar T, Castel V and Dehaan C.** Livestock's long shadow **2006**; environmental issues and options,FAO.
- 5- **Ebrahiem M, Bushara I, Mekki D, Turki I and Haroun H.** The effect of breed on skin/leather quality of Sudan Desert Sheep. *Global Journal Science Research.* **2014**; 3: 6-10. [https://www.researchgate.net/publication/331646571\\_The\\_effect\\_of\\_breed\\_on\\_Skin\\_Leather\\_Quality\\_of\\_Sudan\\_Desert\\_Sheep](https://www.researchgate.net/publication/331646571_The_effect_of_breed_on_Skin_Leather_Quality_of_Sudan_Desert_Sheep).

- 6- **Medrano R and Hua H.** Advances in thyroid hormones function relate to animal nutrition. *Annals of Thyroid Research.* **2016;** 2: 45-52. <https://austinpublishinggroup.com/thyroid-research/fulltext/thyroids-v2-id1013.php>.
- 7- **Shi Y, Ritchi JW and Taylor PM.** Complex regulation of thyroid hormone action: multiple opportunities for pharmacological intervention. *Pharmacology Therapy.* **2002;** 94: 235-251. <https://www.ncbi.nlm.nih.gov/pubmed/12113800>.
- 8- **Rijnberk A, Kooistra HS and Janmol A.** Endocrine diseases in dogs and cats: similarities and differences with endocrine diseases in humans. *Growth Horm IGF Res.* **2003;** 13: 158-164. <https://www.ncbi.nlm.nih.gov/pubmed/12914747>.
- 9- **Omidi A, Sajedi Z, Torbati MB and Nik HA.** Lipid profile and thyroid hormone status in the last trimester of pregnancy in single-humped camels (*Camelus dromedarius*). *Tropical Animal Health and Production.* **2014;** 46: 609-614. <https://www.ncbi.nlm.nih.gov/pubmed/24429808>.
- 10- **Yokus B, Cakir D, Kanay Z, Gulten T and Uysal E.** Effects of seasonal and physiological variations on the serum chemistry, vitamins and thyroid hormone concentrations in sheep. *Journal of Veterinary Medicine.* **2006;** 53: 271-276. [https://www.researchgate.net/publication/6886514\\_Effects\\_of\\_Seasonal\\_and\\_Physiological\\_Variations\\_on\\_the\\_Serum\\_Chemistry\\_Vitamins\\_and\\_Thyroid\\_Hormone\\_Concentrations\\_in\\_Sheep](https://www.researchgate.net/publication/6886514_Effects_of_Seasonal_and_Physiological_Variations_on_the_Serum_Chemistry_Vitamins_and_Thyroid_Hormone_Concentrations_in_Sheep).
- 11- **Ingvartsen KL.** Feeding and management related diseases in the transition cow. Physiological adaptations around calving and strategies to reduce feeding-related diseases. *Animal Science Technology.* **2006;** 126: 175-213. <https://www.sciencedirect.com/science/article/pii/S0377840105003184>
- 12- **Johnson CA.** Thyroid issues in reproduction. *Clinical Technology Small Animal Practice.* **2002;** 17: 129-132. <https://www.ncbi.nlm.nih.gov/pubmed/12476816>.
- 13- **Abu Damir H, Barri ME, Tageldin MH and Idris OF.** Clinical and subclinical colloid goiter in adult camels (*Camelus dromedarius*) at Kordofan Region of the Sudan. *British Veterinary Journal.* **1990;** 146: 219-227. <https://www.ncbi.nlm.nih.gov/pubmed/2364252>
- 14- **El-tayeb MM, Daoud OM, Ajabeldour AA, Khalid, KE and Ali KE.** Biochemical and clinical assessment of thyroid status in patients with thyroid disorders referred to El-obied regional health laboratory. *Gezira Journal of Health Science.* **2008;** 4:1-10.

[https://www.researchgate.net/publication/281209532\\_Biochemical\\_and\\_Clinical\\_Assessment\\_of\\_Thyroid\\_Status\\_in\\_Patients\\_Referred\\_to\\_El-Obied\\_Regional\\_Health\\_Laboratory](https://www.researchgate.net/publication/281209532_Biochemical_and_Clinical_Assessment_of_Thyroid_Status_in_Patients_Referred_to_El-Obied_Regional_Health_Laboratory).

- 15- **Gad Al-kareem I, Abdelgdir A and Elmalik K.** Study on prevalence of parasitic diseases in cattle in Abyei area, Sudan. *Journal Cell Animal Biology*. **2012**; 6: 88-98. <http://www.wku.edu.sd/en/images/pub/2006.pdf>.
- 16- **Rognoni F and Ronchini A.** Research on the intestinal absorption of glucose-1-phosphate. *Bollettino della Societa italiana biologia sperimentale*. **1964**; 40: 1485. <https://www.ncbi.nlm.nih.gov/pubmed/5878014>.
- 17- **King EJ and Wootton ID.** *Microanalysis in Medical Biochemistry*, 4th ed. London: Churchill Livingstone. **1965**; 101-103.
- 18- **Fabian DL and Ertingshausen G.** Automated reaction rat methods for determination of serum creatinine with centerfichem. *Clinical Chemistry*. **1971**; 17: 696-700. <https://www.ncbi.nlm.nih.gov/pubmed/5562281>.
- 19- **Todini L.** Thyroid hormones in small ruminants: Effects of endogenous, environmental and nutritional factors. *Animal*. **2007**; 1: 997-1008. <https://www.ncbi.nlm.nih.gov/pubmed/22444802>.
- 20- **Casey BM and Leveno KJ.** Thyroid disease in pregnancy. *Obstetrics and Gynecology*. **2006**; 108: 1283-1292. <https://www.ncbi.nlm.nih.gov/pubmed/17077257>.
- 21- **Glinoeer D.** Pregnancy and iodine. *Thyroid*. **2001**; 11: 471-481. <https://www.ncbi.nlm.nih.gov/pubmed/11396705>.
- 22- **Chen YT and Jhon DH.** Thyroid diseases in pregnancy. *Ann. Acad.* **2002**; 31: 296 -302. <http://library.um.edu.mo/ebooks/b28357334.pdf>.
- 23- **Idris I, Srinivasan R, Simm A and Page RC.** Maternal hypothyroidism in early and late gestation: Effect on neonatal and obstetric outcome. *Journal Endocrinology*. **2005**; 63: 5605-5605. <https://www.ncbi.nlm.nih.gov/pubmed/16268809>.
- 24- **Alexander EK, Pearce EN, Brent GA, Brown RS, Chen H, Dosiou C, Grobman WA, Laurberg P, Lazarus JH, Mandel SJ and Peeters RP.** Guidelines of the American Thyroid Association for the diagnosis and management of thyroid disease during pregnancy and the postpartum. *Thyroid*. **2017**; 27: 315-389. <https://www.ncbi.nlm.nih.gov/pubmed/28056690>

- 25- Yahi D, Ojo N and Mshelia G.** Effects of pregnancy on plasma glucose and some serum metabolic hormones in Sahel goats. *Annals of Borno*. **2015**; 25:179. [http://journals.unimaid.edu.ng/index.php/annals\\_of\\_Borno/article/view/18](http://journals.unimaid.edu.ng/index.php/annals_of_Borno/article/view/18).
- 26- Ahmed YF, Mahmoud KG M, Kandiel MM, Nawito M and Abdel Razik A.** Histomorphometry aspect of thyroid gland and biochemical profile in pregnant and non-pregnant dromedary camels. *African Journal Biotechnology*. **2016**; 15: 370-375. <https://www.ajol.info/index.php/ajb/article/view/132771>.
- 27- McDonald BJ, Stocks DC, Connell JA and Hoey WA.** Thyroxine concentration in maternal and foetal plasma during pregnancy in Australian feral goats. *Journal of Agricultural Science*. **1988**; 110: 25-30. <https://europepmc.org/article/agr/ind87106642>.
- 28- Kilbya MD, Barbera K, Hobbsa E and Franklynb JA.** Thyroid Hormone Action in the Placenta. *Placenta*. **2005**; 26: 105-113. <https://www.ncbi.nlm.nih.gov/pubmed/15708111>.
- 29- Okab AB, Elebanna IM, Mekkiw MY, Hassan GA, Elnouty FD and Salem MH.** Seasonal-changes in plasma thyroid hormones, total lipids, cholesterol and serum transaminases during pregnancy and at parturition in barki and rahmani ewes. *Indian Journal of Animal Science*. **1993**; 63: 946-951. <http://agris.fao.org/agris-search/search.do?recordID=IN9301404>.
- 30- Yildiz A, Balikci E and Gurdogan F.** Changes in some serum hormonal profiles during pregnancy in single- and twin-foetus-bearing Akkaraman sheep. *Medycyna Weterynaryjna*. **2005**; 61: 1138-1141. [https://www.researchgate.net/publication/285818920\\_Changes\\_in\\_some\\_serum\\_hormonal\\_profiles\\_during\\_pregnancy\\_in\\_single\\_and\\_twin\\_foetus-bearing\\_Akkaraman\\_sheep](https://www.researchgate.net/publication/285818920_Changes_in_some_serum_hormonal_profiles_during_pregnancy_in_single_and_twin_foetus-bearing_Akkaraman_sheep).
- 31- Colodel M, Martins E, Martins V and Marques Júnior A.** Serum concentration of thyroid hormones in crioula lanada serrana ewes in gestation and lactation. *Archivos de zootecnia*. **2010**; 59 :509-517. [http://scielo.isciii.es/scielo.php?script=sci\\_arttext&pid=S0004-05922010000400004](http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S0004-05922010000400004).
- 32- Polat H, Dellal G, Baritci I and Pehlivan E.** Changes of thyroid hormones in different physiological periods in white goats. *Journal of Animal and Plant Sciences*. **2014**; 24: 445-449. [https://www.researchgate.net/publication/262115694\\_Changes\\_of\\_thyroid\\_hormones\\_in\\_different\\_physiological\\_periods\\_in\\_white\\_goats](https://www.researchgate.net/publication/262115694_Changes_of_thyroid_hormones_in_different_physiological_periods_in_white_goats).
- 33- Alameen AO and Abdelatif AM.** Metabolic and endocrine responses of crossbred dairy cows in relation to pregnancy and season under tropical conditions. *Am-Euras. Journal of Agriculture*

and Environmental Sciences. **2012**; 12: 1065-1074.

[https://www.researchgate.net/publication/294891875\\_Metabolic\\_and\\_Endocrine\\_Responses\\_of\\_Crossbred\\_Dairy\\_Cows\\_in\\_Relation\\_to\\_Pregnancy\\_and\\_Season\\_Under\\_Tropical\\_Conditions](https://www.researchgate.net/publication/294891875_Metabolic_and_Endocrine_Responses_of_Crossbred_Dairy_Cows_in_Relation_to_Pregnancy_and_Season_Under_Tropical_Conditions).

- 34- Henneman HA, Reineke EP and Griffin SA.** The thyroid secretion rate in sheep as affected by season, age, breed, pregnancy and lactation. *Journal of Animal Science*. **1955**; 14: 419-434. <https://academic.oup.com/jas/article-abstract/14/2/419/4761922?redirectedFrom=fulltext>.
- 35- Falconer I and Robertson H.** Changes in thyroid activity during growth in the sheep. *Journal of Endocrinology*. **1961**; 22: 23-30. <https://www.ncbi.nlm.nih.gov/pubmed/13697997>.
- 36- Jacob N and Vadodaria VP.** Concentrations of glucose and cortisol in blood of Patanwadi Ewes around parturition. *Indian Veterinary Journal*. **2001**; 78: 890-892. [https://www.researchgate.net/publication/281371063\\_Levels\\_of\\_glucose\\_and\\_cortisol\\_in\\_blood\\_of\\_Patanwadi\\_ewes\\_around\\_parturition](https://www.researchgate.net/publication/281371063_Levels_of_glucose_and_cortisol_in_blood_of_Patanwadi_ewes_around_parturition).
- 37- Balikci E, Yildiz A and Gurdogan F.** Blood metabolites concentration during pregnancy and postpartum in Akkaraman ewes. *Small Rumin Research*. **2007**; 67: 247-251. <https://www.sciencedirect.com/science/article/abs/pii/S0921448805004268>.
- 38- Antunovic Z, Novoselec J, Sauerwein H, Speranda M, Vegara, M and Pavic V.** Blood metabolic profile and some of hormones concentration in ewes during different physiological status. *Bulgarian Journal of Agricultural Science*. **2011**; 17: 687-691. [https://www.researchgate.net/publication/258977104\\_Blood\\_Metabolic\\_Profile\\_and\\_some\\_of\\_Hormones\\_Concentration\\_in\\_Ewes\\_During\\_Different\\_Physiological\\_Status](https://www.researchgate.net/publication/258977104_Blood_Metabolic_Profile_and_some_of_Hormones_Concentration_in_Ewes_During_Different_Physiological_Status).
- 39- Haffaf S and Benallou B.** Changes in energetic profile of pregnant ewes in relation with the composition of the fetal fluids. *Asian Pacific Journal of Tropical Biomedical*. **2016**; 6: 256-258. <https://www.sciencedirect.com/science/article/pii/S2221169115002786>.
- 40- Swenson MJ.** Physiological properties and cellular and chemical constituents of blood. In: *Dukes' Physiology of Domestic Animals*. 11<sup>th</sup> Edition. (Edited by Swenson, M.J. and Williams, O. R.). **1993**; pp.15-41 and 518-527. Cornell University Press, Ithaca and London.
- 41- Nazifi S, Saeb M and Ghavami SM.** Serum lipid profile in Iranian fat tailed sheep in late pregnancy, at parturition and during the post-parturition period. *Journal of Veterinary Medicine Series*. **2002**; 49: 9-12. <https://www.ncbi.nlm.nih.gov/pubmed/11913828>.

- 42- **Lanna D and Bauman D.** Effect of somatotropin, insulin, and glucocorticoid on lipolysis in chronic cultures of adipose tissue from lactating cows. *Journal of Dairy Science*. **1999**; 82: 60-68. [https://www.journalofdairyscience.org/article/S0022-0302\(99\)75209-4/fulltext](https://www.journalofdairyscience.org/article/S0022-0302(99)75209-4/fulltext).
- 43- **Christie WW.** The composition, structure and function of lipids in the tissues of ruminant animals. In: *Lipid metabolism in ruminant animals*. (Edited by W.W. Christie). **1978**; pp 95., Pergamon Prsss, New York. <https://www.ncbi.nlm.nih.gov/pubmed/390540>.
- 44- **Piccione G, Caola G, Giannetto C, Grasso F, Runzo S, Zumbo A and Pennisi P.** Selected biochemical serum parameters in ewes during pregnancy, post-parturition, lactation and dry period. *Animal Science Papers and Reports*. **2009**; 27: 321-330. [https://www.researchgate.net/publication/228622761\\_Selected\\_biochemical\\_serum\\_parameters\\_in\\_ewes\\_during\\_pregnancy\\_post-parturition\\_lactation\\_and\\_dry\\_period](https://www.researchgate.net/publication/228622761_Selected_biochemical_serum_parameters_in_ewes_during_pregnancy_post-parturition_lactation_and_dry_period).

**Table 1. Effects of stages of pregnancy and ecotype on TSH concentration (mIU/L) in Hamari and Kabashi ewes (n = 80)**

Stages of pregnancy	Ecotype		LS
	Hamari	Kabashi	
<a href="#">Empty Dry</a>	<sup>A</sup> 0.28±0.07 <sup>a</sup>	<sup>A</sup> 0.22 ±0.05 <sup>a</sup>	NS
Early Pregnancy	<sup>B</sup> 0.36±0.10 <sup>a</sup>	<sup>B</sup> 0.28±0.09 <sup>a</sup>	NS
Mid Pregnancy	<sup>AB</sup> 0.29±0.04 <sup>a</sup>	<sup>B</sup> 0.35 ±0.10 <sup>a</sup>	NS
Late Pregnancy	<sup>A</sup> 0.27 ±0.09 <sup>a</sup>	<sup>AB</sup> 0.25±0.08 <sup>a</sup>	NS
LS	*	*	

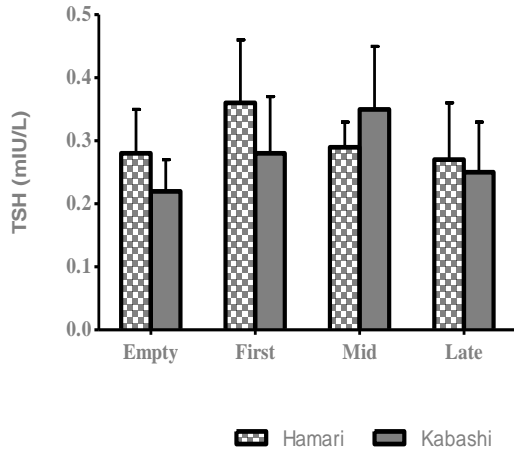
<sup>A, B</sup>: Mean values within the same column with different superscripts (capital) are significantly different [at what probability? at 1 or 5%? specify](#).

<sup>a, b</sup>: Mean values within the same row with different superscripts (small) are significantly different.

LS: [Concentration Level](#) of significance \* [P<0.05](#)

NS: Not significant

\* [P<0.05](#)



Please change empty to “dry”

Figure 1: Effects of stages of pregnancy and breed on TSH in ewe

Table 2. Effects of stages of pregnancy and ecotype on serum T<sub>4</sub> concentration (µg/dL) in Hamari and Kabashi ewes (n = 80)

Stages of pregnancy	Ecotype		LS
	Hamari	Kabashi	
<u>Empty Dry</u>	<sup>A</sup> 5.37±1.18 <sup>a</sup>	<sup>A</sup> 5.05±0.93 <sup>a</sup>	NS
Early Pregnancy	<sup>A</sup> 6.40±1.74 <sup>a</sup>	<sup>A</sup> 5.48±1.30 <sup>a</sup>	NS
Mid Pregnancy	<sup>A</sup> 5.49±1.29 <sup>a</sup>	<sup>A</sup> 4.89±0.60 <sup>a</sup>	NS
Late Pregnancy	<sup>B</sup> 4.15± 0.65 <sup>a</sup>	<sup>B</sup> 3.90±0.66 <sup>b</sup>	*
LS	**	**	

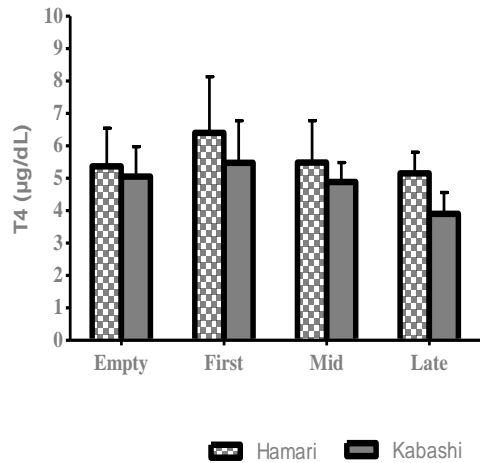
<sup>A, B</sup>: Mean values within the same column with different superscripts (capital) are significantly different.

<sup>a, b</sup>: Mean values within the same row with different superscripts (small) are significantly different. LS:

Concentration of significance

NS: Not significant \* P< 0.05 \*\* P< 0.01

Comment [Repet!15]: ?



[Please change empty to “dry”](#)

**Figure 2: Effects of stages of pregnancy and breed on serum thyroxine hormone T<sub>4</sub> in ewe**

**Table 3. Effects of stages of pregnancy and ecotype on serum T<sub>3</sub> (ng/mL) in Hamari and Kabashi ewes (n = 80)**

Stages of pregnancy	Ecotype		LS
	Hamari	Kabashi	
<a href="#">Empty Dry</a>	<sup>A</sup> 1.02±0.30 <sup>a</sup>	<sup>A</sup> 0.30 ±0.08 <sup>b</sup>	**
Early Pregnancy	<sup>B</sup> 2.35±0.57 <sup>a</sup>	<sup>A</sup> 0.48 ±0.22 <sup>b</sup>	***
Mid Pregnancy	<sup>C</sup> 1.50±0.87 <sup>a</sup>	<sup>A</sup> 0.50 ±0.45 <sup>a</sup>	NS
Late Pregnancy	<sup>D</sup> 0.35±0.12 <sup>a</sup>	<sup>A</sup> 0.34 ±0.12 <sup>a</sup>	NS
LS	***	**	

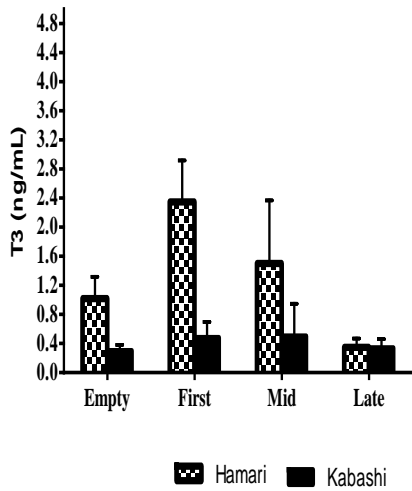
A, B, C, D: Mean values within the same column with different superscripts (capital) are significantly different.

<sup>a, b</sup>: Mean values within the same row with different superscripts (small) are significantly different

LS: Concentration of significance

Comment [Repept!16]: ?

NS: Not significant \*\* P<0.01 \*\*\* P<0.001



[Please change empty to "dry"](#)

Figure 3: Effects of stages of pregnancy and breed on serum triiodothyronine T<sub>3</sub> in ewe

Table 4. Effects of stages of pregnancy and ecotype on plasma glucose (mg/dL) in Hamari and Kabashi ewes (n = 80)

Stages of pregnancy	Ecotype		LS
	Hamari	Kabashi	
<a href="#">Empty Dry</a>	<sup>A</sup> 52.9±4.13 <sup>a</sup>	<sup>A</sup> 51.4±5.89 <sup>a</sup>	NS
Early Pregnancy	<sup>AB</sup> 44.3±6.48 <sup>a</sup>	<sup>A</sup> 49.8±5.43 <sup>a</sup>	NS
Mid Pregnancy	<sup>B</sup> 42±6.67 <sup>a</sup>	<sup>B</sup> 43±7.08 <sup>a</sup>	NS
Late Pregnancy	<sup>CB</sup> 39±6.69 <sup>a</sup>	<sup>B</sup> 40.3±5.55 <sup>a</sup>	NS
LS	***	***	

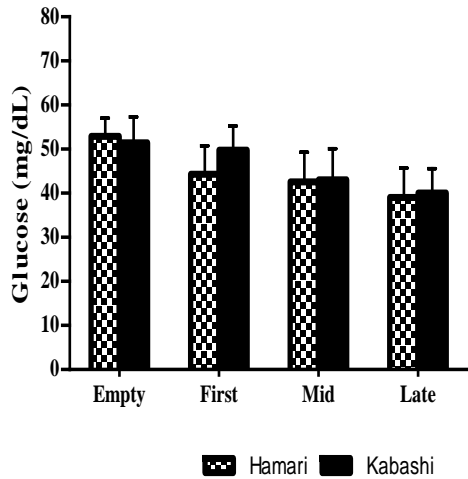
A, B, C: Mean values within the same column with different superscripts (capital) are significantly different.

a, b: Mean values within the same row with different superscripts (small) are significantly different.

LS: Concentration of significance

Comment [Repept!17]: ?

NS: Not significant \*\*\* P<0.001



[Please change empty to “dry”](#)

Figure 4: Effects of stages of pregnancy and breed on plasma glucose in ewe

Table 5. Effects of stages of pregnancy and ecotype on serum triglycerides (noml/dL) in Hamari and Kabashi ewes (n = 80)

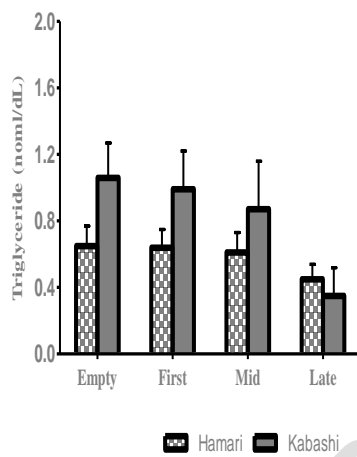
Stages of pregnancy	Ecotype		LS
	Hamari	Kabashi	
<a href="#">Empty Dry</a>	<sup>A</sup> 0.65±0.12 <sup>a</sup>	<sup>A</sup> 1.06±0.21 <sup>b</sup>	***
Early Pregnancy	<sup>A</sup> 0.64±0.11 <sup>a</sup>	<sup>A</sup> 0.99±0.23 <sup>b</sup>	***
Mid Pregnancy	<sup>A</sup> 0.61±0.12 <sup>a</sup>	<sup>A</sup> 0.87±0.29 <sup>b</sup>	*
Late Pregnancy	<sup>B</sup> 0.45±0.09 <sup>a</sup>	<sup>B</sup> 0.35±0.17 <sup>a</sup>	NS
LS	*	*	

<sup>A, B</sup>: Mean values within the same column with different superscripts (capital) are significantly different.

<sup>a, b</sup>: Mean values within the same row with different superscripts (small) are significantly different.

**LS**: Concentration of significance

**NS**: Not significant \* P<0.05 \*\* P<0.01 \*\*\* P<0.001



[Please change empty to “dry”](#)

**Figure 5: Effects of stage of pregnancy and breed on serum triglyceride in ewe**