ABSTRACT

Goat husbandry has been supporting the livelihood of over 100 million families living in arid and semi-arid regions of Asia and Africa, but most of them have not been able to earn substantial income, due to poor goat husbandry practices. Key factors influencing goat productivity have been - better management of pregnant does, high weight of kids at birth and acceleration of weight gain during pre-weaning period, apart from general factors such as goat breed, efficient breeding service, health care and marketing. This paper has identified various factors contributing to poor status of goats owned by small goat keepers and suggestions to improve the weight of kids at birth and the growth rate during pre-weaning and post weaning periods, through supplementary feeding and regular monitoring of weight. A suitable extension tool in the form of a Growth Monitoring Chart for different breeds can be developed, which goat keepers can readily use for taking suitable corrective measures. Goat keepers should also be advised on culling weak animals at an early age and replacing them with healthy animals to improve the production.

Keywords: Goat kids; pregnant does; weight gain; goat husbandry.
1. INTRODUCTION

Goat was the first livestock species to be domesticated about 10,000 years B.C. for milk production [1]. Since then, goat has been an animal of economic importance particularly for people living in arid, semiarid, hilly and remote tribal areas. Goat has the ability to withstand heat stress and water scarcity, survive with very little veterinary care, travel long distances in search of feed, graze on inferior quality pastures and thrive well, where cattle and sheep cannot survive [2]. It has a high rate of growth and the most prolific reproductive system with a short gestation period. It produces special quality milk which is consumed by people allergic to cow’s milk and provides supplementary income for marginalised rural families of Asia and Africa [3]. Goat husbandry is most suitable for reducing poverty and ensuring food security in the developing countries, because goats can be easily acquired by the poor, tended by women or children and they also provide valuable nutrients [4].

2. IMPORTANCE OF GOAT IN RURAL ECONOMY

It has been estimated that over 100 million poor families in Asia and Africa have been maintaining goats for supplementing their livelihood and the demand for goats has been steadily increasing during the last six decades. The world goat population was 348.727 million in 1961, which increased to 1045.916 million in 2018, resulting in 200% rise over 60 years [5]. Out of the total, 94.36 per cent goats were located in Asia and Africa. The population increase in Africa and Asia over six decades was by 364.81 percent and 176.65 per cent respectively. Goat accounts for over 95.70% of the total goat population in Africa [5].

A large majority of the goat keepers have been maintaining 1-3 does in Asia and depending on the yield, they have been collecting some milk for home consumption. Generally, male kids were sold after 5 to 12 months and female kids were retained as future breeding stock. As they were dependent on grazing on common lands, there was some income without any investment. Often, these goats served as emergency cash reserves, to meet urgent needs such as medical treatment, education of children, procurement of agricultural inputs, etc. Thus, in spite of prejudice due to environmental issues and lack of support from the Government for development, goat population has been growing at a faster rate compared to other livestock species [6]. However, most of the families dependent on goat husbandry have not been successful in enhancing goat productivity and income, because of various constraints faced by them.

3. CHALLENGES IN IMPROVING PRODUCTIVITY OF SMALL GOAT FLOCKS

The major problems faced by goat keepers in the northern states of India were lack of breeding services, poor veterinary services, scarcity of feed resources and poor marketing facilities [6]. This resulted in heavy genetic erosion and in-breeding, shortage of fodder leading to long grazing hours, neglect of pregnant does and high incidences of diseases, ailments and parasites, culminating in high mortality and morbidity. Goat farmers in several countries of Asia, were faced with challenges, such as shortage of high producing goats, lack of good quality feed during long dry seasons, poor veterinary care and difficulty in taking the produce to the market [7]. Low productivity of small goat flock owners in Ethiopia and India were mainly due to low growth rate and high mortality, particularly of kids [8]. Low weight of does, indiscriminate breeding by stray bucks, low birth weight of kids, poor nutrition, high incidences of diseases and high mortality, were the chain reactions caused by poor husbandry practices.

4. GOAT KID MORTALITY: MAJOR CHALLENGE

Goat kid mortality ranged from 12 to 35 percent, depending on the management of the flock [9, 10]. In Bangladesh, kid mortality of Black Bengal goats was 28-30 per cent, caused by low weight at birth and infectious diseases such as diarrhoea (30%), pneumonia (27%), bloat (23%) and enterotoxaemia (17%). Other studies have observed that the major diseases causing kid mortality were pneumonia and enteritis. The mortality was over 60 per cent in kids weighing less than 0.8 kg at birth, which decreased with the increase in weight at birth [11]. Mortality was higher with lower birth weight, as these kids were susceptible to environmental hazards. In semiarid region of Sudan, kid mortality of Sudanese Nubian goats due to aborted foetuses was 21.2 per cent and pre-weaning kid mortality rate was 15.2 per cent. Pre-weaning mortality rate for kids
was highest at 72 per cent in the first month [10]. In South Africa, major causes of kid mortality were tick-borne gall sickness diseases, endoparasites and ecto-parasites [12]. In another study, pre-weaning mortality rate of Angora kids was 11.5 per cent, caused by predators (39%), weak kids which needed help with suckling (19%), does having no milk (7%) and does abandoning their kids (7%). Birth weight and sex of the kid had a significant influence on pre-weaning mortality rate. Single-born kids had the lowest mortality rate as compared to twins and triplets [13]. The adult mortality in Black Bengal goats was 12–15 per cent, caused by Enterotoxaemia (63.6%), Diarrhoea (6.1%) and Dystocia (9.1%) [11]. In India, PPR disease was a major cause of death in many states in the past and with intensive vaccination programme during the last 10-15 years, the mortality has come down significantly [6]. Apart from diseases, poor nutrition also contributed to high mortality, particularly in kids.

The major reasons for abortion of pregnant goats in Sudan were poor body weight of does, lack of exercise and infection of certain diseases [10]. In Kashmir, sporadic abortion loss in goats was only 1-2 per cent. However, the abortion rate could increase to 10-20 per cent due to bacterial diseases caused by Chlamydia psittaci and Coxiella burnetii [14]. In California, the most common causes of abortions were Chlamydia psittaci and Coxiella burnetii, while abortions caused by virus, fungus and protozoa were insignificant [15]. Many studies have confirmed high mortality of kids, caused by poor management of does, resulting inabortion and birth of weak kids. Low weight at birth, poor feeding and lack of health care of kids have been the major causes of economic losses in goat husbandry.

Many of the development programmes supporting small goat keepers have been ignoring these problems and instead, focusing on providing better breeding facilities and management of adult goats. It was evident that short term development projects had limitation of time to address the issues of production of healthy kids and improvement of native breeds, while goat keepers owning small number of goats were extremely reluctant to take up rigorous culling of inferior stock, which prevented them from replacing these animals with superior animals (personal field observations while interacting with goat keepers). It is difficult to promote sustainable goat development and generate substantial income, without addressing the challenges of producing healthy kids and improving local breeds. Therefore, the present review was undertaken to study various factors and field practices affecting the weight of goat kids at birth, kid mortality and kid weight gain, and impact of the weight of kids at pre-weaning and post weaning stages on the productivity of goats. Based on the problems encountered by small goat keepers, suitable recommendations have also been made to improve the growth of kids.

5. GOAT KID DEVELOPMENT

To reduce mortality of goat kids and adults, and to promote good growth, it is necessary to ensure the birth of healthy kids, with good body weight at birth. Kid weight at birth has been influenced by sex, type of birth, season of birth, maternal age and weight [16]. A study in Mexico [17] reported that apart from sex, breed, type of kidding and dam’s age, the season and year of kidding also had some influence on the weight of newborn goat kids. Birth weight of the kid also increased as age of the dam increased, up to 4 years, reflecting the increase in birth weight of kid with doe parity. Kids born in winter had lower birth weight as compared to those born in spring. A similar observation on Tellicherry goats confirmed that availability of fodder for does during pregnancy, resulted in higher birth weight of kids. The difference between male and female kids increased from 0.21 kg at birth to 1.42 kg at 12 months of age. Most of the environmental factors such as period, parity, season, type of birth and sex of the kid had significant effect on body weight at different ages [18]. The maximum growth was during pre-weaning stage, mainly due to supplementary feeding and other factors such as kidding season and type of birth while parity had a minor impact. As compared to the kids grown on research farms and organised flocks, kids born to the does owned by village goat keepers were in a very poor condition because most of them generally did not carry out supplementary feeding, vaccination, deworming of pregnant does, sanitary measures and control of endo-parasites after kidding [6].

It was observed that does who were heavier at kidding, produced heavier kids at birth than lighter does and also provided better maternal environment for the fetal growth. In Tamil Nadu, pregnant does weighing below 20 kg, produced kids weighing 1.70 kg, while does weighing 21-30 kg and 31-40 kg, produced kids weighing 2.00
The weight of kids at birth had an influence on the growth and on the daily weight gain until weaning. In Tamil Nadu, kids of local nondescript breed weighing less than 1.5 kg at birth, attained 21.17 kg weight in 196 days, with an average daily weight gain of 104 gm. Kids weighing between 1.5 kg and 2.49 kg, gained 22.17 kg in 192 days (110 gm/day), while kids weighing between 2.5 kg and 3.49 kg, gained 24.06 kg in 183 days (121 gm/day) [19]. A study on Sirohi goat kids, confirmed the impact of various factors on the birth weight of kids, which in turn had an influence on the growth during pre-weaning and post weaning periods. The differences in the weight of male and female and single and twin kids were significant from birth to 12 months age. Variation in the weight of kids born in different seasons became insignificant during the post weaning period. Kids allowed to graze on well-maintained pastures performed better than stall fed kids [20]. A similar study undertaken in Trinidad, West Indies on four breeds of goats, namely Anglo-Nubian, Saanen, Toggenberg and Alpine, over a five year period, confirmed that the breed, type of birth, sex and year of birth have significant impact on the birth weight of a kid. The influence on weight gain continued till the 12 week weaning period. However, the influence of the type of birth was not significant on the weight gain at 12-weeks of age [23]. It was clear from these studies that birth weight is the major economic indicator, which has a positive correlation with further growth. Pre-weaning performance of kids provided a stage to perform better in post-weaning phase. Hence, preparing the does to deliver healthy and heavy kids is an important practice for successful goat development.

Birth weight of goat kids and adult goats is also a genetic characteristic, which varies among different breeds. The average body weight of important Indian goat breeds at birth, up to 12 months and at adult stage, presented in Table 1 [24]. Selection pressure on different production characteristics has resulted in the development of different types of goats for different purposes. Sirohi, Beetal, Jamnapari and Osmanabadi, were heavy breeds and hence, the weight of kids was high. Information on average weight of the kids of different breeds at different ages will be helpful for goat keepers to monitor the weight of their goats and take up suitable corrective measures at various ages.

6. GOOD PRACTICES FOR PROMOTING GOAT PRODUCTIVITY

The most significant means of manipulating growth and development in goats include genetic selection, good care of pregnant does, preventive vaccination and deworming of kids, castration of male kids and intensive feeding. The following good practices have been recommended [25]:

Breed and Female Goat Selection: Considering the breed preference for goat keepers, various good practices should be introduced to improve the productivity. This should start with selection of good breeding stock, particularly of the female kid or the doe. Essential considerations for selection of a female goat are body weight above the breed average, good phenotypic breed characters, free from genetic and physical deformities, ailments and diseases and preferably born to a twin or a triplet. In many regions, meat consumers prefer local breeds instead of newly introduced breeds or cross bred goats. Hence, demand for particular breeds in the local market is an important consideration, till the time well organised meat processing facility and outside markets are developed.
Table 1. Body weight of goat kids of different Indian breeds

<table>
<thead>
<tr>
<th>Breed</th>
<th>At Birth</th>
<th>3 Months</th>
<th>6 Months</th>
<th>9 Months</th>
<th>12 Months</th>
<th>Adult Male</th>
<th>Adult Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sirohi</td>
<td>2.82</td>
<td>9.92</td>
<td>13.48</td>
<td>16.95</td>
<td>21.27</td>
<td>50.37</td>
<td>30.00</td>
</tr>
<tr>
<td>Marwadi</td>
<td>2.29</td>
<td>6.00</td>
<td>8.70</td>
<td>13.70</td>
<td>16.28</td>
<td>33.18</td>
<td>25.85</td>
</tr>
<tr>
<td>Beetal</td>
<td>2.80</td>
<td>9.26</td>
<td>12.18</td>
<td>15.42</td>
<td>21.83</td>
<td>59.07</td>
<td>34.97</td>
</tr>
<tr>
<td>Barbari</td>
<td>1.74</td>
<td>6.66</td>
<td>7.80</td>
<td>12.57</td>
<td>14.52</td>
<td>37.85</td>
<td>22.56</td>
</tr>
<tr>
<td>Jamnapari</td>
<td>3.00</td>
<td>12.11</td>
<td>15.56</td>
<td>24.00</td>
<td>29.65</td>
<td>44.66</td>
<td>38.03</td>
</tr>
<tr>
<td>Osmanabadi</td>
<td>2.39</td>
<td>7.34</td>
<td>11.07</td>
<td>15.12</td>
<td>-</td>
<td>33.66</td>
<td>32.36</td>
</tr>
<tr>
<td>Sangamneri</td>
<td>1.86</td>
<td>7.03</td>
<td>10.06</td>
<td>13.44</td>
<td>17.33</td>
<td>38.37</td>
<td>28.97</td>
</tr>
<tr>
<td>Malbari</td>
<td>1.63</td>
<td>5.76</td>
<td>8.73</td>
<td>11.41</td>
<td>14.12</td>
<td>38.96</td>
<td>31.12</td>
</tr>
<tr>
<td>Ganjam</td>
<td>2.31</td>
<td>-</td>
<td>9.52</td>
<td>-</td>
<td>11.69</td>
<td>44.05</td>
<td>31.87</td>
</tr>
<tr>
<td>Black Bengal</td>
<td>1.37</td>
<td>6.01</td>
<td>7.45</td>
<td>8.80</td>
<td>12.60</td>
<td>32.37</td>
<td>20.38</td>
</tr>
<tr>
<td>Chegu</td>
<td>2.10</td>
<td>8.41</td>
<td>12.17</td>
<td>14.75</td>
<td>18.46</td>
<td>39.42</td>
<td>25.71</td>
</tr>
<tr>
<td>Changthangi</td>
<td>2.18</td>
<td>7.76</td>
<td>9.18</td>
<td>11.80</td>
<td>20.37</td>
<td>30.00</td>
<td>19.75</td>
</tr>
</tbody>
</table>

Source: Acharya [24]

Breeding of does through artificial insemination (AI), by using semen of elite buck, is preferable. If insemination service is not available, service of a selected breeding buck, free from disease, may be availed. In case of AI, it is necessary to keep a watch on the doe after 21 days, for heat symptoms, and carry out repeat insemination, if needed.

Preventive Health Care: While buying breeding stock, selected goats should be tested against various diseases such as Brucellosis and Johne’s disease (JD) preferably before bringing them home. Goats which are positive for any of these diseases, must be culled immediately to prevent the spread of diseases to other animals. Depending on the prevalence of diseases in different countries, preventive vaccinations preferably against Peste des Petits Ruminant (PPR), Hemorrhagic Septicemia (HS), Enterotoxaemia and Foot and Mouth Disease (FMD) should be carried out regularly. Periodic deworming based on fecal examination and treating for ecto-parasites are also essential.

Feeding of Pregnant Does and Care after Kidding: Different management systems have been adopted in different regions for feeding goats. A majority of goat keepers in India let out their goats for 3-5 hours and some of them provide supplementary feed in the form of green fodder and a small quantity of concentrate. With regard to pregnant goats, it is essential to provide additional feed along with supplementation of macro and micro nutrients to improve growth and development. As pregnant does attain 60-80 per cent of the fetus growth during the last one month, they should be allowed to graze on good quality pasture 4-5 hours/day, supplemented with 7 kg green fodder and 250–350 gm concentrate mixture. Before kidding and immediately after kidding, the doe should be fed good quality green and dry fodder, with plenty of clean, cool water to provide comfort. Soon after kidding, the doe must be given lukewarm water and after 5-6 hours of kidding, concentrate can be provided which can be increased from the next day. The ration should be divided into 5-6 parts to feed throughout the day. The ration during the first few days should include bulky and laxative feedstuffs and a mixture of wheat bran and barley or oats or maize at 1:1 ratio, is better [25]. Goat keepers must aim at shifting from extensive grazing on community lands to stall feeding with limited grazing on private lands, to transform goat husbandry into a sustainable and prosperous enterprise.

Most of the goat keepers were aware of the need for supplementary feeding but did not practice it. Only 12-17 per cent goat keepers in northern India vaccinated their pregnant does and most of the goat keepers were unaware of the need for deworming of pregnant does and hence, none of them practiced it. These were the reasons for birth of poor quality kids, resulting in poor growth and low production of new progeny [26]. Thus, the goat development programmes should emphasise on the management of pregnant does and new born kids.

7. MANAGEMENT OF NEW BORN KIDS

It is advisable to promote the following practices [25]:

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1. Cutting of umbilical cord, immediately after birth and applying disinfectant such as tincture iodine, to prevent infection.
2. Providing clean, dry and draft-free housing.
3. Weighing of the kid on the day of birth and once a week to monitor growth.
4. Carrying out deworming based on fecal examination, a few weeks after the kids start browsing. Pot-belly and eating soil are symptoms of endo-parasitic infestation. Timely control of ecto-parasites should be undertaken whenever needed.
5. Vaccinations to be carried out as recommended, at the age of three months.
6. Tagging of the kid for identification is desirable.

**Weight gain of kids:** Rapid growth during early life can minimize the cost of rearing and increase the profit margin. As milk production in goat peaks within 2-3 weeks after parturition and then declines rapidly to a low level by 8-10 weeks after parturition, milk supply from the dam alone cannot ensure higher growth performance of kids. Thus, concentrate feeding has been recommended, especially when milk yield is low. The average daily weight gain of newly born goat kids during the pre-weaning period of 3 months has been in the range of 100 to 200 gm. Feeding of Thelassery male kids, with milk replacer in the pre weaning period of 30 days has been in the range of 100 to 200 gm. The average daily weight gain of newly born goat kids during the pre-weaning period of 3 months has been in the range of 100 to 200 gm. Feeding of Thelassery male kids, with milk replacer in the pre weaning period of 30 days has been in the range of 100 to 200 gm.

It has been estimated that 7.25 kcal ME and 0.284 gm CP were required per gram of weight gain by goats. Thus, required quantity of feed has to be provided partly through doe’s milk and the rest through creep feed to enhance pre-weaning growth of kids. Crude fibre appears to be a critical aspect in the normal growth and development of the digestive system [28]. Feeding milk replacer instead of feeding milk reduced the cost of feeding [29] and feeding creep feed was found to be more economical than milk replacer. Creep feed consists of crushed grains, and leaf meal of different fodder species can also be mixed with grains. Generally, kids of 3-4 weeks age, start nibbling, but they can be very selective, with preference shown for leguminous leaf meals, alfalfa in particular [30]. Leaf meals of Acacia, Sesbania, Leucaena and some species of Prosopis are also preferred.

**Creep feeding / Supplementary feeding:** As the highest growth rate of goats is during the first 3 months after birth, proper feeding of kids at pre-weaning stage is the key to successful goat husbandry. To ensure the supply of essential nutrients, goat keepers need to be educated to prepare creep feed at home by making use of locally available feed resources and leaf meal produced from leguminous forage. Creep feed can be given during the third week and increased gradually with other feeds as presented in Table 2.

From the 4th month to the 9th month, grower ration containing 16-18 per cent protein and 2600 K cal energy, should be fed at 100-200 gm, as per the weight of the kid and availability of green and dry forage. After 9 months and at advanced stage of pregnancy, finishing ration containing 12 per cent protein and 2300-2400 K cal energy, is recommended as supplementary feed [25].

**8. RECOMMENDATION FOR USE OF BODY WEIGHT MONITORING CHARTS**

Nutrition requirement for optimising the growth and production of goats has worked very well in many countries. However, there has been a wide gap between the researchers and small goat keepers, due to lack of awareness about creep feeding, inadequate attention paid to goat rearing and absence of resources. In many countries, poor goat keepers start focusing on feeding of kids, only after weaning, except in some families where children and women keep kids around the house like pets and feed them with green forage and leftover food. Thus, major

**Table 2. Feeding schedule for kids from birth to 90 days**

<table>
<thead>
<tr>
<th>Age of kids</th>
<th>Dam’s milk (ml)</th>
<th>Creep feed (gm)</th>
<th>Forage/green (gm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3 days</td>
<td>Colostrum-300 ml, 3 feedings</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4-14 days</td>
<td>350 ml, 3 feedings</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15-30 days</td>
<td>350 ml, 3 feedings</td>
<td>A little</td>
<td>A little</td>
</tr>
<tr>
<td>31-60 days</td>
<td>400 ml, 2 feedings</td>
<td>100-150</td>
<td>Free choice</td>
</tr>
<tr>
<td>61-90 days</td>
<td>200 ml, 2 feedings</td>
<td>200-250</td>
<td>Free choice</td>
</tr>
</tbody>
</table>

SOURCE: Deo and Hegde [25]
opportunity loss would have occurred before goat keepers could start thinking about feeding of kids. Making efforts to feed kids, only after weaning is too late to attain the expected weight gain. Hence, greater awareness should be created to feed pregnant does and new born kids properly, till weaning [6]. It is necessary to educate goat keepers to monitor the kid weight right from birth, at a regular interval of 2-4 weeks. The development organisations or the local extension officers can prepare a weight monitoring chart from birth of kid up to 3, 6, 9 and 12 months, based on the average birth weight of specific breed and other factors affecting the growth. A model chart is presented in Fig. 1 based on the data from Table 1, which can be modified to suit local conditions, for male and female kids. Goat keepers can weigh their kids regularly and compare with the expected weight in the chart. If weight of the kid is below average at birth or during later weeks, the goat keepers can take special care for feeding and health care, or sell these animals at the earliest. By culling the weaklings at an early age, the flock can be replaced with healthy kids. Such an initiative will sensitize goat keepers and encourage them to focus on productivity improvement which can result in higher income.

Thus, optimising the growth of goat kids at pre-weaning stage, will not only accelerate the growth of adult goats but also motivate goat keepers to develop suitable infrastructure for developing an efficient value chain. Healthy goats of recognised breeds can fetch higher price and ensure sustainable goat husbandry, without causing any burden on the ecosystem and bring prosperity to goat keepers. Greater awareness has to be created among goat keepers to take good care of pregnant does and new born kids, which can lead to higher growth and production.

9. CONCLUSION

Goat husbandry has been a source of livelihood and nutritional security for over 100 million families in Asia and Africa, who are mostly living in arid and semi-arid regions. However, as the productivity of these goats is poor, the tendency has been to increase the flock size, causing pressure on community pastures and biodiversity. Most of the goat keepers have been negligent about feeding and health care of pregnant does and new born kids, which have been the major reasons for low growth and production in the developing countries. Hence, priority should be given to introduction of good husbandry practices, through awareness and effective extension tools. Use of a weight monitoring chart for kids by goat keepers, can be very effective in monitoring the growth and culling weak animals. This can transform goat husbandry into a powerful tool for empowering the poor and women headed families in Asia and Africa.

COMPETING INTERESTS

Authors have declared that no competing interests exist.
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