Indian Journal of Small Ruminants 2021, 27(1): 83-90

Indian Journal of Small Ruminants

EFFECT OF MILK REPLACER SUPPLEMENTATION ON GROWTH AND DISPOSAL OF NEONATAL LAMBS OF INDIAN SHEEP

C.P. Swarnkar*, S.R. Sharma and G.G. Sonawane

Division of Animal Health

ICAR-Central Sheep and Wool Research Institute, Avikanagar- 304 501, Rajasthan

**E-mail address: swarnkarcp@yahoo.com*

Manuscript received on 03.10.2020, accepted on 26.10.2020

DOI: 10.5958/0973-9718.2021.00023.4

ABSTRACT

A study was conducted to assess the effect of milk replacer (MR) supplementation on growth and mortality of neonatal lambs. The lambs in treatment group were supplemented MR (Memnaprash©) from 4 to 28 days of age in addition to ewe suckling as compared to only ewe suckling in the control. Observations were recorded for daily milk intake, body weight at birth, 7th, 15th, 22nd and 30th days of age and mortality / culling, if any. In single-born lambs, MR intake varied significantly (P<0.001) from 103.8±5.2, 91.9±11.7 and 124.3±15.2 ml (on 4th day of age) to 373.4±27.0, 392.1±26.2 and 433.2±21.7 ml (on 26th-28th days of age) and in multiple- born lambs, from 79.4±6.6, 75.8±11.2 and 130.6±7.0 ml (4th day of age) to 358.6±27.3, 440.8±35.4 and 431.7±11.0 ml (on 27th-28th) day of age in Malpura, Avikalin and Avishaan sheep, respectively. In comparison to the control the total lamb weight per ewe at one month of age was higher (5.67% in Malpura, 15.5% in Avikalin and 11.4% in Avishaan) in MR supplemented group. The overall disposal was almost two times higher in control (27.32%) as compared to treatment group (14.05%). After supplementation of MR for 25 days, the net return increased by Rs 218.00 per ewe (18.53%) over the control. The study suggested that supplementation of MR in lambs is a remurerative approach for improving growth and reducing disposal of lambs in Indian sheep.

Key words: Growth, Milk replacer, Mortality, Neonatal lambs, Supplementation

For sheep rearers in Rajasthan, the major component (around 85%) of income is through sale of live animals, particularly lambs at 2 to 4 months of age (Singh et al., 2018). In order to fetch higher price of lamb *vis-a-vis* more income from flock, it is essential to have minimum loss of lambs and optimum growth during neonatal phase. Native sheep breeds in semi-arid region of Rajasthan produce insufficient milk to support rapid growth of their lambs (Singh et al., 2015). Further, poor average daily gain in lambs are consequential to poor mothering from the undernourished dam and non-existent or inadequate supplemental nutrition of the pre- and post-weaning lambs (Sahoo et al., 2015). Perinatal and neonatal mortality in lambs has been considered as a major cause of low return from sheep rearing (Barlow et al., 1987). In recent years, increased interest in rearing of prolific sheep breeds necessitated supplementary feeding to reduce neonatal lamb morbidity and mortality (Dwyer et al., 2016) and to increase farm productivity. For faster growth of lambs and to obtain higher weaning weight, supplementary feeding (high energy) of lambs is essential during early phase (Shinde and Naqvi, 2015). Successful and efficient rearing systems wherein lambs are fed milk replacer for production of marketable sheep have been reported (Bimczok et al, 2005; Bhatt et al., 2009). An increased milk intake above conventional rates was reported to accelerate growth and decreased incidence of diseases (Ollivett et al., 2012). Milk replacer supplementation studies are scarce in sheep. Therefore, a study was conducted to investigate the effect of milk replacer (MR) supplementation on growth and mortality of neonatal lambs in semi-arid Rajasthan.

MATERIALS AND METHODS

A study was conducted at ICAR-Central Sheep and Wool Research Institute (ICAR-CSWRI), Avikanagar (Rajasthan) to assess the effect of MR supplementation on growth and mortality of neonatal lambs for consecutive three major lambing seasons (spring 2016 to 2018) involving three different genetic groups (Malpura, Avikalin and Avishaan) (Table 1). Among them, genotypes, Malpura is native, while Avikalin is a crossbred sheep with 50% exotic Rambouillet and 50% native Malpura inheritance and Avishaan is a prolific strain with 12.5% Garole, 37.5% Malpura and 50.0% Patanwadi inheritance. Lambs were housed under hygienic conditions with clean straw bedding (changed every 2-3 days) in lamb nursery. Lambing pens as well as lamb nurseries were periodically disinfected with spray of benzalkonium chloride (1-2% solution in water). The lambs at 4^{th} day of age were randomly divided into two groups (treatment and control). All the lambs were allowed to suckle their dam. In addition, lambs of treatment group were also supplemented with MR (Memnaprash©, ICAR-CSWRI, Avikanagar) in morning hours from 4 to 28 day of age. On dry matter basis, MR contained 24-28% crude protein, 10-12% fat and 15-17% total solid. Measured quantity of liquid MR was offered in milk feeding bottles. Liquid milk replacer was prepared by dissolving one kg of Memnaprash in six litres of warm water. The contents were mixed thoroughly using blender. The liquid MR was then cooled to 40±1°C. The feeding bottles were washed with detergent after each feeding and dried.

Table 1. Data structure for the animals used in present study

Year	Breed and group	No. of ewes	No. of lambs		
			Single-born	Twin-born	Multiple-born
2016-17	Avikalin				
	Treatment	30	24	12	-
	Control	10	10	-	
	Malpura				
	Treatment	28	23	10	
	Control	11	11	-	
2017-18	Avishaan				
	Treatment	79	28	84	27
	Control	66	53	26	-
2018-19	Malpura				
	Treatment	87	74	24	-
	Control	78	67	16	-

The observations were recorded for daily milk intake, body weight at birth, 7^{th}, 15^{th}, 22^{nd} and 30^{th} days of age along with mortality / culling, if any. For the purpose of economic evaluation, milk replacer feeding cost, cost of animal, labour charges, gain in lamb's body weight, total lamb weight harvested per ewe and mortality losses were recorded. The data were subjected to adjustment for the year effect using least squares analysis of variance (Harvey, 1990). The least squares constants were derived for the year effect (3 subclasses) and the phenotypic observation against each animal were adjusted for the particular year effect. The corrected data was then used for further analysis of variance using General Linear Model (SPSS 16.0) and means were compared using Duncan's mutiple range test.

RESULTS AND DISCUSSION

The magnitude of mean daily intake of liquid MR in neonatal lambs is presented in Table 2. Irrespective of breed and type of birth of lamb, the overll mean daily intake of liquid MR showed a linear increase with advancement of age and varied significantly (P<0.001) from 86.08±4.33

ml (on 4[th] day of age) to 421.91±10.84 ml (on 28[th] day of age). The breed has significant (P<0.001) influence on quantum of daily intake of liquid MR throughout the neonatal phase with relatiely higher intake by lambs of prolific sheep strain (Avishaan) as compared to non-prolific sheep breeds (Malpura and Avikalin). Mean daily intake of liquid MR varied significantly (P<0.001) from 87.59±5.91 ml (on 4[th] day of age) to 347.42±19.32 ml (on 27[th] day of age) in Malpura lambs, from 61.67±10.51 ml (on 4[th] day of age) to 444.08±23.51 ml (on 28[th] day of age) in Avikalin lambs and from 108.69±5.94 ml (on 4[th] day of age) to 469.60±13.762 ml (on 28[th] day of age) in Avishaan lambs.

Irrespectie of breed, birth type of lamb had non-significant (P>0.05) influence on daily MR intake and it varied from from 91.76±5.87 ml (on 4[th] day of age) to 419.99±15.39 ml (on 28[th] day of age) in single-born lambs and from 80.41±6.24 ml (on 4[th] day of age) to 423.83±15.15 ml (on 28[th] day of age) in twin or multiple-born lambs (Table 2). In the present study, the higher total MR intake and average daily MR intake in twin/ multiple- born lambs might be due to less availability of mother's milk for consumption as the milk of mother gets shared with the other sibling in the twin/multiple-born lambs as compared to singleborn lambs that get complete milk of the mother.

Table 2. Factor-wise mean (±S.E.) daily reconstituted milk replacer intake (ml) in neonatal lambs

Age of lamb (days)	Overall	Breed				Type of birth		
		Malpura	Avikalin	Avishaan	P value	Single-born	Twin / multiple born	P value
4	86.08±4.33	87.59z5.91[b]	61.67±10.51[a]	108.69z5.94[b]	0.001	91.76z5.87	80.41z6.24	0.181
5	130.57±5.70	108.03±7.79[b]	78.55±13.85[a]	205.12±7.73[c]	0.001	114.10±7.70	117.04±8.20	0.015
6	151.44±7.08	136.24±9.65[b]	101.02±17.21[a]	217.06±9.61[c]	0.001	159.13±9.56	143.75±10.19	0.265
7	163.96±7.26	153.90±9.95[b]	112.33±17.63[a]	225.67±9.87[c]	0.001	162.91±9.80	165.02±10.49	0.882
8	171.62±7.48	173.82±10.19[b]	113.35±18.15[a]	227.68±10.23[c]	0.001	175.78±10.03	167.45±10.89	0.570
9	184.63±7.86	186.86±10.82[b]	129.99±19.04[a]	237.14±10.74[c]	0.001	187.63±10.55	181.64±11.48	0.699
10	201.88±7.92	197.27±10.96[a]	160.54±19.13[a]	247.82±10.82[b]	0.001	200.96±10.65	202.79±11.55	0.907
11	228.56±8.73	192.57±12.34[a]	171.50±21.01[a]	321.61±11.92[b]	0.001	232.39±11.74	224.74±12.89	0.660
12	249.20±8.84	216.25±12.51[a]	194.93±21.25[a]	336.42±12.05[b]	0.001	239.63±11.88	258.77±13.03	0.278
13	264.74±8.48	217.36±12.03[a]	225.66±20.37[a]	351.19±11.64[b]	0.001	260.21±11.47	269.26±12.51	0.594
14	275.46±9.03	238.58±12.81[a]	262.33±21.68[a]	325.47±12.39[b]	0.001	266.14±12.20	284.78±13.32	0.303
15	283.68±9.28	240.76±13.33[a]	248.23±22.20[a]	362.04±12.73[b]	0.001	276.59±12.56	290.77±13.72	0.448
16	295.64±8.93	237.86±13.00[a]	266.10±21.29[a]	382.98±12.23[b]	0.001	284.45±12.10	306.84±13.24	0.215
17	315.67±9.72	255.53±14.28[a]	284.79±23.10[a]	406.68±13.27[b]	0.001	297.38±13.22	333.96±14.37	0.063
18	324.76±9.11	267.35±13.70[a]	278.33±21.49[a]	428.62±12.37[b]	0.001	339.41±13.44	339.41±13.44	0.113
19	334.75±9.51	289.63±14.37[a]	327.43±22.37[a]	387.19±12.88[b]	0.001	310.88±13.01	358.62±13.99	0.014
20	343.91±10.04	285.30±15.51[a]	351.60±23.47[b]	394.83±13.54[c]	0.001	330.52±13.75	357.30±14.87	0.191
21	345.86±10.14	284.06±15.83[a]	341.24±23.57[b]	412.29±13.63[c]	0.001	324.34±13.92	367.38±14.94	0.037
22	352.92±10.77	298.60±17.00[a]	366.81±24.89[b]	399.36±14.41[b]	0.001	332.71±14.83	373.14±15.79	0.065
23	366.48±10.47	300.51±16.98[a]	275.27±23.94[a]	423.66±13.89[b]	0.001	352.13±14.49	380.83±15.28	0.177
24	376.76±10.17	296.51±16.90[a]	379.87±22.95[b]	453.89±13.32[c]	0.001	364.22±14.18	389.29±14.66	0.221
25	384.80±10.95	319.59±18.71[a]	398.52±24.39[b]	436.30±14.19[b]	0.001	382.60±15.33	387.01±15.69	0.841
26	401.15±10.66	325.56±18.38[a]	408.29±23.63[b]	469.60±13.76[c]	0.001	411.32±14.98	390.99±15.20	0.342
27	407.91±11.01	347.42±19.32[a]	428.51±24.14[b]	447.82±14.07[b]	0.001	412.47±15.56	403.35±15.53	0.678
28	421.91±10.84	342.71±19.30[a]	444.08±23.54[b]	478.95±13.74[b]	0.001	419.99±15.39	423.83±15.15	0.858

Means bearing different superscripts in the same row differ significantly

However, within breed analysis exhibied significant (P<0.05) influence of birth type on MR intake (Fig. 1). In Malpura breed higher intake wasnoticed in single-born on days 4 and 5 of age but, with the advancement of age relatively higher intake was noticed in twin-born lambs as compared to single-born lambs. In Aikalin breed, birth type had influence on MR intake with relatively higher intake in twin-born lambs on majority of days. In Avishaan sheep relatively higher intake was recorded in multiple-born lambs on majority of the days. The difference in daily milk intake was more evident during first half of neonatal phase in single-born lambs as compared to during later half of phase in multiple-born lambs. Among single-born lambs daily MR intake was relatively higher in Avishaan throughout the neonatal phase; however, in multiple-born lambs it remained higher in Avishaan up to 19th day of age and thereafter in Avikalin. In the present study, the higher total MR intake and average daily MR intake in twin/ multiple- born lambs might be due to less availability of mother's milk for consumption as the milk of mother gets shared with the other sibling in the twin/multiple-born lambs as compared to singleborn lambs that get complete milk of the mother.

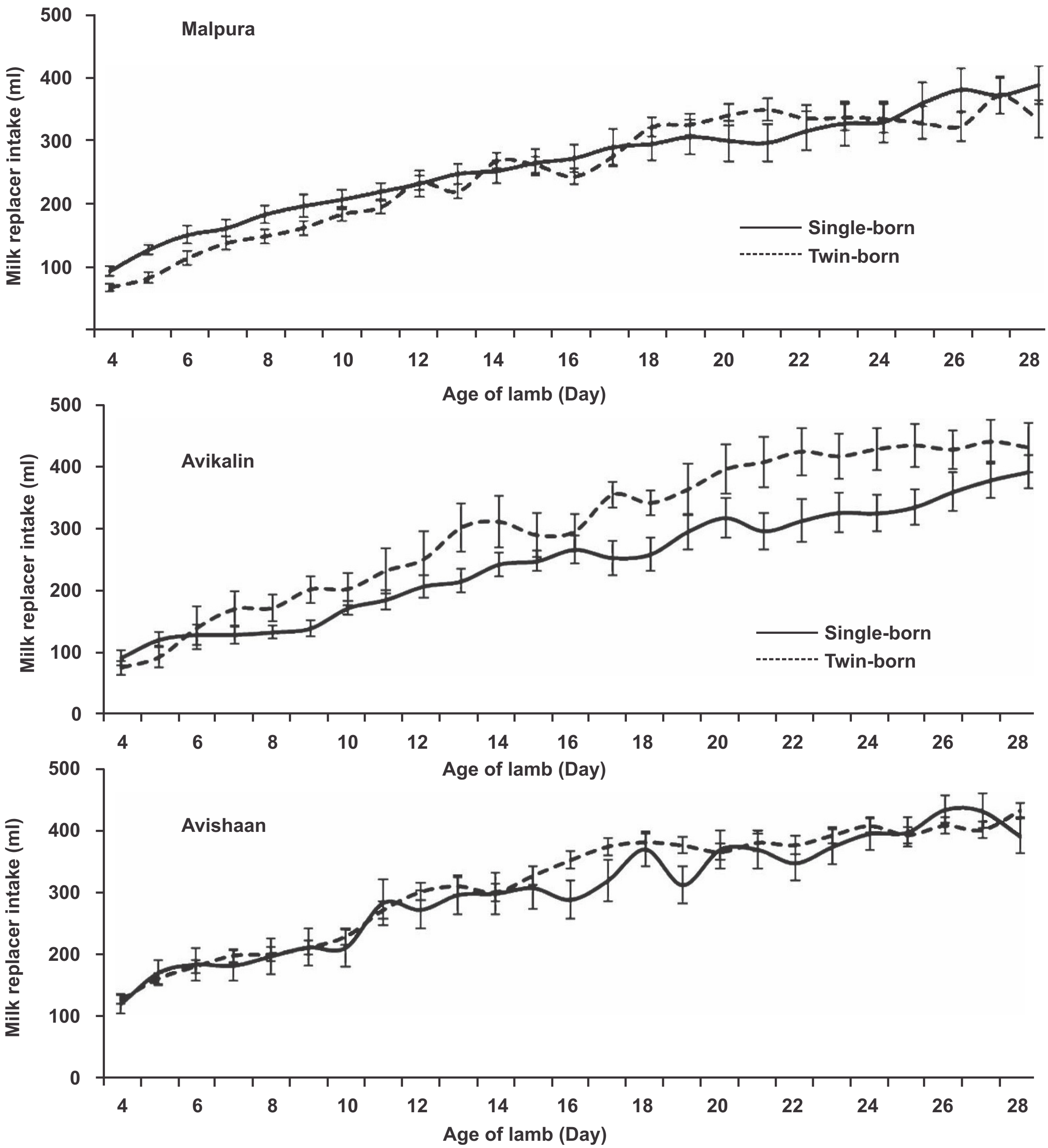

Fig. 1. Mean (±S.E.) daily reconstituted milk replacer intake (ml) in neonatal lambs

The mean body weights at different age intervals showed non-significant influence of MR supplementation in singles as well as in twin/multiple-born lambs of all the three genotypes except singles of Malpura sheep where from birth to 22nd day of age it remained significantly (P<0.05) higher in the control group as compared to their contemporaries in the treated group (Table 3). Likewise the magnitude of average daily gain in body weight showed non-significant variation at all the stages in all the groups except during 0 to 7 days of age in singleton Malpura lambs where it was significantly higher in the control group. The growth magnitude among twins of Avikalin and triplets/quadruplets in Avishaan could not be compared as all those lambs were kept on MR supplementation in order to avoid losses due to neonatal inanition.

Table 3. Effect of milk replacer supplementation on mean (±S.E.) body weights and average daily gain in neonatal lambs

Age	Malpura		Avikalin		Avishaan		
(Day)	Single	Twin	Single	Twin	Single	Twin	Multiple
			A. Body weight (kg)				
Birth	*	NS	NS		NS	NS	
Control	3.45±0.07 (73)	2.37±0.17 (10)	3.35±0.11 (10)	-	3.61±0.08 (53)	2.42±0.10 (26)	-
Treated	3.14±0.06 (96)	2.62±0.13 (34)	3.08±0.11 (24)	2.56±0.15 (12)	3.48±0.13 (28)	2.29±0.06 (79)	1.79±0.08 (26)
7	*	NS	NS		NS	NS	
Control	4.76±0.11 (73)	3.25±0.25 (10)	4.60±0.14 (10)	-	4.95±0.11 (53)'	3.27±0.14 (26)	-
Treated	4.27±0.09 (96)	3.69±0.18 (34)	4.23±0.19 (24)	3.18±0.22 (12)	4.74±0.18 (28)	3.09±0.09 (79)	2.46±0.12 (26)
15	*	NS	Ns		NS	NS	
Control	6.43±0.17 (36)	5.68±0.13 (2)	5.98±0.17 (10)	-	5.95±0.15 (52)	3.97±0.16 (25)	-
Treated	5.65±0.13 (83)	5.38±0.22 (26)	5.57±0.22 (24)	4.13±0.31 (12)	5.85±0.24 (27)	3.74±0.11 (79)	3.04±0.15 (26)
22	-	NS	NS		NS	NS	
Control	7.68±0.23 (29)	6.70 (1)	6.87±0.12 (10)	-	6.81±0.20 (49)	4.43±0.17 (25)	-
Treated	6.61±0.20 (51)	6.54±0.30 (22)	6.63±0.24 (24)	5.12±0.32 (12)	6.66±0.30 (27)	4.22±0.14 (79)	3.54±0.18 (26)
30	NS		NS		NS	NS	
Control	8.35±0.54 (12)	-	7.74±0.20 (10)	-	8.03±0.28 (45)	5.28±0.24 (24)	-
Treated	7.06±0.39 (24)	8.44±0.40 (12)	7.77±0.26 (24)	6.18±0.39 (12)	7.84±0.37 (27)	5.05±0.17 (78)	4.16±0.23 (26)
			B. Average daily gain (g/day)				
0-7	*	NS	NS		NS	NS	
Control	186.8±8.0 (73)	125.7±17.4 (10)	178.3±11.8 (10)	-	191.4±7.9 (53)	122.1±8.8 (26)	-
Treated	162.5±6.2 (96)	152.2±13.1 (34)	164.9±21.0 (24)	88.3±15.6 (12)	180.9±10.7 (28)	113.6±5.9 (79)	95.6±7.4 (26)
7-15	NS	NS	NS		NS	NS	
Control	194.5±8.6 (36)	159.4±9.4 (2)	172.4±20.7 (10)	-	125.7±9.8 (52)	89.0±8.1 (25)	-
Treated	174.5±6.9 (83)	173.0±12.1 (26)	167.0±10.9 (24)	119.6±13.5 (12)	139.7±9.5 (27)	81.3±4.7 (79)	73.3±5.5 (26)
15-22	NS	NS	NS		NS	NS	
Control	163.1±11.7 (29)	164.3 (1)	128.1±18.7 (10)	-	118.3±6.9 (49)	66.1±6.2 (25)	-
Treated	147.9±10.9 (51)	148.9±13.1 (22)	151.7±13.0 (24)	140.5±10.6 (12)	115.9±11.6 (27)	68.9±4.9 (79)	70.8±6.1 (26)
22-30	NS		NS		NS	NS	
Control	145.2±15.5 (12)	-	107.6±19.7 (10)	-	160.1±11.0 (45)	104.9±10.8 (24)	-
Treated	116.1±9.1 (24)	156.8±14.8 (12)	142.2±13.8 (24)	132.4±15.5 (12)	147.2±13.0 (27)	102.3±7.5 (78)	77.7±8.5 (26)
0-30	NS		NS		NS	NS	
Control	161.8±13.9 (12)	-	146.2±8.5 (10)	-	148.5±7.4 (45)	96.0±5.7 (24)	-
Treated	134.7±8.7 (24)	172.6±8.8 (12)	156.3±7.6 (24)	120.6±8.9 (12)	146.1±9.8 (27)	92.1±4.3 (78)	79.1±5.7 (26)

** - Significant (P<0.05); NS – Non-significant (P>0.05); Figures in parentheses indicate number of observations*

Similar to the present findings, Emsen et al. (2004) recorded higher body weight (8.2 versus 6.72 kg, P<0.01) in ewe reared lambs (control) than lambs fed calf milk replacer until 30 days of age with similar body weights (9.69 and 9.42 kg) at the age of 6 weeks. Masum et al. (2009) reported higher total body weight gain (14.2 kg) in lambs reared on ewe milk as compared to those reared on milk replacer (13.8 kg). Musharraf et al. (2014) observed higher ADG (175 g/day) and total weight gain (14.5 kg) in Kajli lambs fed with mother milk as compared to those fed with milk replacer (118 g/day ADG and 10.4 kg total weight gain) and attributed to relatively increased nutrients intake and absorption from dam's milk. Relatively lower average daily gain in treated group compared to control lambs could be attributed to feed restriction due to exogenous supplement action of artificial milk (Napolitano et al., 2002). The lower ADG in artificially reared lambs could also be due to fact that feeding milk replacer at early age limited the growth as compared with the lambs reared on whole milk (Emsen et al., 2004). The lower body weights in artificially reared lambs may also be attributed to smaller accumulation of fat in their adipose tissue as a result of constant level of fat in milk replacer compared to continuously increased concentration of fat in ewe milk (Pattinson and Thomas, 2004).

At the end of neonatal phase of lambs, in order to ascertain the impact of milk replacer supplementation on growth, survival and net yield per ewe bearing single or twin/multiple births; total weight harvested per ewe was calculated for both the control and supplemented group. In comparison to the control, the total lamb weight harvested per ewe at one month post lambing was higher (5.67% in Malpura, 15.5% in Avikalin and 11.4% in Avishaan) in group supplemented with MR during neonatal phase in all the genotypes under study. However, the differences were significant (P<0.05) in Avikalin and Avishaan (Table 4).

Table 4. Effect of milk replacer supplementation on mean (±S.E.) total weight (kg) lambs/ewe

Age	Malpura		Avikalin		Avishaan	
(Day)	Control	Treated	Control	Treated	Control	Treated
Birth	3.50±0.07 (76)	3.41±0.08 (110)	3.35±0.11 (10)	3.64±0.12 (30)	3.82±0.10[a] (65)	4.26±0.13[b] (75)
7	4.82±0.11 (76)	4.67±0.11 (110)	4.60±0.14 (10)	4.83±0.18 (30)	5.23±0.14[a] (65)	5.77±0.19[b] (75)
15	6.43±0.18 (36)	6.24±0.16 (96)	5.98±0.17 (10)	6.41±0.22 (30)	6.32±0.17[a] (64)	7.10±0.23[b] (73)
22	7.68±0.23 (29)	7.50±0.24 (61)	6.87±0.12 (10)	7.66±0.27 (30)	7.22±0.21[a] (61)	8.09±0.28[b] (73)
30	8.30±0.54 (12)	8.77±0.43 (30)	7.74±0.20[a] (10)	8.94±0.31[b] (30)	8.58±0.28[a] (57)	9.56±0.35[b] (73)

Means with different superscripts differ significantly (P<0.05) among group within breed

During neonatal phase, over the years, the overall disposal was almost two times higher in lambs kept solely on dam's suckling (27.32%) as compared to those supplemented with milk replacer in addition to suckling (14.05%). The higher disposal of neonatal lambs in control group was observed for both the single- and twin/multiple- born lambs (Table 5). The yearly variation in disposal rate of lambs was attributed to occurrence of mineral deficiency in 2017-18 in Avishaan flock and an outbreak of coli-septicaemia in 2019-20 in Malpura flock. Further, the majority of disposals were during post-hebdomadal phase suggesting that practice of milk replacer supplementation to neonatal lambs helps in reducing mortality during crucial phase (hebdomadal, first week) of neonatal life.

Table 5. Effect of milk replacer supplementation on disposal rate (%) of lambs during neonatal phase

Age	Control			Treated			Total
(Day)	Single	Twin	Total	Single	Twin	Muliple	
2017-18	0.00 (0/21)	-	0.00 (0/21)	0.00 (0/47)	0.00 (0/22)	-	0.00 (0/69)
2018-19	7.55 (4/53)	7.69 (2/26)	7.59 (6/79)	3.57 (1/28)	7.14 (6/84)	3.70 (1/27)	5.76 (8/139)
2019-20	44.78 (30/67)	87.50 (14/16)	53.01 (44/83)	33.78 (25/74)	41.67 (10/24)	-	35.71 (35/98)
Total	24.11 (34/141)	38.10 (16/42)	27.32 (50/183)	17.44 (26/149)	12.31 (16/130)	3.70 (1/27)	14.05 (43/306)

Similar to the present findings, higher (25%) mortality in control group of lambs compared to 15% in lambs fed calf milk replacer was reported by Emsen et al. (2004). In the present study in spite of lower growth performance, better survival rate was observed in lambs during neonatal phase. High lamb mortality during the first few weeks of life is a major contributor to this loss (Gowane et al., 2018; Swarnkar et al., 2019a and b). Under farm conditions, Mandal et al. (2007) reported highest mortalities in Muzaffarnagari lambs within the first 15 days of life with pneumonia and starvation as major causes. Mortality due to general weakness and debility could be attributed to the poor nutritional status of dam as well as of young ones. The early neonatal mortality rate (within 48 h of age) was 2.01% and represented 62.1% of the neonatal mortalities with starvation-mis-mothering-exposure as one of the main factors (Sharif et al., 2005). On comparison with past records on neonatal mortality at same farm (Anon, 2016), it was found that supplementation of milk replacer to lambs during neonatal phase resulted in curtailing the losses caused by neonatal deaths particularly due to neonatal inanition in weak and twin lambs.

After supplementation of MR for 25 days, on the basis of average weight harvested / ewe, the net return was increased by Rs. 218.00 per ewe (18.53%) over the control (Table 6). More return from milk replacer-fed lambs was attributed to better survival rate with higher weight harvested. In conformity with the present observations, MR was used successfully for raising the lambs at lower feed cost than ewe rearing (Aquino et al., 2008; Masum et al., 2009; Peiman et al., 2013) and supplementation of milk replacer to lambs during neonatal phase offers a potential increase in economic returns for sheep producers (Emsen et al., 2004). However, Salahuddin et al. (2018) reported higher net profit at weaning in Kacchi lambs reared on whole milk as compared to those reared on milk replacer.

Table 6. Economics of milk replacer supplementation (on the basis of wt harvested / ewe)

Variable	Control			Treated		
	Single-born	Twin/Multiple-born	Overall	Single-born	Twin/Multiple born	Overall
Av. daily milk replacer intake (ml)/lamb	-	-	-	251.5±7.5	292.3±8.1	272.4±5.6
Total milk replacer intake in 25 days (lit)/lamb	-	-	-	6.29	7.31	6.81
Cost (Rs.) of liquid milk replacer (@ Rs. 21.00/lit)	-	-	-	132.10	153.50	143.00
Labour cost/lamb (@ Rs. 200x2x25/100)	100.00	100.00	100.00	100.00	100.00	100.00
Disposal rate (%)	24.11	38.10	27.32	17.44	10.83	14.05
Loss due to disposal (@ Rs. 1500.00 per lamb)	361.70	571.50	409.80	261.60	162.50	210.80
A. Overall total input cost (Rs.)		509.80			453.80	
Av. live wt (kg) harvested / ewe (in 30 days)		8.43			9.24	
B. Income from live wt (@ Rs. 200.00 / kg)		1686.00			1848.00	
C. Net return (Rs.) / ewe (B-A)		1176.20			1394.20	
% Gain over control		-			18.53	

It could be concluded that suitable and sufficient supply of nutrients to neonatal lambs through liquid milk replacer improved growth and survival and higher return from sale of lambs.

ACKNOWLEDGEMENTS

We are grateful to the Director, ICAR-Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) for providing facilities. The authors are thankful to the All India Network Programme on Neonatal Mortality in Farm Animals, Indian Council of Agricultural Research, New Delhi, India for providing financial assistance for carrying out this research work.

REFERENCES

Anon. 2016. Annual Report 2016-17. ICAR-Central Sheep and Wool Research Institute, Avikanagar, Rajasthan.

Aquino, D.L., Maroon, M.C., Abesamis, A.F. and Rosario, M.V. 2008. Utilization of milk substitute in lamb rearing. Journal of Veterinary and Animal Sciences 4: 30-42.

Barlow, R.M., Gardiner, A.C., Angus, K.W. Gilmour, J.S., Mellor, D.J., Cuthbertson, J.C., Newlands G. and Thompson, R. 1987. Clinical, biochemical and pathological study of perinatal lambs in a commercial flock. Veterinary Record 120: 357-362.

Bhatt, R.S., Tripathi, M.K., Verma, D.L. and Karim, S.A. 2009. Effect of different feeding regimes on pre weaning growth, rumen fermentation and its influence on post weaning performance of lambs. Journal of Animal Physiology and Animal Nutrition 93: 568-576.

Bimczok, D., Rohl, F.W. and Ganter, M. 2005. Evaluation of lamb performance and costs in motherless rearing of German Grey Heath sheep under field conditions using automatic feeding systems. Small Ruminant Research 60: 255-265.

Dwyer, C.M., Conington, J., Corbiere, F., Holmoy, I.H., Muri, K., Nowak, R, Rooke, J., Vipnod, J. and Gaitier, J.M. 2016. Invited review: Improving neonatal survival in small ruminants: Science into practice. Animal 10: 449-459.

Emsen, E., Yaprak, M., Bilgin, O.C. and Ockerman, H.W. 2004. Growth performance of Awassi lambs fed calf milk replacer. Small Ruminant Research 53: 99-102.

Gowane, G.R., Swarnkar, C.P., Prince, L.L.L. and Kumar, Arun. 2018. Genetic parameters for neonatal mortality in lambs at semi-arid region of Rajasthan India. Livestock Science 210: 85-92.

Harvey W.R. 1990. User's Guide for LSMLMW and MIXMDL PC-2 version. Mixed model least-squares and maximum likelihood computer program. Ohio State University, Columbus,Ohio, USA.

Mandal, A., Prasad, H., Kumar, A., Roy, R. and Sharma, N. 2007. Factors associated with lamb mortalities in Muzaffarnagari sheep. Small Ruminant Research 71: 273-279.

Masum, A.K.M., Islam, M.N. and Khan, M.A.S. 2009. Utilization of soya milk as milk replacer for lambs. Journal of Animal Science 38: 102-107.

Musharraf, A.A., Bhatti, S.A., Sarwar, M., Muhammad, G. and Basra, M.J. 2014. Comparative growth performance of Kajli lambs suckling their dams or offered buffalo-milk, cow-milk or milk replacer during pre-weaning period. Journal of Animal Production Science 54: 1502-1506.

Napolitano, F., Cifuni, G.F., Pacelli, C., Riviezzi, A.M. and Girolami, A. 2002. Effect of artificial rearing on lamb welfare and meat quality. Meat Science 60: 307-315.

Ollivett, T.L., Nydam, D.V., Linden, T.C., Bowman, D.D. and Van Amburgh, M.E.. 2012. Effect of nutritional plan on health and performance in dairy calves after experimental infection with *Cryptosporidium parvum*. Journal of the American Veterinary Medical Association 241: 1514-1520.

Pattinson, S.E. and Thomas, E.W. 2004. The effect of sire breed on colostrum production of crossbred ewes. Livestock Production Science 86: 47-53.

Peiman, E., Jalili, M. and Dadgar, N. 2013. The effect of milk replacer and whole milk on performance of Holstein calves growth. European Journal of Experimental Biology 1: 263-264.

Sahoo, A., Bhatt, R.S. and Tripathi, M.K. 2015. Stall feeding in small ruminants: emerging trends and future perspectives. Indian Journal of Animal Nutrition 32: 353-372.

Salahuddin, Menghwar, D.R., Baloch, M.H. and Qureshi, U. 2018. Rearing of Kachhi lambs by using milk replacer. Journal of Livestock Science 9: 88-95.

Sharif, L., Obeidat, J. and Al-Ani, F. 2005. Risk factors for lamb and kid mortality in sheep and goat farms in Jordan. Bulgarian Journal of Veterinary Medicine 8: 99-108.

Shinde, A.K. and Naqvi, S.M.K. 2015. Prospects of dairy sheep farming in India: an overview. Indian Journal of Small Ruminants 21: 180-195.

Singh, D., Swarnkar, C.P. and Khan, F.A. 2018. Epidemiology of gastrointestinal parasites and impact of worm management schemes in sheep flocks of Rajasthan. Small Ruminant Research 164: 22-27.

Singh, S., Poonia, R.K., Singh, R., Mehta, S.C., Patil, N.V. 2015. Analysis of milk constituents of Indian sheep, goat, camel and buffalo. Indian Journal of Small Ruminants 21: 122-123.

Swarnkar, C.P., Gowane, G.R., Prince, L.L.L. and Sonawane, G.G. 2019a. Risk factor analysis for neonatal lamb mortality in Malpura sheep. Indian Journal of Animal Sciences 89: 640-644.

Swarnkar, C.P., Narula, H.K. and Chopra, A. 2019b. Risk factor analysis for neonatal lamb mortality at an organized farm in arid Rajasthan. Indian Journal of Small Ruminants 25: 59-69.