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Body weight at different stages of reproduction, reproductive performance and body condition score (BCS) of Mahabubnagar local does under different systems of rearing

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Abstract
Sixty does (60, 3x20) of Mahabubnagar local does for reproductive performance were selected from the Goat unit, Livestock Research Station, Mahabubnagar. They were divided in to three groups G1 (Intensive), G2 (Semi-intensive) and G3 (Extensive) in a Completely Randomized Design. G1 group animals were provided with farm-grown chaffed green fodder with concentrate feed @ 1% of body weight, G2 group animals were provided with 200 grams of concentrate feed along with 6 hours of grazing per day and G3 group of animals were sent for grazing for about 8-10 hours per day and no supplemental feed was offered in the sheds. Significant (p<0.05) difference was observed between G1 and G2 groups while G2 and G3 groups were non-significantly (p<0.05) different in terms of the mean age at puberty of doe kids. The body weight at puberty in the G1 group doe kids had a significant (p<0.05) difference with G2 and G3, but G3 group had lower body weight at puberty than G2 group and statically non- significantly (p<0.05) differ with G3. The mean age at first service was lowest in G1 (344.05±1.43) followed by G2 (377.10±1.09) and G3 (396.60±1.34) groups and significant (p<0.05) difference was observed among the three groups. Conception and kidding rate in the G1 and G2 groups was 75 and 70%, respectively, and corresponding values in the G3 group were 70 and 60%. The gestation period had no significant (p<0.05) difference between the three groups. The mean body weight (kg) of does at the time of breeding was significantly (p<0.05) higher in G1 than in G2 and G3 groups. The overall mean body weight (kg) of pregnant does was higher in the G1 (30.33±0.05) group and lower in the G3 (27.51±0.05) group with significant difference (p<0.05) between the three groups in the 5th month of pregnancy. The overall mean body weight (kg) of does in the G1 group was significantly (p<0.05) higher than G2 (25.44±0.02) and G3 (24.06±0.03) groups from the kidding to weaning period. The mean BCS at breeding in the G2 group does have nonsignificant (p<0.05) difference with the G3 group does. The average BCS of does during pregnancy in the G1 group had a significant (p<0.05) difference with G2 and G3 groups, but the mean BCS of the G2 and G3 groups were non- significant (p<0.05). The total gain of BCS during the pregnancy period in the G1, G2 and G3 groups were 0.65±0.07, 0.53±0.07 and 0.45±0.12 respectively. The mean BCS after 48 hrs of kidding was significantly (p<0.05) higher in the G1 (3.00±0.00) group followed by the G2 (2.75±0.07) and G3 (2.38±0.07) group. The BCS of the does had linear decrease in all the groups from kidding to weaning. A significantly (p<0.05) higher coefficient of determination was found between body weight and BCS compared to other body measurements of does.

Keywords: Mahabubnagar local does, reproductive performance, completely randomized design, group etc.

Introduction
Goat is known as “Poor Man’s Cow” and considered the best option for rural farmers in developing countries, as it improves the status of household nutrition, helps in fulfilling household’s emergency cash needs, as well as boosts capital storage, the best utilization of family labour and self-employment (Pandey *et al*., 2015) [47]. Small ruminants play a predominant role in the economies of millions of people and provided meat, milk, skin, wool, and fiber for centuries (Al-Dawood, 2017) [3]. Goat milk is very well known for its medicinal properties (Devi *et al*., 2020) [14] and the farmers recognized goat manure as moving fertilizers, because of the high manurial value of its dropping (Sahoo *et al.*, 2018) [52]. The marketing of goats is the major source of income followed by milk, manures, and urine. Chevon was the important source of protein to provide essential amino acids in addition to any other meat

(Bharti *et al*., 2018) [6]. Three types of rearing systems for small ruminant are generally practiced in the country i.e extensive (free-range), intensive (stall feeding), and semi-intensive grazing with supplementation, (Mohini *et al*., 2018) [41]. On the other hand, the population of goats and sheep is increasing rapidly to meet the demand for meat, this causing overcrowding of available grazing lands and a sharp deterioration of grazing resources (Devi *et al*., 2020) [14]. In the coming years, goat rearing under the intensive and semi-intensive system would gain prominence and the traditional extensive system would decrease because of continuous shrinkage in common grazing resources. Hence, a possible alternative system of small ruminant rearing for meat purposes can be a stall-fed system on a commercial scale in areas where pasture lands are shrinking (Kumar and Pant, 2003). However, now-a-days many young entrepreneurs are setting up goat/sheep units using scientific rearing practices. Improving the economic status, the demand for high-quality meat products, the shifting population of metropolis cities, and a shift in family values toward animal protein are all likely to drive up demand for chevon/mutton in the future (Sahoo *et al.,* 2015) [47]. However, the demand for goat meat, which is leaner and has low cholesterol, is expected to rise at a faster pace in the domestic as well as international markets (Kumar *et al*., 2010).

Materials and Methods

The present study was undertaken at Livestock Research Station, Mahabubnagar district, situated between $77^0$15' and 79^0 15'E, of eastern longitudes and $15^0$55' and 17^0 20N, of northern latitudes. For the study sixty Mahabubnagar local goats of above one year age were selected in a Complete Randomized Design (CRD). These sixty does were assigned to each of the rearing systems (3x20) *viz*., Intensive group (G1), Semi-intensive group (G2), and Extensive group (G3).

Feeding management

The does in the intensive (G1) systems were fed with a concentrated mixture of 1% of their body weight and *ad libitum* quantity of chaffed green fodder (CO3, CO4, APBN, Super Napier) in the morning and evening. The animals in the semi-intensive (G2) system were fed with 200 gm of concentrate + 6 hours of grazing/day. In extensive system (G3) of rearing, does were allowed for grazing from 9.00 AM to 5.00 PM every day during the entire experimental period and were not provided with any supplemented feed and fodder. All the experimental animals were provided with clean, fresh drinking water in the shed during the entire experimental period.

Feed consumption

The does were offered weighed quantities of concentrate feed and the leftover concentrate and green fodder was weighed the next day morning before cleaning to find out daily feed intake in intensive and semi-intensive groups.

Body weight recording

The body weights of the does were recorded with the help of digital balance. This was performed in the morning before the animals were allowed for grazing. The body weight of does were recorded before breeding, during pregnancy (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} month of pregnancy), and during lactation (fortnights) period up to weaning of kids.

Reproductive traits

Puberty in Doe Kids

The puberty was recorded, when doe kids showed their first oestrus behaviour. Aproned Bucks above 20 kg of body weight (60% of adult body weights) were introduced into the flock in the pen mating system in all the three rearing systems, to detect the onset of the first oestrus. Bucks were introduced twice daily at 8 AM and 5.30 PM, respectively for 30-60 minutes. Doe kids being receptive for buck and standing to be mounted by the buck were considered to be in oestrus. The onset of the first oestrus was taken as an indicator for the onset of puberty. The date of onset of the first oestrus was recorded for each doe kid for arriving at the age of puberty (months and day).

Detection of Oestrus

The oestrus does were identified by using aproned bucks with paint at the brisket region as a teaser. These aproned bucks were daily allowed in each doe flock at the ratio of 1:30 at 5.00 AM and then it was removed from flock on the next day morning at 7.00 AM. At the same time, all the does with markings were segregated which were considered to be in oestrus.

Serving of Does

By breeding mandate of the farm, the breeding was carried out as per the stipulated guidelines in vogue. Oestrus does were segregated and bred on the same day morning before allowed for grazing. At the time of breeding, buck number was noted to prevent inbreeding, and care was taken to avoid breeding of does with the buck belonging to its sire line.

Conception Rate

The conception rate was measured as the number of does conceived during the first service to the total number of does mate in each rearing system.

Kidding Rate

The kidding rate was measured as the number of kids born to the total number of does mated in each rearing system.

Twinning Percentage

The twinning percentage was measured as the number of does giving birth to twins to the total number of animals mated in each rearing system.

Birth Weight of Kids

The birth weight of kids was recorded using a digital weighing balance immediately after kidding.

Body condition scoring (BCS) Assessment

The condition score was assessed by palpation of the doe in the lumbar region, on and around the backbone in the loin area immediately behind the last rib (Ghosh *et al*. 2019).

1. An assessment was made of the prominence (the degree of sharpness or roundness) of the spinous processes of the lumbar vertebrae.
2. The prominence and the degree of fat cover over the transverse processes of the vertebrae are assessed.
3. The extent of the muscular and fatty tissues below the tra nsverse processes is judged by the ease with which the fingers pass under the ends of these bones.
4. The fullness of the eye muscle area and its degree of fat

cover in the angle between the spinous and transverse processes are estimated.

Animals are then awarded a score based on the following scale:

Score 0
They are extremely emaciated and on the point of death. It is not possible to detect any muscular or fatty tissue between the skin and the bone.

Score 1.0
The spinous processes are felt to be prominent and sharp. The transverse processes are sharp, the fingers are passed easily under the ends and it is possible to feel between each process. The eye muscle areas are shallow with no fat cover.

Score 2.0 The spinous processes still feel prominent, but smooth and individual processes can be felt only as fine corrugations. The transverse processes are smooth and rounded and it is possible to pass the fingers under the ends with a little pressure. The eye muscle areas are of moderate depth but have a little fat cover.

Score 3.0 The spinous processes are detected only as small elevations; they are smooth and rounded and individual bones can be felt only with pressure. The transverse processes are smooth and well covered and firm pressure is required to feel over the ends. The eye muscle areas are full and have a moderate degree of fat cover.

Score 4.0
The spinous processes can just be detected with pressure as a hard line between the fat-covered muscle areas. The ends of the transverse processes cannot be felt. The eye muscle areas are full and have a thick covering of fat.

Score 5.0
The spinous processes cannot be detected even with firm pressure and there is a depression between the layers of fat in the position where the spinous processes would normally be felt. The transverse processes cannot be detected. The eye muscle areas are very full with a very thick fat cover. There may be large deposits of fat over the rump and tail.
Evaluation of Body Condition Score (BCS) was done by full-unit scores and the scale was subjectively divided further into half-unit scores (Russel, 1984).
The BCS of the does were recorded before breeding, at the time of breeding, throughout pregnancy, and lactation period.

Statistical analysis
The data were subjected to analysis of variance (Snedecor and Cochran, 1989). Correlations between body weight and body measurements were studied using Pearson's formula. The comparison of means of different subgroups was made by Duncan's multiple comparison post hoc tests as using SPSS 25 statistical software. The level of significance was determined at $p<0.05$ described by Kumar (1957).

Results and Discussion
Reproductive performance of does
The reproductive performance of Mahabubnagar local doe in different systems of rearing is presented in Tables 1 and 2 respectively.

Age at Puberty
The mean age (days) at puberty in doe kids was 321.75±2.58, 356.80±1.40, and 380.00±1.64, respectively in the G1, G2 and G3 group. The mean age at puberty in G1 group was significantly ($p<0.05$) lower than G2 and G3 group but G2 and G3 group had non- significant ($p<0.05$) difference.
The doe kids reared in the G1 group were attained puberty at an earlier than G2 and G3 groups and there was a significant difference among the G1 and G2 groups, puberty being directly related to growth and body weight more than age. Similar results were reported by Tabbaa *et al.* (2005) [59], Hassan *et al.* (2010) [23], and Kunbhar *et al.* (2016) [35]. Further, the mean age at puberty observed in the present study was 321 to 380 days. Lower age at puberty compared to the present study was observed by Faruque *et al.* (2010) [16], Hasan *et al.* (2014) [21], Hasan *et al.* (2015), Khandoker *et al.* (2018) [29], Sahoo *et al.* (2018) [52], Delgadillo *et al.* (2007) [12] and Bushara *et al.* (2017) [8].
However, the variation in age at puberty may be due to the presence of bucks in the herd, plane of nutrition, availability of good quality forages, and climatic variation. While the onset of puberty or sexual maturity was regulated by pituit ary gonadotrophins, gonadal hormones and factors including s pecies, breed, the genetic potential of animals, season, and management which includes feeding, breeding, housing, and disease control could affect, the initiation of age at puberty in goats.

Body Weight at Puberty
The overall mean body weight (kg) of doe kids at puberty was highest in G1 group followed by G2andG3 group. The G1 group doe kids body weight at puberty had significant ($p<0.05$) difference with G2and G3, but G3 group had lower body weight at puberty than G2 group and statically non-significant ($p<0.05$).
A higher growth rate and desirable body weight at an early age in growing doe kids are indispensable factors for attaining puberty. Early body weight attainment through strategic feeding interventions in various farming systems during the critical post-weaning growth phase is crucial for effective reproductive performance, which could be achieved by an intensive system of rearing. The body weight of doe kids in the G1 group at the time of puberty was significantly ($p<0.05$) higher followed by G2 and G3 groups.
A similar result was reported by Tabbaa *et al.* (2005) [59], whereas, Delgadillo *et al.* (2007) [12] observed higher body weight at puberty than present studies. However, Chinnamani *et al.* (2018) [10] reported a nonsignificant difference in the intensive and semi intensive systems of rearing on weight at first mating.
Lower body weight at puberty compared to the present study was observed by Kumar *et al.* (2006), Faruque *et al.* (2010) [16], Chowdhury *et al.* (2002) [11], Hassan *et al.* (2010) [23], Patel and Pandey (2013) [48], and Bushara *et al.* (2017 and 2018) [7-8].

Age at First Service
The mean age at first service (days) was lowest in G1 (344.05±1.43) than G2 (377.10±1.09) and G3 (396.60±1.34) groups. The significant ($p<0.05$) difference was observed in the age at first service among the three groups.

The age at first service in the present study was significantly (p<0.05) higher in young kids reared in the extensive system (G3) because the age at puberty was higher and body weight gain was lower than the doe kids reared in G2 and G1 groups. A similar finding to the age at first service was reported by Hassan *et al.* (2010) [23] and Kumar *et al.* (2018) in Mahabubnagar local breed in field conditions.

The mean age at first service in the present study was higher than those observed by Thiruvenkadan and Karunanithi (2006) [60], Ravimurugan *et al.* (2009) [51], Hasan *et al.* (2014) [21], Sahoo *et al.* (2018) [52], and Hasan *et al.* (2015). Higher age at first service compared to the present study was observed by Patel and Pandey *et al.* (2013) [48] and Yadav *et al.* (2017) [63].

The stress factors in different rearing systems particularly the under-nutrition that interferes with the breeding characteristics of indigenous does, birth weight, litter size at birth, and season of birth, may affect the age at first conception and the average age at first conception.

Body Weight at First Service

The overall mean body weight (kg) at first service was highest in G1 (28.55±0.41) and lowest in the G3 (25.05±0.21) group. Whereas, significant (p<0.05) difference in body weight (kg) at first service was present among the G1 and G2, but G3 groups non significant difference to G2 group.

The lower body weight of doe kids at first service was recorded in the G3 group, it may due to a slower growth rate in the post-weaning period than G2 and G1 groups. In the present study, the body weight of doe kids at first service in the G3 group was 25.05 kg this might be due to under nourishment during post weaning period. Lower body weight at first service compared to the present study was observed by Chinnamani *et al.* (2018) [10] in Salem black goats, Patel and Pandey (2013) [48] in the Mehsana breed.

BCS at Puberty and First Service

The BCS of doe kids at puberty and first service was the similar in all the three groups and non-significant difference was observed among the groups. The BCS of doe kids at puberty and first service in G1 group was relatively higher than the G2 and G3 groups.

Though statistically non-significant the mean BCS in the doe kids at puberty and first service in the G1 group were higher than the G2 and G3 group in the present study. It could be due to a higher plane of nutrition and fast growth rate in the intensive system of rearing, since the kids got appropriate nutrient as per their requirement. Similar BCS at puberty and first service were reported by Melesse *et al.* (2013) [39] and Silva *et al.* (2011) [55]. While Khalil *et al.* (2013) [27] reported that body condition at kidding decreased significantly at week 4th and then increased significantly (p<0.05) during the mid and late part of lactation, whereas, Msalya *et al.* (2017) [44] reported lower BCS at mating.

The targeted BCS for Mahabubnagar local goat kids at first service might be considered to be about 2.5. The BCS of the doe kids in the present study at first service in G2 and G3 groups are slightly lower than 2.5 due to lower growth rates, which is indicating that the kids reared on semi-intensive and extensive system as rearing deprived with nutrient availability.

Gestation Period

The gestation period had non-significant (p<0.05) difference between G1 (150.05±0.05), G2 (149.55±0.20) and G3 (149.65±0.11) groups in Mahabubnagar local does.

The gestation length of goats in the three groups had a statistically non- significant difference in the present study. Bradford *et al.* (1972) stated that the feeding system is not known to have a role in altering the gestation length of species but the genotype of the fetus has a crucial role in determining the length of gestation in any species. Similar gestation length compared to the present study was found by Kunbhar *et al.* (2016) [35], Yadav *et al.* (2017) [63], Khandoker *et al.* (2018) [29], Gautam *et al.* (2018) [18], and Doley *et al.* (2018) [15]. Whereas lower gestation lengths compared to the present study were reported by Chowdhury *et al.* (2002) [11] and Miah *et al.* (2016) [40]. It may be due to the effect of parity, flock, and generation on gestation length, and the season of kidding influence the gestation length.

Serving Rate

The serving rate of seventeen out of twenty does (17/20) in G1 and G2 groups showed oestrous with the serving percent of 85.00. In the G3 group eighteen out of twenty does came to oestrous with serving rate of 90.00 percentage while the serving rate was higher in the G3 group than G1 and G2 groups.

The serving rate of does was slightly higher in the G3 group than G2 and G1 groups in the present study. The findings of the present study were contrary to the findings of Kumar and Vasanthakumar (2016) [32], who reported that supplemented group had a higher serving rate than the non-supplemented group, however, Kumar *et al.* (2017), Chowdhury *et al.* (2002) [11], Sultana *et al.* (2011) [58] reported similar serving rate to in agreement with present study. Further Chinnamani *et al.* (2018) [10] reported that the system of management did not significantly influence the services per conception.

Conception Rate

The conception rate (percent) observed was the similarin G1 and G2 groups i.e.,75.00 and corresponding values in G3 group was 70.00 percent.

In the present study, the conception rate in the G1 and G2 groups were similar but higher percentage than the G3 group. Despite the higher serving rate in the extensive system, the lower conception rate is a clear reflection of the poor nutritional status of the does as the does were unable to meet their nutrient requirements solely from grazing. Similar results were reported by Kochewad (2015) [30] in Deccani sheep. However, Moni and Samad (2019) [42] and Bharti *et al.* (2018) [6] reported a higher serving rate than the present study in Sirohi, Black Bengal, Changthangi, Crossbre d goat breeds. Chinnamani *et al.* (2018) [10] reported that the system of management did not influence significantly the services per conception.

Kidding Rate

The Kidding rate (percentage) was higher in the G1 (70.00) and G2 (70.00) groups than the G3 (60.00) group in the present study. No twinning was observed in all the three groups. One of the fifteen conceived animals in the G1 and G2 groups experienced gestational accidents such as abortion

and stillbirth, respectively, at the rate of 5.00 percent whereas in the G3 group, two out of fourteen conceived animals showed stillborn, at the rate of 10.00 percent.

A higher kidding rate was recorded in the intensive and semi-intensive systems and this could be the effect of increased body weight gain in does who have been offered supplemented feed-in pre-mating and gestation period. Whereas, the kidding rate in the G3 group was lower than the G2 groups, it was due to that, in the G3 group, 10 percent of the does had stillbirths. The kidding rate observed in the present study was similar to the findings of Kochewad (2015) [30], Chinnamani *et al.* (2018) [10]. Singh *et al.* (2009) and Patel *et al.* (2005) [49] who revealed that the system of management significantly influences the kidding percentage.

The kidding percentage of Mahabubnagar local goats in the present study was comparatively lower than those reported by Deokar *et al*. (2006) [13] and Joshi *et al.* (2005). The higher kidding percentage indicated that the goats have the potential to show better reproductive efficiency which could be optimized by providing excellent managemental practices and climatic factors. The lower rate of kidding percentage of Mahabubnagar local goats in the present finding as compared to the earlier workers may be attributed to the fact that the flock was developed at the farm as a result of selective breeding in Mahabubnagar local climatic conditions. Kidding percentage is an important parameter that reflects reproductive efficiency. However, management plays an important role in increasing reproductive efficiency.

In the present study, twinning was not observed in any of the groups. On the contrary, twinning was observed by Gaikwad (1999), Neeur *et al*. (2004) Deokar *et al.* (2006) [13], Hassan *et al.* (2007) [22], Kuralkar *et al.* (2013) [37], Abd-Allah *et al.* (2015) [1], Hasan *et al.* (2015) and Bharti *et al.* (2018) [6] in different breeds of goats. Further Chinnamani *et al.* (2018) [10] reported higher twinning and kidding percentage in Salem black goats. Breed characteristics are responsible for twins and triplets in goats and twinning might be affected by nutritional level, body weight, parity, age, and genetic factors also with the advance in age and parity will be the result of increased ovulation rate, uterine capacity, and other maternal traits affecting the reproductive efficiency.

Bodyweight of does during different reproductive stages

The body weight (kg) of Mahabubnagar local does during reproductive stages in different systems of rearing is presented in Table 3 and Fig 1. The mean body weight (kg) of does at the time of breeding in G1, G2 and, G3 groups were 28.33±0.05, 26.41±0.07and, 26.23±0.03, respectively. The sig nificant (P<0.05)difference was observed among the G1 and G2 groups but G2 and G3 group had non-significant difference in the body weight of does at the time of breeding.

The mean body weight (kg) of does during pregnancy in the G1 group was 28.88±0.05, 29.51±0.05, 30.33±0.05, 31.13±0.05, and 31.82±0.05kg in the 1st, 2nd, 3rd, 4th and 5th month, respectively. The mean body weight (kg) of does in G2 group in the 1st and 5th month of pregnancy was 26.80±0.07and 30.13±0.07, respectively. The mean body weight (kg) of does in the G1 group was significantly higher than the G2 and G3 groups. The mean body weight (kg) in G3 group does was lower than the G1 and G2 groups throughout the pregnancy period. The overall mean body weight (kg) of pregnant does was higher in the G1 (30.33±0.05) group than G2 (28.35±0.07) and G3 group (27.51±0.05), but body weight of G3 group was significantly (P<0.05)lower than G2 group.

The statistical analysis of the data on body weight (kg) of pregnant does reveal a significant difference (P<0.05) between the three groups in the 5th month of pregnancy. The overall mean body weight (kg) of pregnant does in G2 group had non-significant difference with G3 group but significantly (P<0.05) differ with G1 group.

The body weight of does at the time of breeding was significantly higher (P<0.05) in G1 compared to the G2 and G3 group, The means of G2 and G3 were comparable. Similar findings compared to the present study w ere reported by Thiruvenkadan *et al.* (2008) [61], Sivakumar *et al.* (2009) [57], and Kumar and Vasanthakumar (2016) [32] in their studies, whereas Msalya *et al.* (2017) [44] and Haldar *et al.* (2014) [19] found lower body weight at breeding.

The body weight of does in the G1 group had higher body weight during pregnancy than other groups. In the first and second trimesters of pregnancy G2 group had a higher body weight than G3, but the difference was statistically non-significant, while the difference was significant (P<0.05) during the last trimester of pregnancy. The growth of the fetus accelerated during the last 6 weeks of pregnancy. In an extensive system of rearing sufficient nutrients may not be available to meet the nutrient requirement and it could be the reason for lower body weight. In support of the present studies, Sahoo *et al.* (2016) reported that supplementary feeding had a higher weight than the grazing animals. Further, Thiruvenkadan *et al.* (2008) [61] reported similar results concern to body weight.

Bodyweight of does during the lactation period

The body weight (kg) of Mahabubnagar local does during lactation period in different systems of rearing is presented in table 4 and Fig 2. The overall mean body weight (kg) of does after kidding was 28.48±0.02, 26.74±0.01and 25.49±0.02 in the G1, G2, and G3 groups, respectively. The mean body weight (kg) of does in the G3 group at the 2nd, 4th, 6th, 8th, 10th and 12th week during lactation period was 24.95±0.01, 24. 56±0.03, 24.18±0.03, 23.73±0.05, 23.53±0.05 and 23.38±0.05 , respectively, which is lower than the other two groups.

The overall mean body weight (kg) of does in G1, G2 and G3 groups had significant difference (P<0.05) from kidding to 12th week. The average mean bodyweight (kg) of the does in G1 (27.89±0.06kg) group had a significant (P< 0.05) difference with G2 (25.44±0.02kg) and G3 group, while G2 group significantly (P<0.05) differ with G3 group. The average body weight of does in the present study was ranged between 28.8 to 31.8 kg 48 hours before kidding and 25.49 to 28.48 kg, 48 hours after kidding. Similar body weights were reported by Tailor and Yadav (2012). Further, it was observed that the does in the G1 group lost their body weight from kidding to 4th weeks, then slowly gained body weight up to the 12th week of lactation. Whereas in G2 and G3 groups, closest body weight recorded throughout the lactation period, while loss in the body weight in G3 group was higher in the present study. This might be due to the mobilization of body reserves in semi-intensive and extensive rearing systems to meet the additional nutrient requirements for milk production, resulting in loss of body weight. Similar results were reported by Kumar and Vasanthakumar (2016) [32] and who reported that the non-supplemented group lost more body weight than supplemented group during the lactation period. The body weight loss in G2 and G3 groups during the lactation period

was between 2 to 2.5 kg and similar results were reported by Naik *et al*. (2016).

However lower body weight of does during the lactation period was reported by Chowdhury *et al.* (2002) [11], Haque *et al.* (2013), Bushara *et al.* (2018) [8], Msalya *et al.* (2017) [44], and Islam *et al.* (2009) [24], Whereas Patel and Pandey (2013) [48], Patel *et al.* (2005) [49] and Faruque *et al.* (2010) [16] observed higher body weights compared to present study.

Body condition score (BCS) of does during different reproductive stages

The body condition score **(**BCS) of Mahabubnagar local does during reproductive stages in different systems of rearing is presented in Table 5 and Fig 3. The mean BCS of does was 2.97±0.03, 2.47±0.03 and 2.33±0.06 in G1, G2 and G3 groups, respectively at the time of breeding. The significant (P<0.05) difference was observed in the BCS of does at the time of breeding between G1 and G2 groups, whereas, the G2 group was differed non significantly (p<0.05) with G3 group.

The BCS of does in the 1st, 2nd, 3rd, 4th and 5th months of pregnancy were 3.00±0.00, 3.27±0.06, 3.41±0.05, 3.47±0.03 and 3.65±0.06 in the G1 group, respectively and corresponding values in G2 group were 2.50±0.00, 2.65±0.06, 2.82±0.06, 2.94±0.04,and 3.03±0.03, respectively. The BCS of the does in G3 group, from the 1st month of pregnancy (2.33±0.06) was linearly increased up to t he 5thmonth (2.78±0.06) of pregnancy. BCS of G2 group does during pregnancy had non significant (p<0.05)difference with BCS of G3 group does. The average BCS of does during pregnancy in G1group had significant (p<0.05) difference with G2 and G3 group. The total gain of the BCS during pregnancy period in the G1, G2, and G3 groups were 0.65±0.07, 0.53±0.07and 0.45±0.12 respectively. The BCS gain in G1group was comparable with the G2 group during pregnancy and G1 group significantly (P<0.05) differ with the G3 group.

The mean BCS of does at the time of breeding in the G1 group was significantly (P<0.05) higher than G2 and G3, whereas the mean BCS of the G2 and G3 groups were comparable. Higher BCS at the time of breeding in the supplemented group than in the non-supplemented group was reported by Thomas *et al.* (1987) and Berhanu *et al.* (2013). Maurya *et al.* (2009) [38], Sejian *et al.* (2010) [53], Aliyari *et al.* (2012) [4] and Vatankhah *et al.* (2012) [62] recommended maintaining of BCS at 3 to 3.5 during breeding to optimize profitability in the breeds of their study. Furthermore, recommendation to maintain the BCS in a moderate condition (2.5 or 3) at breeding to optimize the profitability of flocks by Abdel-Mageed (2009) [2] and Yilmaz *et al.* (2011) [64].

Based on the results of several researchers, the BCS of the Mahabubnagar local goats at breeding was targeted at 2.5-3.0. In the present study, G1 and G2 groups had reached targeted BCS at breeding, which contributed to higher conception rate, kidding percentage, and higher birth, and weaning body weight of kids. Due to lower BCS than the targeted mean BCS in the G3 group at breeding the reproductive efficiency was lower than that of the G1 and G2 groups. This might be due to a reduction in production of GnRH in the undernourished animals in the present study. This in turn affects the pre-ovulatory LH surge, fertilization, and early embryonic development.

The gain in BCS during pregnancy in the G1, G2, and G3 groups was 0.65±0.06, 0.53±0.06, and 0.45±0.11, respectively. Alvarez *et al.* (2012) reported that BCS gains from the 1st to 4th month of pregnancy were greater with BCS <3.0 and 3.0 than in >3.0 at the time of breeding.

In the present study, the G3 group had higher prenatal mortality than G1 and G2 groups. Caldeira *et al.* (2007) [9], and - *et al.* (1992), reported that the lowest prenatal mortality for the higher BCS range of 2.5-3.0. It indicated the importance of BCS about gestation from a profitable point of view in terms of the kid crop. Further, Kenyon *et al.* (2007) [26] opined that a low BCS during gestation would be a high risk in mid to late gestation and can reduce fetal growth and birth weight. Hasan *et al.* (2015) and Mourand *et al.* (2000) [43] reported that as the fertility rate increases, the abortion rate decreases with the increase of age.

This was proved in the present study that, G1 (13.54 kg vs 3.34 BCS) group kids had significantly (P<0.05) higher weaning weight than G2 (11.94 vs 2.78 BCS) and G3 (10.82 vs 2.52) group. Whereas, Melesse *et al.* (2013) [39] and Moeini *et al.* (2014) reported that flushingis beneficial for improving body condition score and reproductive efficiency in does under poor body conditions. The finding of the present st udy coincided with the studies of Msalya *et al.* (2017) [44] and Pathan *et al.* (2018) [50]. This indicates that the higher BCS have higher weaning and pregnancy rate.

Based on the literature and the results of the present study, the BCS of the Mahbubnagar local goats was targeted at 2.5-3.0 during early to mid-pregnancy and 3.0-3.5 in the last trimester of pregnancy. In the G3 group, the lower birth and weaning weight of kids might be due to lower BCS during breeding and pregnancy.

Body condition score (BCS) of does during lactation period

The BCS of Mahabubnagar local does during the lactation period in different systems of rearing is presented in Table 6 and Fig 3. The mean BCS of does at 48 hrs after kidding was higher in the G1 (3.00±0.00) group followed by the G2 (2.75±0.07) and G3 (2.38±0.07) group. Statistical analysis of the data revealed that, the BCS of the does at 48 hrs after kidding in the G1 group was non- significantly (P<0.05) differ with the G2 group whereas, significant (P<0.05) difference was observed with G3 group. The BCS of the does had linear decrease in all the groups from kidding to weaning. Further significant (P<0.05) effect was observed among the group G1, G2, and G3 from 4th to 12th week of lactation, but in 2nd week G1 group significantly differ with G2 and G3 groups, while G2 and G3 groups were non-significant (P<0.05).

The overall mean BCS of does during the lactation period in the G1, G2 and G3 group was 2.72±0.06, 2.28±0.04,and 1.91±0.07, respectively. The G1 group had significant (p<0.05) difference with G2 and G3 group, while G2 group significantly (p<0.05) differ with G3 group does in mean BCS during lactation period. The does during lactation period had lost BCS at rate 0.30±0.01, 0.62±0.06 and 0.76±0.05 in G1, G2, and G3 groups, respectively. Statistical analysis of the data revealed, that G1group had significant (p<0.05) difference in the loss of BCS with G2 and G3 group, whereas G2 group had non- significant (p<0.05) difference with G3 groups.

The mean BCS of does in the G1 group was higher than G2 and G3 groups immediately after kidding. The mean BCS of

the does at the 12th week of postpartum was 2.70±0.07, 1.96±0.06, and 1.58±0.06, respectively in the G1, G2, and G3 groups.

The loss of mean BCS in does of the G1, G2 and G3 group from kidding to 12th week of lactation was - 0.30±0.01, - 0.62±0.08, and - 0.76±0.07, respectively. Omar *et al.* (2019) reported a loss of BCS (-0.12 to -0.4) in different concentrate and roughage rations offered to doe from the day of kidding to the 8th week of lactation. The loss in the body condition in all groups could be attributed to the loss of body reserves through colostrum and milk feeding for the kids until weaning. The trends observed in post-parturient BCS loss indicated that the doe flocks that had higher BCS during pregnancy had a minimal loss in BCS after parturition.

The ideal BCS at the time of kidding was 3.0 - 3.5 and should not be less than BCS 2.0 after 12th weeks of lactation or at the time of weaning. In comparison, G2 and G3 groups showed significant declines in BCS at postpartum, which was less than 2.0 at the 12th week of lactation. It could be due to insufficient forage and feed for compensating the losses due to parturition and milk drain after parturition. The studies of Khalil *et al.* (2013) [27] and Msalya *et al.* (2017) [44] are in agreement with the present studies.

From the present study, it was observed that does with good BCS have subsequently lost their condition when rearing their kids, suggesting that their kids had been fed with the energy reserves which they had gained before kidding. In addition, using BCS as a method to identify does with low BCS at kidding time will preferentially help feed them properly to take care and during kid rearing, which is likely to be advantageous and increase the growth of kids.

Correlation coefficient of BCS with body weights and body measurements

The correlation coefficient (R^2) of body weight with pin shoulder-length, height at withers, heart girth, paunch girth, and BCS in the Mahabubnagar local does reared in the different system were -0.29, 0.12, 0.75, 0.74 and 0.79 respectively. There was a positive and highly significant correlation between body weight, heart girth and paunch girth but there was a negative correlation with pin shoulder length. Similarly, significantly (p<0.05) higher coefficient of determination was found between body weight and BCS compared to other body measurements.

The correlation (R^2) coefficient between BCS with body meas urements indicated that BCS had a highly significant relationship with body weight (0.792) followed by heart girth (0.752) and paunch girth (0.740). A positive correlation between BCS and body weight was also supported by Sezenler *et al.* (2011) [54] and Anusha (2016) [5]. Whereas, a linear association between BCS and heart girth was observed by Maurya *et al.* (2004) which was in coincided with present studies. The does with higher heart girth measure ments and higher BCS indicate the appropriate utility of the BCS method to identify healthy animals since more heart girth is an indicator of animal health and better performance.

Table 1: Reproductive performance of Mahabubnagar local doe kids in different systems of rearing

S. No	Parameter	G1	G2	G3
1	Age of Puberty (days)	321.75±2.58^{a}	356.80±1.40^{b}	380.00±1.64^{bc}
2	Body weight at Puberty (kg)	27.05±0.35^{a}	25.15±0.30^{b}	24.30±0.36^{b}
3	Age at first service (days)	344.05±1.43^{a}	377.10±1.09^{b}	396.60±1.34^{c}
4	Bodyweight at first service kg)	28.55±0.41^{a}	26.35±0.31^{b}	25.05±0.21^{bc}
5	BCS at puberty	2.97±0.03	2.47±0.03	2.33±0.06
6	BCS at first service	2.97±0.03	2.47±0.03	2.33±0.06
7	Gestation period	150.05±0.05	149.55±0.20	149.65±0.11

$^{a\,b\,c}$ Means with different superscripts row-wise differ significantly at (P<0.05) in Duncan multiple comparisons post-hoc test G1: Intensive system, G2: Semi-intensive system, G3: Extensive system

Table 2: Reproductive performance of Mahabubnagar local doe kids in different systems of rearing

S. No	Parameter	G1 (N=20)	G2 (N=20)	G3 (N=20)
1	Serving rate	17 (85.00)	17 (85.00)	18 (90.00)
2	Conception rate	15 (75.00)	15 (75.00)	14 (70.00)
3	Kidding percentage	14 (70.00)	14 (70.00)	12 (60.000
4	Twinning percentage	0 (0.00)	0 (0.00)	0 (0.00)
5	Abortion percentage	1 (5.00)	0 (0.00)	0 (0.00)
6	Still birth percentage	0 (0.00)	1 (5.00)	2 (10.00)

The Figures in parenthesis indicate the percentage G1: Intensive system, G2: Semi-Intensive system, G3: Extensive system.

Table 3: Bodyweight (kg) of Mahabubnagar local does during reproductive stages in different systems of rearing

S. No	Group	At the time of breeding	During Pregnancy					Overall Mean body weight
			1st month	2nd month	3rd month	4th month	5th month	
1	G1	28.33±0.05^{a}	28.88±0.05^{a}	29.51±0.05^{a}	30.33±0.05^{a}	31.13±0.05^{a}	31.82±0.05^{a}	30.33±0.05^{a}
2	G2	26.41±0.07^{b}	26.80±0.07^{b}	27.54±0.07^{b}	28.24±0.07^{b}	29.06±0.07^{b}	30.13±0.07^{b}	28.35±0.07^{b}
3	G3	26.23±0.03^{bc}	26.46±0.02^{bc}	26.78±0.03^{bc}	27.61±0.08^{bc}	28.17±0.08^{bc}	28.52±0.08^{c}	27.51±0.05^{bc}

Means within a column having different superscripts differ significantly (P<0.05) in Duncan multiple comparisons post-hoc test G1: Intensive system,G2: Semi-intensive system,G3: Extensive system

Table 4: Bodyweight (kg) of Mahabubnagar local does during the lactation period in different systems of rearing

S. No	Group	During Lactation							Overall Mean body weight
		48 hrs after kidding	2nd week	4th week	6th week	8th week	10th week	12th week	
1	G1	28.48±0.02^{a}	27.96±0.06^{a}	27.54±0.07^{a}	27.66±0.07^{a}	27.85±0.07^{a}	28.06±0.07^{a}	28.25±0.07^{a}	27.89±0.06^{a}
2	G2	26.74±0.01^{b}	26.21±0.02^{b}	25.84±0.02^{b}	25.56±0.02^{b}	25.33±0.02^{b}	25.04±0.02^{b}	24.67±0.02^{b}	25.44±0.02^{b}
3	G3	25.49±0.02^{c}	24.95±0.01^{c}	24.56±0.03^{c}	24.18±0.03^{c}	23.73±0.05^{c}	23.53±0.05^{c}	23.38±0.05^{c}	24.06±0.03^{c}

Means within a column having different superscripts differ significantly (p<0.05) in Duncan multiple comparisons post-hoc test
G1: Intensive system, G2: Semi-intensive system, G3: Extensive system

Table 5: Body condition score of Mahabubnagar local does during reproductive stages in different systems of rearing

S. No	Group	At the time of breeding	During Pregnancy					Overall mean BCS in pregnancy	Mean gain/loss of BCS
			1st month	2nd month	3rd month	4th month	5th month		
1	G1	2.97±0.03^{a}	3.00±0.00^{a}	3.27±0.06^{a}	3.41±0.05^{a}	3.47±0.03^{a}	3.65±0.06^{a}	3.36±0.11^{a}	0.65±0.07^{a}
2	G2	2.47±0.03^{b}	2.50±0.00^{b}	2.65±0.06^{b}	2.82±0.06^{b}	2.94±0.04^{b}	3.03±0.03^{b}	2.78±0.12^{b}	0.53±0.07^{ab}
3	G3	2.33±0.06^{bc}	2.33±0.06^{bc}	2.42±0.05^{bc}	2.61±0.05^{bc}	2.78±0.06^{bc}	2.78±0.06^{bc}	2.58±0.11b^{bc}	0.45±0.12^{b}

Means within a column having different superscripts differ significantly(p<0.05) in Duncan multiple comparisons post-hoc test
G1: Intensive system, G2: Semi-intensive system, G3: Extensive system

Table 6: Body condition score of Mahabubnagar local does during the lactation period in different systems of rearing

S. No	Group	After kidding							Average BCS	Mean gain/ loss in BCS
		48 hrs after kidding	2ndweek	4th week	6th week	8th week	10th week	12th week		
1	G1	3.00±0.00^{a}	2.97±0.03^{a}	2.67±0.06^{a}	2.60±0.05^{a}	2.53±0.03^{a}	2.63±0.06^{a}	2.70±0.07^{a}	2.72±0.06^{a}	-0.30±0.01^{a}
2	G2	2.75±0.07^{a}	2.54±0.04^{b}	2.43±0.07^{b}	2.25±0.07^{b}	2.14±0.06^{b}	1.93±0.05^{b}	1.96±0.06^{b}	2.28±0.04^{b}	-0.62±0.06^{b}
3	G3	2.38±0.07^{b}	2.29±0.07^{bc}	2.00±0.00^{c}	1.83±0.07^{c}	1.71±0.07^{c}	1.63±0.07^{c}	1.58±0.06^{c}	1.91±0.07^{c}	0.76±0.05^{bc}

$^{a, b, c}$ means with different superscripts column-wise differ significantly at (p<0.05) in Duncan multiple comparisons post-hoc test
G1: Intensive system, G2: Semi-intensive system, G3: Extensive system

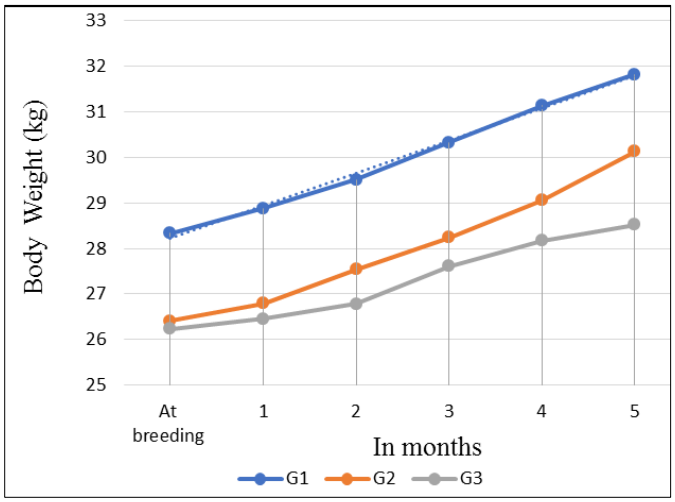

Fig 1: Bodyweight (kg) of Mahabubnagar local does during reproductive stages in different systems of rearing

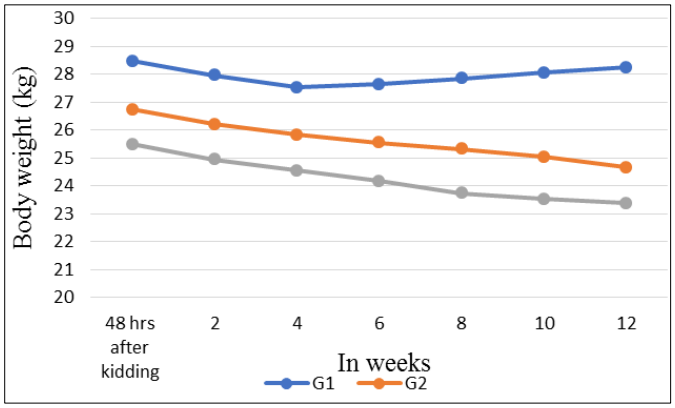

Fig 2: Bodyweight (kg) of Mahabubnagar local does during the lactation period in different systems of rearing

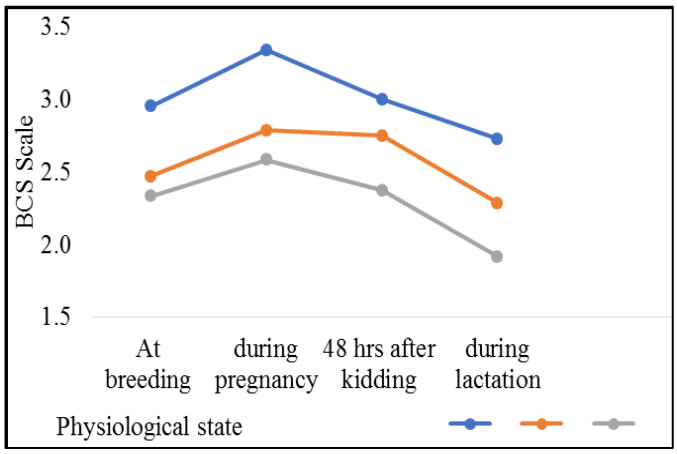

Fig 3: BCS of Mahabubnagar local does in different physiological stages in different systems of rearing

Conclusion

By using BCS method it will be possible to identify does with low body condition scores at the time of breeding, kidding and lactations. BCS indicates significance of extra allowance concentrate feeding to maintaining BCS of 2.5-3.0 at the time of breeding, 3.0 at early and mid-gestation, 3.5 at the time kidding and 2.5 at the time of weaning of kids for optimum growth and productions.

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Declaration of Conflicting Interests

The authors have no conflict of interest to declare.

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