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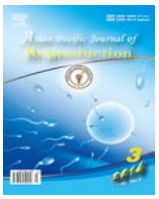

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# Influence of growth hormone on growth and onset of puberty of Rahmani ewe lamb

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ABSTRACT

**Objective:** To study the effect of somatotropin administration on growth and puberty attainment of Rahmani ewes -lamb. **Methods:** Twelve Rahmani ewes-lamb of 6-7 months of age and average body weight (24.75 ± 0.16) kg were randomly allotted into two equal groups. The first group served as control and the second group was somatotropin-treated. The ewe-lambs were weighed at the start and at the end of the experiment. In addition, the body condition score, withers height and heart girth were determined at the end of the study. Blood samples were collected weekly till the end of experiment (Twelve weeks). Sera samples were assayed for progesterone, insulin-like growth factor-1 (IGF-1) glucose, total cholesterol, high density lipoprotein and urea. **Results:** It indicated that the somatotropin-treated group attained puberty 2.5 weeks (18 days) earlier than control one. Somatotropin-treated Rahmani ewe lambs had higher body weight, and body condition score than those of the control one. A similar tendency was observed in average daily gain, withers height and heart girth. Somatotropin administration had a beneficial effect on blood born metabolites as indicated by increased serum glucose, total lipids, cholesterol, IGF-1 and decreased urea of Rahmani ewes- lamb as compared to control one. **Conclusion:** Somatotropin administration enhanced puberty in Rahmani ewe lambs. This is due to increased provision of trophic signals (represented by increased Serum IGF-1 secretions) and/or blood-borne metabolites (glucose, cholesterol and lipid).

## 1. Introduction

Rahmani sheep produces good quality meat and respond well to genetic improvement through selection. They are also known for their ability to walk long distances and the ability to cope with harsh environmental conditions such as long periods of drought and high temperatures. Therefore, they had been introduced in several Egyptian areas. Characterization of puberty and early sexual development is a valuable tool for selection within the males of a given breed. The onset of puberty in sheep is influenced by genetic and environmental factors such as breed climate nutrition and strain differences. Workers on age at puberty agree that the early age is associated with the time of birth and the nutritional planes. Differences in sexual puberty behavior among ram and ewe lambs have been recognized for many years[1]. The onset of puberty is the result of a series of complex developmental events that occur within the reproductive endocrine axis. Just before the onset, there is a high frequencey rhythm of GnRH secretion and a sustained rise in basal luteinizing hormone (LH) secretion[2]. In addition, there are a number of paracrine factors, including growth hormone and insulin-like growth factor 1, which can also modify the GnRH synthesis and action on the pituitary gonadotrophs[3]. Regarding the effect of growth hormone axis on puberty of ruminants, in heifers, growth hormone (GH) deprivation induced by immunonuetralization

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of growth hormone releasing factor was associated with delayed puberty[4,5]. Moreover, it was reported[6,7] that the decrease in somatotropin concentration can delay the onset of puberty in heifers. On the other hand, Radcliff[8] found that manipulation of the soamatropin axis with recombinant bovine soamatotropin improved the heifer's growth and reduced age at first calving. From the above it is apparent that several reports dealt with the effect of growth hormone axis on cattle's puberty, except for Hayat H El-Nour[9] who recorded early puberty in somatotropin treated Barki ewe lambs; the studies directed toward the effect of growth hormone on puberty of sheep are scarce. Depending on the previous consideration, and the finding of Sharafeldin MA [10] that Rahamini ewe lambs attain puberty at age ranged from 233-420 days and body weight range of 25-38 kg bw; the present investigation was conducted on this Egyptian native breed of ewe lambs to study the effects of prepubertal (>50 days before puberty[11]) administration of somatotropin on puberty attainment (based on serum progesterone level), serum IGF-1 and some of blood-borne metabolites (glucose, total cholesterol, high density lipoprotein and urea).

## 2. Materials and methods

### 2.1. Animals and ration

This study was conducted at Faculty of Veterinary Medicine, Cairo University, Egypt located in the south part of Nile Delta (latitude 30′ 01″ N; longitude 31′21″ E) during summer season. Twelve Rahmani ewe- lambs aged between 6 to 7 months and average body weight (24.25±0.38) kg. Animals were randomly allocated into two groups of 6 ewe-lambs each and kept in separate groups. The first group was kept as a control and second group was injected subcutaneously, every two weeks, with somatotropin (Smatech, Elanco, Austria) in a dose of 0.1 mg/kg bw/day [12], The biweekly dose of somatotropin was calculated to release the previously mentioned dose level, moreover, the changes in body weight were taken in consideration during the dose computation. The study period was twelve weeks. Animals were fed with a basal diet of hay (64.2%) and barley grain (35.0%) plus minerals and vitamins (0.8%). Additionally, the ewe-lambs were given *ad libitum* access to feed and clean water was available at all times. The ewe lambs were weighed at the start and biweekly thereafter, after a fast of 24 hours from feed and 16 hours from water. The initial and the final body weights, and the overall daily body gain for both groups were estimated. Furthermore, at the end of the study, the body condition score, withers height and heart girth were determined.

### 2.2. Blood sampling

Individual blood samples were collected prior to the beginning of the study (pretreatment or 0 blood samples), thereafter, blood samples were weekly obtained till the end of the study period. Blood samples were allowed to clot and sera were separated by centrifugation at 3 000 rpm for 15 minutes. Sera were divided into aliquots and frozen at -20 ℃ until assayed for insulin-like growth factor-1 (IGF-1), progesterone, glucose, total cholesterol, high density lipoprotein and urea.

### 2.3. Data collection techniques

#### 2.3.1. I-Hormonal assay

A-Insulin-like growth factor-1 (IGF-1) assying: Insulin-like growth factor-1 was assayed, in the pretreatment sample and then every two weeks till the end of the investigation, by two-sites immunoradiometric assay (IRMA) according to the method adopted by Miles LM[13] using kit purchasded from DSL,Webster, Texsas, USA. It is noteworthy that Francis GL[14] reported that the sequence of ovine IGF-1 and human IGF-1 are identical except for the substitution in the sheep of Ala for Pro at residue 66; accordingly, Spicer LJ[15] stated that the standard of this kit was believed to be suitable for IGF-1 assaying in sheep.

B-progesterone determination: Progesterone level was determined in the weekly collected serum samples (as a measure for puberty attainment[3, 16] by competitive ELISA using kits obtained from Dima, Germany.

II-Blood-Borne Metabolites: Serum glucose, total cholesterol, high density lipoprotein and urea were determined spectrophotometrically in the pretreatment and the weekly serum samples. Serum glucose was determined by kits brought from Biodiagnostics, Egypt; total cholesterol was assayed and the kits were obtained from Biocon Diagnostik, Germany. Additionally, serum low and very low densities lipoproteins were percipitated by percipitating reagent obtained from Stanbio Laboratory, Texas, USA. After percipitation, serum high density lipoprotein cholesterol was estimated by total cholesterol kits brought from Chema Diagnostica, Italy. Meanwhile, urea was analyzed using kits of Stanbio Laboratory, Texas, USA.

### 2.4. Statistical procedures

Data were presented as means±SE and analyzed by two way analysis of variance (ANOVA) according to Snedecor GW[17]. Treatment means were compared by the least significance difference test (LSD). Moreover, unpaired '*t*' test was used to evaluate the differences between the two groups in their body weight, overall body weight gain,

overall dry matter intake, body condition score, heart girth and withers height. Additionally, control group's cumulative numbers of ewe-lambs attaining puberty that were presented in our previous study were compared with those of somatotropin treated one using *chi* square test. Significant differences were set at $P<0.05$.

## 3. Results

Control animals had significantly decreased body weight and body condition score (30.67±0.95 kg and 2.00 ± 0.00) than those on the somatotropin treated group (33.33 ±0.30 kg and 2.25 ±0.09, $P<0.05$ respectively). Furthermore, dry matter intake and average daily gain were significantly improved in somatotropin treated group than those in control one (1.31± 0.03, 111.1 ± 3.55 g *vs.* 1.20 ± 0.02, 73.17 ± 11.27 g, respectively). In addition, withers height and heart girth were significantly ($P<0.05$) increased in somatotropin treated ewe-lambs than those in control one (71.5 ±1.65, 89.80 ±3.52 *vs.* 60.50 ±1.58, 76.75 ±2.70 cm, respectively). Puberty was first detected in somatotropin treated group after 5 weeks of study. All ewe-lambs in the somatotropin treated- and control groups attained puberty 7 and 10 weeks after the start of the experiment, respectively.

Serum progesterone concentration among different groups is shown in Table 1. At the beginning of study, there were no significant differences between the groups in the concentration of serum progesterone. It was observed that the effect of somatotropin administration on serum progesterone concentration was time-dependent; as the level of progesterone in somatotropin treated group was significantly higher ($P< 0.05$ ) at the 6th and 7th week of the study than those of the control one ( Table 2). It is clear from that the overall effect of somatotropin on serum progesterone level was statistically irrelevant. However, there was statistically relevant interaction, since, at the 9th week of the study, serum progesterone concentration in the control was higher than that of the treated group (Table 3).

The overall concentration of insulin-like growth factor-1 (IGF-1) in somatotropin group was higher than that of the control one. Moreover, the increasing effect of somatotropin was interacting with the weeks of the study, since the level of (IGF-1) in the somatotropin group was significantly ($P< 0.05$ ) elevated than that of the control during the 2nd, 4th and 10th week of the investigation (Table 4). Data presented in Table 5 showed that the overall serum glucose concentration in the somatotropin administered Rahmani ewe lambs was higher than that of the control. Except for the 6th week when serum glucose level of the treated group was lower than that of control. The level of the glucose in somatotropin treated ewe lambs at the 3rd, 7th, 9th and 12th week was increased by 13.52%, 20.86%, 27.06% and 21.8%, respectively relative to that of the control. Similar tendency was observed in the serum concentration of cholesterol where the level of total cholesterol in somatotropin treated

**Table 1**
Serum progesterone concentration (ng/mL) in control and somatotropin-administered Rahmani ewe lambs during the first four weeks of the study.

| Groups | Weeks of the study | | | | | Overall mean of treatment effect |
|---|---|---|---|---|---|---|
| | 0 week | 1st week | 2nd week | 3rd week | 4th week | |
| Control | 0.05±0.00 | 0.06±0.00 | 0.11±.010 | 0.10±0.00 | 0.08±0.00 | 0.08±0.00 |
| Somatotropin-treated | 0.05±0.00 | 0.06±0.00 | 0.10±0.00 | 0.11±0.00 | 0.11±0.00* | 0.08±0.00 |

L.S.D. of treatment x duration interaction =0.0194, *$P<0.05$ control vs. smatotropin-treated group.

**Table 2**
Serum progesterone concentration (ng/mL) in control and somatotropin-administered Rahmani ewe lambs during the second four weeks of the study.

| Groups | Weeks of the study | | | | Overall mean of treatment effect |
|---|---|---|---|---|---|
| | 5th week | 6th week | 7th week | 8th week | |
| Control | 0.73±0.07 | 0.76±0.09 | 0.77±0.20 | 0.82±0.10 | 0.77±0.06 |
| Somatotropin | 1.11±0.26 | 1.51±0.18* | 1.52±0.15* | 1.05±0.18 | 1.30±0.10* |

L.S.D. of overall treatment effect =0.24, L.S.D. of treatment x duration interaction =0.48, *$P<0.05$ control vs. smatotropin-treated group.

**Table 3**
Serum progesterone concentration (ng/mL) in control and somatotropin-administered Rahmani ewe lambs during the last four weeks of the study.

| Groups | Weeks of the study | | | | Overall mean of treatment effect |
|---|---|---|---|---|---|
| | 5th week | 6th week | 7th week | 8th week | |
| Control | 1.36±0.41 | 1.52±0.43 | 0.41±0.07 | 0.44±0.04 | 0.93±0.17 |
| Somatotropin | 0.61±0.03* | 1.22±0.17 | 0.72±0.01 | 0.32±0.03 | 0.72±0.07 |

L.S.D. of treatment x duration interaction = 0.638, *$P<0.05$ control vs. smatotropin-treated group.

group at the 2nd, 3rd, 5th, 7th and 10th week of the study was increased by 24.45%, 22.66%, 22.39%, 14.56% and 16.89%, respectively as compared to control one (Table 5). Somatotropin had an overall and time-interacting increasing effect on serum high density lipoprotein in Rahmani ewe lambs regarding the time-dependent effect of treatment, somatotropin raised serum high density lipoprotein by 10.28%, 20.63%, 29.99%, 28.03% and 21.17% at the 1st, 3rd, 8th, 10th and 11th week, respectively relative to that of control experiment (Table 5). Serum urea concentration in the somatotropin treated ewe lambs was significantly ($P$<0.05) decreased than that of control at the 1st, 4th, 6th and 10th week of the investigation.

**Table 4**
Effect of bovine somatotropin administration for twelve weeks on serum insulin-like growth factor 1 concentration (IGF-1, μg/L) of Rahmani ewe lambs.

| Weeks of the study | Groups | |
|---|---|---|
| | Control | Somatotropin-treated |
| 0 week | 130.48±18.93 | 124.87±18.58 |
| 2nd week | 163.30±11.94 | 258.42±6.05* |
| 4th week | 135.50±3.07 | 228.76±14.44* |
| 6th week | 186.45±10.19 | 229.71±32.58 |
| 8th week | 188.60±11.10 | 223.39±25.28 |
| 10th week | 218.47±9.18 | 337.32±24.57* |
| 12th week | 338.17±29.18 | 350.00±9.07 |
| Overall treatment means | 192.73±13.05 | 250.38±13.17* |

LSD of overall treatments effect=24.52, LSD of treatments-duration interaction=64.86, *$P$<0.05 control *vs.* smatotropin-treated group.

**Table 5**
Effect of bovine somatotropin administration on serum glucose concentration, serum total cholesterol concentration,serum high density lipoprotein concentration, serum urea concentration of Rahmani ewe lambs(mg/dL).

| Weeks of the study | Serum glucose[a] | | Serumtotal cholesterol concentration[b] | | Serum high density lipoprotein concentration[c] | | Serum urea concentration[d] | |
|---|---|---|---|---|---|---|---|---|
| | Control | Somatotropin-treated | Control | Somatotropin-treated | Control | Somatotropin-treated | Control | Somatotropin-treated |
| 0 week | 41.49±4.13 | 40.05±4.08 | 22.80±1.11 | 24.41±1.02 | 28.95±2.09 | 30.95±1.13 | 9.88±0.76 | 9.40±0.66 |
| 1st week | 46.45±4.56 | 44.89±0.61 | 62.23±3.99 | 63.27±3.67 | 53.10±1.00 | 58.56±5.23* | 23.17±1.07 | 17.75±0.39* |
| 2nd week | 66.26±1.35 | 61.25±4.34 | 67.11±2.55 | 83.52±4.63* | 55.32±2.63 | 57.21±2.65 | 12.13±0.46 | 13.33±0.45 |
| 3rd weeek | 54.07±1.36 | 61.38±2.09 | 57.45±2.03 | 70.47±1.96* | 49.30±1.25 | 59.47±1.58* | 18.48±0.95 | 19.12±1.21 |
| 4th week | 59.22±1.70 | 53.80±0.83 | 70.54±1.32 | 59.85±1.99* | 34.32±1.81 | 32.74±0.79 | 14.39±0.82 | 11.15±1.01* |
| 5th week | 50.40±1.73 | 57.20±0.58 | 68.82±1.89 | 84.23±7.09* | 41.72±0.74 | 45.72±0.62 | 12.82±1.15 | 14.84±0.31 |
| 6th week | 65.05±3.55 | 57.61±3.97 | 35.77±1.11 | 31.95±3.07 | 40.53±0.62 | 35.61±0.64 | 13.33±0.65 | 10.67±0.39* |
| 7th week | 48.18±1.72 | 58.23±1.19 | 64.22±3.70 | 73.57±4.31* | 30.90±2.49 | 33.89±1.24 | 11.52±0.49 | 11.71±0.54 |
| 8th week | 48.29±2.00 | 51.69±2.69 | 64.84±2.67 | 60.52±0.10 | 38.65±1.98 | 50.24±1.72* | 21.25±1.11 | 23.17±0.83 |
| 9th week | 36.69±2.00 | 46.62±2.30* | 67.29±1.44 | 70.50±1.71 | 46.32±0.85 | 40.23±1.60* | 19.95±1.24 | 23.00±1.53* |
| 10th week | 38.70±1.61 | 42.61±2.98 | 58.02±0.86 | 67.82±1.12* | 37.35±0.44 | 47.82±1.40* | 15.26±0.18 | 11.99±0.34* |
| 11th week | 39.55±1.75 | 45.55±0.87 | 74.42±2.08 | 78.24±3.16* | 38.11±1.45 | 46.18±1.64* | 13.74±0.34 | 11.58±0.48 |
| 12th week | 65.19±2.18 | 79.41±2.84* | 37.80±0.52 | 35.17±1.90 | 43.18±1.40 | 45.95±1.04 | 13.18±0.71 | 11.99±0.48 |
| Overall mean of treatment effect | 50.73±1.31 | 53.88±1.33* | 57.82±1.79 | 61.83±2.28 | 41.37±0.97 | 45.05±1.18* | 15.32±0.49 | 14.63±0.54* |

*$P$<0.05 control *vs.* somatotropin-treated group. [a]LSD of overall treatments effect=1.98, LSD of treatments-duration interaction=7.12; [b]LSD of overall treatments effect=2.06, LSD of treatments-duration interaction=7.42; [c]LSD of overall treatments effect=1.39, LSD of treatments-duration interaction=5.48; [d]LSD of overall treatments effect=0.63, LSD of treatments-duration interaction=2.27.

## 4. Discussion

The results of the current study identified that somatotropin-treated ewe lambs attained puberty earlier than control ones by about (2.5 weeks; ~ 18 days), as indicated by a rise of serum progesterone concentration to a level of ≥ one μg/L for two consecutive weeks[3, 16] Similarly, the injection of Recombinant bovine somatotropin (rbST) reduced age ($P$<0.05) at puberty by 60 days. They added that, the live body weight at puberty were significantly heavier in treated than that in control group[18]. This is in the agreement of our results. The observed increase in LBW of lambs accompanied treatment with rbST during post weaning period was also detected in the same lambs during suckling period as a response to treating lactating dams with the same material[19]. Moreover, results were similar to that reported by[20-22] in Rahmani lambs, goats and cows, respectively.

In the present finding the effect of somatotropin administration on serum progesterone concentration was time-dependent; as the level of progesterone in somatotropin treated group was significantly higher at the 6th and 7th week of the study than those of the control one. Similar finding was observed by Chadio SE[23] who recorded that somatotropin

treatment resulted in a tendency for higher progesterone levels in treated ewes[24] and heifers[25]. In contrast the overall plasma progesterone concentrations during the experimental period was not affected by rbST treatment being the same in treated (0.41± 0.08 ng/L) and non treated ewe lambs (0.35± 0.08 ng/L) [18]. This rise in progesterone is indicative of the occurrence of ovulation[16, 26]. This puberty stimulating effect of somatotropin was associated with enhanced body growth as indicated by increased final body weight, growth rate and skeletal growth as reflected by increased withers height and heart girth. These previously mentioned alterations may be due to the changes evoked by somatotropin at serum insulin-like growth factor-1 (IGF-1) and/or general metabolic pool levels (i.e. serum glucose, total cholesterol, high density lipoprotein and urea). This speculation is supported by the proposition of Suttie JM [27]. The current study recorded increased IGF-1 in Rahmani ewe lambs treated with somatotropin this finding is in accord with that reported by[9] in Barki ewe lambs-administered with somatotropin.

IGF-1 may be one of the potential signals by which somatotropin exerted its early puberty initiating effect. In Shiba goat, Sakurai[26] observed that plasma IGF-1 concentration didn't markedly change until 5 weeks before puberty, they began to rise between weeks-4 and -1 and this increase continued throughout the onset of puberty and IGF-1 had a role in the initiation of puberty in ruminants[26]. The recorded higher IGF-1 in the treated group might lead to an early activation of GnRH network, which is the rate limiting step of puberty onset; this would result in an increase in GnRH discharge and cosequently LH secretions. This explaination is supported by Adam CL[28] who reported that an increase in IGF-1 within the physiological range stimulated LH secretion in sheep. Additionally, the expected increase in ovarian IGF-1, in the present study, as a result of the increased serum IGF-1 due to the administration of somatotropin to Rahmani ewe lambs seems plausible. Since, there was a positive correlation between ovarian and circulating IGF-1 and they suggested that ovary might derive IGF-1 from the peripheral source[33]. This expected increase in ovarian IGF-1 might enhance the ovarian activity in an outweighing manner relative to that of control. Furthermore, the current study reported an increase in serum glucose level that may represent another cue by which somatotropin exhibited its effect. This finding indicated that the treated Rahmani ewe lambs had greater glucose availability than their corresponding control; this increased glucose availability in the treated group may enhance the onset of puberty. It has been identified that glucose availability is one of metabolic regulators of the GnRH pulse generator in ruminant species and had a critical role in the onset of puberty[30]. In sheep, it was found that administration of glucose inhibitor inhibited pulsatile LH secretion[31]; also, when glucose concentrations were decreased by iv administration of insulin, LH pulses were inhibited[32]. Furthermore, the hypothalamic GnRH pulse generator was suppressed by 2-deoxy glucose (2DG)-induced glucoprivation or insulin-induced hypoglycemia in estradiol 17 β -treated ovariectomized goats[30]. In addition to the central action of the increased glucose; glucose could affect positively the ovarian metabolism via acting as energy substrates and as a stimulator for the ovarian uptake of the precursors required for steroid hormones biosynthesis; since, the glucose may promote cholesterol uptake into the ovine ovarian cells or vice versa[33].

With regard to urea, the decreased serum urea level in the treated group reflected the anabolic effect of somatotropin; also this urea decreasing effect indicates decreased urea cycle activity. The expected decrease in urea cycle might lead to an increase of argenine availability in treated Rahmani ewe lambs; this probable increase in argentine might participate in somatotropin potentiating effect on puberty induction through an increase in LH supply to the ovary[34, 35]. From the above, it could be mentioned that increased serum IGF-1 and/or serum metabolites mainly glucose may constitute the probable underlying mechanism (s) by which somatotropin indirectly enhanced the early puberty initiation of Rahmani ewe lambs; however, the existence of a possible direct role of somatotriopin in this regard cant be ruled out. Since, high growth hormone and LH in cattle and buffalo heifers, respectively treated with growth hormone releasing factor[36, 37]. Additionally, the growth hormone axis was important for timing of the later stage of puberty in female monkeys and they concluded that factors that reduce growth hormone secretion may have deleterious effect on the completion of puberty[38]. So Growth Hormone (GH) is important factor in sexual maturation and attainment of puberty[39].

In conclusion, somatotropin administration led to early puberty in Rahmani ewe lambs this may be due to increased provision of trohpic signals (represented by increased GnRH and LH secretions) that may arise from the early activation of GnRH pulse generator; increased nutrients availability crucial for ovarian function and/or local enhancement of

ovarian activity. These effects may resulted from direct and/or indirect influences of somatotropin on the previously mentioned levels. Serum IGF-1 and/or blood-borne metabolites (mainly glucose) may be the potential signals by which somatotropin exerted its indirect effect.

## Conflict of interest statement

We declare that we have no conflict of interest.

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## References

[1] EI. Khalifa ME. Ahmed YH, Hafez OA. El-Zolaky KM, Bahera AA, Abido. Age at puberty and fertility of Rahmani sheep fed on biological inoculated corn silage. *Ann Agric Sci* 2013; **58**(2): 163-172.

[2] Foster DL. Puberty in sheep. In: Knobil E, Neil JD (eds.). *The physiology of reproduction.* (2nd ed.) New York: Raven Press; 1994, p. 411.

[3] Chandrashekar V, Bartke A. The role of insulin-like growth factor-I in neuroendocrine function and the consequent effects on sexual maturation: inferences from animal models. *Rep Biol* 2003; **3**(1):7.

[4] Simpson RB, Armstrong JD, Harvey RW, Miller DC, Heimer EP, Campbell RM. Effect of active immunization against growth hormone-releasing factor on growth and onset of puberty in beef heifers. *J Anim Sci* 1991; **69**: 491.

[5] Cohick WS, Armstrong JD, Whitacre MD, Lucy MC, Harvey RW, Campbell RM. Ovarian expression of insulin-like growth factor-I (IGF-I), IGF binding proteins, and growth hormone (GH) receptor in heifers actively immunized against GH-releasing factor. *Endocrinol* 1996; **137**:167.

[6] Armstrong JD, Cohick WS, Harvey RW, Heimer EP, Campbell RM. Effect of feed restriction on serum somatotropin, insulin-like growth factor-I-(IGF-I) and IGF binding proteins in cyclic heifers actively immunized against growth hormone releasing factor. *Domest Anim Endocrinol* 1993; **10**: 315-324.

[7] Armstrong JD, Benoit AM. Paracrine, autocrine, and endocrine factors that mediate the influence of nutrition on reproduction in cattle and swine: An *in vivo*, insulin-like growth factor-1 perspective. *J Anim Sci* 1996; **74**(Suppl. 3): 18-35.

[8] Radcliff RP, VandeHaar MJ, Kobayashi Y, Sharma BK, Tucker HA, Lucy MC. Effect of dietary energy and somatotropin on components of the somatotropic axis in Holstein heifers. *J Dairy Sci* 2004; **87**: 1229.

[9] Hayat H El-Nour. Some biochemical changes in ruminants due to injection of recombinant somatotropin hormone. Ph. D. Thesis (Biochemistry), Cairo Univ. 2001.

[10]Sharafeldin MA, Ragab MT, Khalil IA. Sexual behavior of female lambs as affected by the plane of nutrition. *World Rev Anim Prod* 1969; **5**: 83.

[11]Kinder J, Berfgeld E, Wehrman ME, Peters KE, Kojina FN. Endocrine basis for puberty in heifers and ewes. *J Rep Fert* 1995; **49**: 393.

[12]Davis JJ, Sahlu T, Puchala R, Herselman MJ, Fernandez JM, McCann JP, Coleman S W. The effect of bovine somatotropin treatment on production of lactating Angora does with kids. *J Anim Sci* 1999; **77**: 17.

[13]Miles LM, Lipschitz DA, Bieber CP, Cook JD. Measurment of serum ferritin by a 2-site immunoradiometric assay. *AnalytBiochem* 1974; **61**: 209-224.

[14]Francis GL, McNeil KA, Wallace JC, Ballard FJ, Owens PC. Sheep insulin-like growth factors I and II: Sequence and assays. *Endocrinology* 1989; **124**: 1173.

[15]Spicer LJ, Zavy MT. Concentrations of insulin-like growth factor-1 in serum of sheep with different ovulation rates: changes during the estrous cycle. *Theriogenology* 1992; **37**: 395.

[16]Boulanouar B, Ahmed M, Klopfenstein T, Brink D, Kinder J. Dietary protein or energy restriction influences age and weight at puberty in ewe lambs. *J Anim Sci* 1995; **40**: 229.

[17]Snedecor GW, Cochran WG. *Statistical methods*. 7th ed. Ames: Iowa State University Press; 1980.

[18]El-Gohary ES, Abdel-Khalek EA, Ashmawy TAM, Teleb DF, Sallam AA. Effect of recombinant bovine somatotropin (rbST) on growth performance and puberty incidence of male and female lambs born from rbST treated ewes. *Egyp J Sheep & Goat Sci* 2011; **6**(2): 47-57,

[19]Abdel-Khalek AE, Ashmawy TAM, El-Gohary ESH, Sallam AA, Doaa F. Teleb. Effect of recombinant bovine somatotropin treatment on productive, reproductive performance of ewes and their offspring growth. *J Agric Sci* 2009; **34**(5): 4211-4227.

[20]Sallam SMA, Nasser MEA, El-Waziry AM , Yousef MI. Economics of using recombinant bovine somatotropin in small ruminants. *J Appl Sci Res* 2005; **1**(2): 156-160.

[21]Davis JJ, Sahlu T, Puchala R, Herselman MJ, Fernandez JM, McCann JP, et al. The effect of bovine somatotropin treatment on production of lactating Angora does with kids. *J Anim Sci* 1999; **77**:

17-24.

[22]Bareille N, Faverdin P, Hay M. Modification of feed intake response to B2- agonist by bovine somatotropin in lactating or dry cows. *J Dairy Sci* 1997; **80** : 52.

[23]Chadio SE, Menegatosa AJ, Zervasb G, Goulasb CS. Deligeorgisc, Kalogiannisa D. Pituitary responsiveness to gonadotropin- and thyrotropin-releasing hormones in goats treated with recombinant bovine somatotropin. *Small Rumi Res* 2002; **46**: 149-157.

[24]Brozos CN, Saratsis PH, Boscos C, Kyriakis SC, Alexopoulos Brozos C. The effect of bovine somatotropin (bST) administration on reproduction, progesterone concentration during lactation and LH secretion during estrus, in dairy ewes. *Anim Reprod Sci* 1999; **56**: 177-187.

[25]Gong JG, Bramley T, Webb R. The effect of recombinant bovine somatotropin on ovarian function in heifers: Follicular populations and peripheral hormones. *Biol Reprod* 1991; **45**: 941.

[26]Sakurai K, Ohkura S, Matsuyama S, Katoh K, Obara Y, Okamura H. Body growth and plasma concentrations of metabolites and metabolic hormones during the pubertal period in female Shiba goats. *J Rep Dev* 2004; **50**:197.

[27]Suttie JM, Foster DL, Veenvliet BA, Manely TR, Corson ID. Influence of food intake but independence of body weight on puberty in female sheep. *J Reprod Fertil* 1991; **92**: 33.

[28]Adam CL, Findlay PA, Moore AH. Effects of Insulin-like growth factor-1 on luteinizing hormone secretion in sheep. *Anim Reprod Sci* 1998; **50**: 48.

[29]Zulu VC, Nakao T, Sawamukai Y. Insulin-like growth factor-1 as a possible mediator of nutritional regulation of reproduction in cattle. *J Vet Med Sci* 2002; **64**: 657.

[30]Ohkura S, Ichimaru T, Itoh F, Matsuyama S, Okamura H. Further evidence for the role of glucose as a metabolic regulator of hypothalamic gonadotropin-releasing hormone pulse generator activity in goats. *Endocrinol* 2004; **145**: 3239.

[31]Ohkura S, Tanaka T, Nagatani S, Bucholtz DC, Tsukamura H, Maeda KI, et al. Central, but not peripheral, glucose-sensing mechanisms mediate glucoprivic suppression of pulsatile luteinizing hormone secretion in the sheep. *Endocrinology* 2000; **141**: 4472.

[32]Medina CL, Nagatani S, Darling TA, Bucholtz DC, Tsukamura H, Maeda KI, et al. Glucose availability modulates the timing of the luteinizing hormone surge in the ewe. *J Neuroendocrinol* 1998; **10**: 785.

[33]Rabiee AR, Lean IJ. Uptake of glucose and cholesterol by the ovary of sheep and cattle and the influence of arterial LH concentrations. *Anim Reprod Sci* 2000; **64**: 199.

[34]Sinclair KD, Broadbent PJ, Hutchinson JSM. Naloxone evokes a nutritionally dependent LH response in post partum beef cows but not in mid luteal phase maiden heifers. *Anim Sci* 1995; **61**: 21

[35]Recabarren SE, Jofre A, Lobos A, Orellana P, Parilo J. Effect of arginine and ornithine infusions on luteinizing hormone secretion in prepubertal ewes. *J Anim Sci* 1996; **74**(1): 162.

[36]Jimenez-Krassel F, Binelli M, Tucker HA, Ireland JJ. Effect of long-term infusion with recombinant growth hormone-releasing factor and recombinant bovine somatotropin on development and function of dominant follicles and corpora lutea in Holstein cows. *J Dairy Sci* 1999; **82**: 1917.

[37]Mondnal M, Prakash BS. Effects of long term GH releasing factor administration on patterns of GH and LH secretion in growing female buffaloes (*Bubalus bubalis*). *Reproduction* 2004; **127**: 45.

[38]Wilson ME, Chikazawa K, Fisher J, Mook D, Gould KG. Reduced growth hormone secretion prolongs puberty but does not delay the developmental increase in luteinizing hormone in the absence of gonadal negative feedback. *Biol Reprod* 2004; **71**: 588.

[39]ÇİFTCİ HB. Estrogen and gowth hrmone and their rles in rproductive fnction. *Int J Anim Veter Adv* 2013; **5**(1): 21-28.