SOME ASPECTS OF REPRODUCTIVE EFFICIENCY IN AWASSI EWES: A REVIEW

Jalal E. Alkass **Hani N. Hermiz** **Mevan Ibrahim Baper**
Prof. **Prof.** **Lecturer**
Coll. Agric., University Dohuk **Coll. Agric., University Salahaddin** **Akre Technical Coll. University Duhok Polytechnic**
nljealkas2001@yahoo.com **profdrhani59@gmail.com** **mevan.ibrahim@dpu.edu.krd**

ABSTRACT

Reproductive efficiency in terms of fertility, Prolificacy and survival rate are considered the major components of overall efficiency in sheep productivity. While fertility of Awassi ewes is moderate to high depending on feeding and management practices, however, litter size is low and Awassi is not considered a prolific breed. Heritability estimates of these traits are rather low, and reflect small genetic variation in these traits. The possible avenues for increasing reproductive capacity environmentally and genetically are discussed in the text of this review article.

Key words: Awassi, Fertility, Reproductive Efficiency, Heritability.

بعض جوانب الكفاءة التناسلية في النعاج العواسية

جلال ايليا القس[1] **هاني ناصر هرمز[2]** **ميفان إبراهيم بابير[3]**
أستاذ **أستاذ** **مدرس**
كلية الزراعة **كلية الزراعة** **كلية عقرة التقنية**
جامعة دهوك **جامعة صلاح الدين** **جامعة دهوك البوليتكنيك**

المستخلص

تعتبر الكفاءة التناسلية المتمثلة بالخصوبة، الخصب ومعدل البقاء على قيد الحياة من المكونات الرئيسية لكفاءة الأغنام الإنتاجية. تتراوح خصوبة النعاج العواسية بين متوسطة وعالية إعتمادًا على برامج التغذية والإدارة ، وعلى أية حال ، فإن حجم البطن الواحدة تعتبر منخفضة وعليه لا تعتبر العواسي سلالة خصبة. إن تقديرات المكافئ الوراثي لهذه الصفات منخفضة نوعًا ما وتعكس التباين الجيني الصغير في هذه الصفات. تم مناقشة السبل الممكنة لزيادة الكفاءة التناسلية بيئيًا ووراثيًا في نص المقالة هذه.

الكلمات المفتاحية: عواسي، الخصوبة، الكفاءة التناسلية، المكافئ الوراثي.

Received:11/2/2020, Accepted:3/5/2020

INTRODUCTION

In Sheep, reproductive efficiency is an important attribute even where most of the emphasis is on the milk or wool, but where meat production is the main aim, reproductive efficiency is considered the major component of overall efficiency. As Turner and Young (48) stated that the level of reproduction in a flock of sheep is of interest for several reasons, first to ensure replacement, second to provide surplus stock either for sale or to build up numbers and finally to ensure as high as a selection differential as possible. The aim of the present article is to review the available information of different aspects of reproductive capacity of Awassi ewes.

Breeding season, estrus activity and ovulatipon rate

Awassi ewes are usually mated during early summer (June and extended up to September or October). In Iraq, data collected in an experimental flock (n=120 Awassi ewes) at the college of Agriculture, University of Baghdad, and data collected from state farms revealed that the Iraqi Awassi sheep is a non-seasonal breeder, as the breed exhibits year round estrus and ovulatory activity (15). Further, Kaymakci and Sonmez (36) concluded that the length of mating season was 104.7 days in Awassi ewe lambs in Tin Turkey. Length of the estrus cycle, duration of estrus, gestation length and post-partum estrus in Awassi ewes are presented in Table (1). However, almost all of the estimates fall within the ranges unique to sheep.

Ovulation rate

Ovulation rate was determined twice using 40 estrus – synchronized Awassi ewes aged 1.5, 2.5 and 3.5 year old. The first time under the influence of synchronizing treatment and the second time without treatment. Ovulation rate averaged respectively 1.00, 1.11 and 1.40 in the case of first treatment and 1.00, 1.11 and 1.55 in the second treatment (33). To study the effect of different levels of feeding prior to mating on ovulation rate of Awassi ewes in Iraq (9) reported that ovulation rate averaged 0.8 and 1.2 for ewes fed low and high of level of feeding, respectively (Table 1).

Puberty

Traditionally ewes are mated for the first time at about 1.5 years old. However, studies on age at puberty revealed that Awassi ewe lambs attained puberty between 257 and 327.1 days (Table 2). Moreover, workers on age at puberty agree that the early age is associated with the high level of feeding (5, 20). This may well be one of the reasons responsible for the wide range in age and weight at puberty displayed by Awassi ewe lambs. Also, it was observed in Iraq that Awassi ewe lambs born in autumn attained puberty at an earlier age than their respective spring- born lambs (298.4 vs. 356.1 days) (29).

Fertility

Fertility expressed as a percentage of ewes lambed to total ewes exposed to rams in different locations are presented in table (3). It seems from the table that fertility ranged between 73-95% in Awassi ewes depending on feeding and management practices followed in each location for example, Kassem et al. (35) reported that fertility in the Awassi ewes in Syria ranged from 80-85%. It can also reach 90% in exceptional years but can also drop to 60% in dry years. Moreover, fertility is not often included as a selection criterion in breeding programs as it is always subject to selection and has low heritability. However, to achieve high genetic potential for fertility, Bradford and Berger (19) suggested that systematic culling of unproductive animals may be the most important management practice to increase the number of lambs born in a flock of sheep. Also, improvement of the body condition of ewes prior and during mating through flushing is feasible.

Prolificacy

Prolificacy in terms of litter size expressed as a percentage of lambs born to ewes lambed in Awassi sheep is given in table (3). It appears from the table that litter size is low and ranged between 0.8 – 1.12, and Awassi is not considered a prolific breed. Such low level of prolificacy might be the result of the fact that producers prefer, and so select, large framed, fast growing male lambs as replacement rams. Choosing single-born male lambs showing all these desirable traits might have negatively selected against twining, as twin lambs would be smaller (21). However, an increase in prolificacy may be achieved by selection or crossing with prolific breed. Although the heritability of this trait I rather low (Table 3),

however selection for multiple births in sheep has been shown in several studies to increase litter size by 1-2% per year (18). However, selection needs consistent, long time efforts, continuity and funding. Crossing with prolific breeds is another way for improvement litter size but generally poor adaptability of exotic breeds to an environment different from their own is the major disadvantage in using those breeds and finally improvement of body condition of ewes pre- and post- mating through flushing could improve twining rate of Awassi ewes as well the possibility of using hormonal therapy.

Control reproduction in the ewe

Attempts have been undertaken to improve the reproductive performance of ewes through hormonal administration, namely with intravaginal application of hormone – impregnated sponges and injections or PMSG. In the Iraqi Awassi synchromate was used together with 600 or 800 i.u. PMSG by Markotic et al. (43). The former treatment increased the percentage of lambs born per total number of ewes exposed from 65 to 100. While the later treatment increased the percentage of lambs born per total number of ewes lambed from 63 to 73. Also, 50 mg MAP, together with 500 i.u. PMSG increases the percentage of ewes lambed per total number of ewes exposed from 16.1 to 45.4 (12). An increase of 20-25% in twining rate in Awassi ewes has been achieved by a dose of 500 i.u. PMSG (4). When 829 adult Awassi ewes were treated either with 400 i.u. (n=86; T1) or 600 i.u. (n=293; T2) eCG after the withdrawl of MAP- impregnated sponges or left as a control (n=450; C), Alkass et al., (8) reported that administration of 600 i.u. eCG improved significantly lambing and twining rates by 27 and 73%, respectively and that litter size increased significantly in T2, as compared with the control (1.62 vs. 1.14). To study the combined effect of vitamin A and PMSG on the reproductive Awassi ewes, Alkass et al., (7) demonstrated that administration of PMSG together with vitamin A or using PMSG only improved significantly lambing rate by 8.41 and 13.5 %, and twining rate 49.3 and42.7%, respectively as compared to untreated ewes. Similarly in Jordan, it was observed that using progesterone sponges and PMSG (600 i.u.) resulted in an increase in lambing and twining rates compared with the control (44).

Lamb mortality

The percentages of lamb losses in Awassi sheep are demonstrated in table (4). It can be seen from the table that in general mortality rate ranged between 4.0-17.0 %. It is known that survival rate has a low heritability (Table 4), and so will respond slowly to genetic selection. Therefore several steps can be taken to improve survival. The first is to set mean prolificacy at a level appropriate to the feeding and management system feasible, secondly, the mating season should be scheduled so that lambing occur at a time favorable for survival and thirdly, improvements in feeding and management before and at lambing (19).

Heritability

It is well known that development of breeding objectives and effective genetic improvement programs require knowledge of the genetic variation among economically important traits and the genetic covariation among these traits (22). Fertility, litter size and survival rate are the components of the overall ewe reproductive efficiency. With the exception of age and body weight at puberty, it seem from table (5) that heritability estimates of these traits are rather low, and reflect the generally small genetic variance for most reproductive traits. Furthermore, litter size has a higher heritability (0.16) than fertility (0.10) and survival rate (0.07-0.09). However, analysis of reproductive traits presents problems in devising adequate models, especially to account for the discrete or binomial nature of data, a combination of the full-sib and half-sib progeny and extended relationships amongst parents (22). Age and body weight at puberty had a moderate heritability being 0.35 and 0.26, respectively (Table 5). Also, the genetic and phenotypic correlations between age at puberty and each of weaning weight (-0.14, -0.1) and growth rate from weaning to puberty (-0.57, -0.27) suggest that selection weaning weight and / or growth rate would result in genetic improvement and advancing puberty in Awassi ewe lambs (30).

CONCLUSION

It is known that Awassi breed is well adapted to harsh environmental conditions in ari and

semi-arid areas, and is distributed in more than 30 countries of its origin. Efforts to improve the reproductivity of this breed could be done by applying accelerated lambing due to their non-seasonality. Moreover, Awassi ewes are not prolific, however, improvement litter size in countries of its origin, through selection is often very favorable, but substantial time is required to achieve goals. Furthermore, the advantages of selection are that the effects are more cumulative over time and relatively permanent.

Table 1. Some aspects of reproduction in Awassi ewes.

Trait	No.	Mean	References
Estrus cycle (days)	60	16.4	(6)
	424	17.3 ± 1.63	(35)
	n.a	16.9	(36)
Duration of estrus (hour)	424	40.0 ± 2.85	(35)
	n.a	32.0	(36)
Ovulation rate	30	0.8, 1.2 (1)	(9)
	40	1.0– 1.4 (2) 1.0– 1.5 (3)	(35)
Gestation length (days)	120	148.7	(6)
	129	152.7	(14)
	n.a	151.7 ± 2.17	(34, 35)
	16	152	(50)
	n.a	149.2	(38)
	14	149	(28)
	30	150.6, 151.0 (4)	(51)
Post – partum estrus (days)	24	67	(5)
	98	83	(34, 35)

(1) Law and high level of feeding
(2) After synchronization
(3) Without synchronization
(4) Fast and low growing
n.a Not available

Table 2. Age and weight at puberty in Awassi ewe lambs

Country	No.	Age (days)	Weight (kg)	References
Iraq	60	292.9 (273.9[a]-311.9[b])	38.0	(5)
	96	327.1	40.1	(39)
	72	318.9 (298.4[c]-356.1[d])	37.0	(29)
	113	286.2	30.0	(10)
Syria	n.a	257.0 -281.0	n.a	(34)
	30	359.5 [e], 394.9 [f]	48.4 [e], 42.8 [f]	(51)
Turkey	n.a	304.5	n.a	(36)

a High level of feeding
b Medium level of feeding
c Lambs born in autumn
d Lambs born in spring
e Fast growing
f Low growing
n.a Not available

Table 3. Fertility and prolificacy of Awassi ewes raised in different countries

Country	No.	Fertility %	Litter Size	References
Jordon	16800 [a]	88 – 89	1.02	(2)
	453 [b]	88 – 95	n.a	(45)
	1248 [b]	95.7	n.a	(42)
Iraq	56	90	1.08	(41)
	4623 [b]	83.0	1.12	(40)
	1355 [b]	75.6	1.08	(37)
	936	86.32		(27)
	3010 [b]	76.2	1.08	(1)
	333 [b]	73.9	1.12	(3)
	234 [b]	91.5	1.12	(47)
	339 [a]	67.3	1.34	
	n.a		1.02-1.12 [e]	(13)
	n.a	82.5		(35)
Syria	200 [c]	85.0	1.02	(32)
	400 [d]	80.0	1.07	
	n.a		1.11-1.45 [e]	(33)
Saudi Arabia	n.a	82.2	1.15	(49)
	n.a	85.0	1.12	(46)
Turkey	15020 [b]	92.9	1.12	(23)
	n.a [b]	85.6	n.a	(24)

a Traditional flocks
b Research station
c Settled in pastoral areas
d Settled in nomadei areas
e review
n.a Not available

Table 4. Mortality rate from birth-weaning in Awassi ewes

Country	No.	Mortality rate %	References
Iraq	1817	13.3	(16)
	2958	9.5	(31)
	1355	17.6	(37)
	2398	12.7	(11)
Syria	n.a	6.4 - 10.7	(32)
Jordan	n.a	4.2 – 15.0	(26)
Turkey	n.a	2.0 – 13	(25)

n.a Not available

Table 5. Heritability estimates (h^2 ± S.E.) for some reproductive traits in Awassi sheep.

Traits	No.	h^2	Method of estimate *	Reference
Litter weight at birth	1355	0.32	PHS	(17)
Litter size at birth	2314	0.19	PHS	
Fertility	3010	0.10 ± 0.04	ML	(1)
Litter size at birth	2178	0.16 ± 0.06	ML	
No. lambs born alive	2178	0.07 ± 0.03	ML	
No. lambs weaned	2128	0.17 ± 0.07	ML	
Survival rate up to weaning	2102	0.07 ± 0.06	ML	
Pre-Weaning Mortality rate	2398	0.085	REML	(11)
Post-Weaning Mortality rate	2398	0.099	REML	
Age at Puberty	113	0.35	REML	(10)
Weight at Puberty	113	0.26	REML	

*** PHS= Paternal half-sib**
ML = Maximum Likelihood
REML= Restricted Maximum Likelihood

REFERENCES

1. Abdul-Rahman, F.Y. 1996. A study of the Genetic and Phenotypic Variance of Reproductive Performance in Awassi Sheep. Ph.D. Dissertation, College of Agriculture and Forestry, University of Mosul, Iraq. (In Arabic).

2. ACSAD (Arab Center for Studies of Arid Zones and Dry Lands). 1983. Natural and Human Resources. Livestock in the AlHamad of Jordan. pp. 1-175. Damascus, Syria

3. Al-Ameri, M. H. 1999. A Comparison of some Reproductive Efficiency Traits in Awassi and Awassi Crossbreed with Assaf and Turkish Awassi Sheep. M.Sc. Thesis, college of Agriculture, University of Baghdad. (In Arabic).

4. Al-Haboby, A. H., M. H., Al-Salman, H. A.Hassan, and M. S. Faraj, 1991. Oestrus synchronization and super ovulation in Awassi sheep. IPA J. Agric. Res., 1:162-173

5. Al-Jubouri, I.H.A. 1977. Studies on some Productive and Reproductive Traits in Awassi Sheep. M.Sc. Thesis, College of Agriculture, University of Baghdad

6. Al-Kamali, A. H. 1976. Effects of Systems of Flushing and Source of Protein on Reproductive Performance of Indigenous Ewes. M.Sc. Thesis, College of Agriculture, University of Baghdad

7. Alkass, J. E., T. A. Abdulkareem, and N. N. Al-Anbari, 1999. The combined effect of PMSG and Vitamin A. administration on some productive performance of Awassi ewes. Iraqi J. Agric., 4:129-135

8. Alkass, J. E., T. A. Abdulkareem, and S. M. Al-Mjamei, 2004. Reproductive performance of Iraqi Awassi ewes in response to treatment with equine ehorionic gonadotropin. J. Agric. invesment, 2:74-77

9. Alkass, J.E. and S. H. Al-Kaisi, 1987. Some reproductive aspects of Awassi ewes as affected by different feeding regimes. J. Agric. Water Reso. Res. 6: 1-11

10. Alkass, J. E., D. A. Aziz, and K. A. Al-Nidawi, 1994. Genetic aspects of puberty in Awassi ewes. Small Ruminant Res., 14: 249-252.

11. Alkass, J. E., D. A. Aziz, and H. N. Hermiz, 1989. Lamb mortality in Awassi sheep. Proc. 5th Scientific Conference, Scientific Research Council, 1 (7): 63-70. Iraq, Baghdad 7-11 Oct

12. Alkass, J. E., A. H. Hamra, and F. F. Ibrahim, 1988. The combined effects of flushing and hormonal treatment on the reproductive performance of Awassi ewes. Indian J. Anim. Sci., 59:1249-1252

13. Alkass, J.E. and K.H. Juma, 2005. Small Ruminant breeds of Iraq. In: Characterization of Small Ruminant Breeds in West Asia, North Africa, vol. 1, West Asia, Luis Ῐniguez. ICARDA, Aleppo, Syria, pp. 63–101

14. Al-Tae, H.M.A. 1981. Some Sources of Variation in some Economic Traits of Awassi Sheep in Central Iraq. M.Sc. Thesis, College of Agriculture, University of Baghdad, Iraq. (In Arabic).

15. Al-Wahab, R.M.H., W.K. Al-Murani, and J.E. Alkass, 1982. Some observations on the breeding season of the Awassi sheep in Iraq. Wld, Rev. Anim. Prod., 18: 57-63

16. Asker, A.A. and I. J. El-Khalisi, 1964. Some observations on commercial flocks of sheep in Iraq. Ann. Agric. Sci. Ain Shams Univ., Cairo, 10:17-28

17. Badawi, F.S. 1989. Studies on Genetic and Phenotypic Parameters of Production Traits of Awassi in Iraq and Crossbreeding of Hmadani Breed with Finnish Landrace. Ph.D. Dissertation, Deemed University, India

18. Bradford, G.E. 1985. Selection for litter size. In: Genetics of Reproduction in Sheep. (eds. Land, R.B. and Robinson, D.W.). Butterworth, London, U.K. pp: 3-17

19. Bradford, G.E. and Y.M. Berger, 1988. Breeding strategies for small ruminants in Arid and Semi-arid areas. In: Increasing Small Ruminants Productivity in Semi-arid Areas. (eds. Thomson, E.F. and Thomson, F.S.). Kluwer Academic Publisher, London. pp: 95-109

20. Dyrmcendsson, O.R. 1987. Advancement of Puberty in Male and Female Sheep. In: New Techniques in Sheep Production. (eds. I.F.M. Marai and J.B. Owen). Butterworth, London.pp:65-76

21. Epstein, H. 1985. The Awassi sheep – with special reference to improve dairy type. FAO. Animal Production and Health. No. 57, FAO, Rome

22. Fogarty, N.M. 1995. Genetic parameters for live weight, fat and muscle measurements, wool production and reproduction in sheep. A Review. Anim. Breed. Abstr., 63: 101-143

23. Gursoy, O. 1992. Effect of age on reproductive performance of Awassi sheep on Ceylaninar state farm. Cukurova Universitesi Ziraat Dergisl, 7:173-188

24. Gursoy, O. 2005. Small Ruminant Breeds of Turkey. In: Characterization of Small Ruminant Breeds in West Asia and North Africa Vol. 1, West Asia (ed. L. Iniguez, International Center for Agricultural Research in the Dry Area. ICARADA, Allepo, Syria).
25. Gursoy, O., E., Pekel, L., Ozcan, O. Torun, and V. Timon, 1992. Genetic selection for milk yield in Awassi sheep. 1. Reproduction and lactation. Doga Turkey J. Vet. and animal Sci., 16: 535-546
26. Hailat, N. 2005. Small Ruminant Breeds of Jordon. In: Characterization of Small Ruminant Breeds in West Asia and North Africa Vol. 1, West Asia (ed. L. Iniguez, International Center for Agricultural Research in the Dry Area. ICARADA, Allepo, Syria).
27. Hermiz, H.N., E. A. Assak and M. T. Shamsa, 1995. Effect of non-genetic factors on some reproductive traits in Awassi ewes. Tech. Res. J., 8(26): 129-137
28. Husein, M.Q. and S.G. Haddad, 2006. A new approach to enhance reproductive performance in sheep using royal jelly in comparison with equine chorionic gonadotropin. Animal Reproduction Science, 93, 24–33
29. Jawad, M.A.J., J.E. Alkass, and R.M.N.Al-Wahab, 1986. Effect of season of lambing and docking on the puberty and reproductive performance of Awassi ewe lambs. Proc. 4th Scientific Conference, Scientific research Counsel, Baghdad, Iraq
30. Juma, K.H. and J. E. Alkass, 2006. Genetic and phenotypic parameters of some economic characteristics in Awassi sheep of Iraq. A Review. Egyptian J. sheep, goat and desert Animal Sciences. 1: 15-29
31. Juma, K.H., J., Eliya, A.A. Alrawi, and H. N. Abu Al-Maali, 1974. Survival of lambs in Awassi sheep. Indian J. Anim. Sci., 44: 250-256
32. Kassem, R. 1998. Sheep production improvement and development in Syria. Proceeding of the symposium on the development of sheep and goat production in the Mid-Eastern Arab Countries, Amman, Jordon, 15-17 March, 1998. Acsad, Damascus, Syria. pp: 115-125
33. Kassem, R. 2005. Small Ruminant Breeds of Syria. In: Characterization of Small Ruminant Breeds in West Asia and North Africa Vol. 1, West Asia (ed. L. Iniguez, International Center for Agricultural Research in the Dry Area. ICARADA, Allepo, Syria).
34. Kassem, R., J.B. Owen, and I. Fadel, 1989. The effect of pre mating nutrition and exposure to the presence of rams on the onset of puberty in Awassi ewe lambs under semi-arid conditions. Anim. Peod., 48: 293-297
35. Kassem, R., J. B., Owen, I. Fadel, H.Juha, and C. J. Whitaker, 1989. Aspects of fertility and lamb survival in Awassi sheep under semi-arid conditions. Research and Development in Agriculture, 6: 161-168
36. Kaymakci, M. and R. Sonmez, 1996. Advanced Sheep Production. In Turkish. Ege Universitesi, Basimevi, Bornova, Izmir, Turkey
37. Kazzal, N. T. and M. Y. Hamdoon, 1986. A study of reproductive performance in Awassi sheep. Zanco, 4: 21-33
38. Khazaal, K. 2005. Small Ruminant Breeds of Lebanon. In: Characterization of Small Ruminant Breeds in West Asia and North Africa Vol. 1, West Asia (ed. L. Iniguez, International Center for Agricultural Research in the Dry Area. ICARADA, Allepo, Syria).
39. Khedeyer, A. N. 1980. The Study of Fertility and Reproductive Capacity of Awassi Ewe Lambs and Determination of their Age at Puberty by Means of Vaginal Smearing. M.Sc. Thesis, College of vet. Med., University of Baghdad
40. Koster, K., H.A. Karam, H.N., Abu Al-Maaly, D.H.L., Rollinson, M.H. Injidi, and R.G. Jones, 1970. Some aspects of infertility in the flock of sheep at Abu-Ghraib. FAO Technical Report No. 46
41. Kridli, R.T., Y.A., Abdullah, M.M. Shaker, and N.M. Al-Smadi, 2007. Reproductive performance and milk yield in Awassi ewes following crossbreeding. Small Ruminant Research, 71, 103–108
42. Lafi, S.Q., N.Q. Hailat, and F.H. Shidaifat, 2001. Reproductive performance of Awassi sheep in the northern Badia of Jordan. J. Egyptian Vet. Medical Association. 61: 379-386
43. Markotic, B., H.P. Mader, K., Al-Omari, N.A. Salah, and A. Neimat, 1975. Report on the effect of synchronmate and PMSG on fertility and prolificacy of the Awassi ewe. FAO publication,Technical Report No. 21

44. Ministry of Agriculture 1998. Technical report for Mashreq / Magreb project 1997/1998. National Center for Agric. Res. and Transfer Technology (NCART), Amman, Jordan. pp: 19-33

45. Ministry of Agriculture 1999. Animal Production Report. pp: 5-25. Amman, Jordan

46. Ozsoy, M. K., Y. Vanlı, and O. Akbulut, 1987. Effect on some factors on ewe productivity in Awassi, Morkaraman crossbreeding. I. Reproduction. Doga Tr. J. Vet. Anim. Sci. 11 (1), 46–58, in Turkish

47. Salman, A.D., H.N.,Hermiz, R.A., Ibrahim, A.H. Al-Haboby, and A.A. Al-Rawi, 2001. Effect of body condition score on reproductive performance of Awassi ewes. IPA J. Agric. Res., 11(2): 75-87

48. Turner, H.N. and S.S.Y. Young, 1969. Quantitative Genetics in Sheep Breeding. Melbourne, Macmillan

49. Yamoor, M.Y., M.A. Mulhim, and S.M. Bather, 1988. Studies on Najdi, Awassi and Dorper sheep in Saudi Arabia. Publication of Al-Hassa Regional Agricultural Research Center, Hofuf, Saudi Arabia, pp: 35

50. Zarkawi, M. 1997. Monitoring the reproductive performance in Awassi Ewes using progesterone radioimmunoassay. Small Ruminant Research, 26, 291–294

51. Zarkawi, M. and M.B. Al-Daker, 2018. Productive and reproductive parameters in high and low growing Syrian Awassi lambs. Acta Scientiarum. Animal Sciences, v. 40, e37983: 1-7.