Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(4): 286-290

Received: 28-05-2018
Accepted: 29-06-2018

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A methodological review on the feed restriction and refeeding in sheep

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Abstract
Feed restriction is becoming forceful nowadays owing to a shortage in green vegetation during off seasons. There are other incidences wherein the feed restriction is adopted during lean seasons and making the animals recouped thereafter. Feeding of those animals between the feed restriction and recoupment period is becoming a challenge for the livestock producers. The objective of this article is to bring the effects of feed restriction at variable levels and the rapid recovery made during re-alimentation process. The process of recoupment in body weight and other parameters after considerable period of feed restriction is called as compensatory growth. Compensatory growth is manifested by the ability of the animal to outgain their better counterparts when given good quality ad-libitum after a period of underfeeding. Compensatory growth is associated with an increased feed intake and increased efficiency of nutrient utilization and also with change in the body composition. The body maintenance energy requirements will be usually low during feed restriction and increases slowly to the new feeding regime that is practiced in re-alimentation. The digestibility of the nutrients will be affected and this will be higher during feed restriction as the feed is retained for more time in the rumen. Decreased maintenance cost increased feed intake and increased efficiency of growth and inherited genetic background along with the increased feedload have been assessed as the key mechanism in the phenomenon of compensatory growth. The visceral organs and liver in special is also affected by compensatory growth. It is concluded that feed restriction and re-alimentation has a considerable effect on serum biochemical parameters, carcass traits and growth performance, nutrient digestibility duly reducing the cost per kg gain and cost of production in sheep. A feed restriction upto 30% of the ad-libitum feeding can be taken up without affecting the performance of the animal.

Keywords: Compensatory growth, Re-alimentation, performance, carcass parameters, blood serum profile

1. Introduction

Globally, the livestock systems are reared mostly on grazing and are dependent unnatural vegetation of range and farm lands. Seasonal fluctuations make the pasture lands or natural vegetation either to deplete from the nutrients or may be fully loaded with [1]. In either way of the cases, the nutrients are either lost or retained. During this process, livestock will have over feeding or underfeeding based on seasonal variations. Both are detrimental to the production capacity. Another point at which the animals are over fed/ underfed is during stall feeding [2]. In general, all the animals that are reared intensively are fed as a group and not individually and the average nutrient requirements are taken into consideration which results in physiological homeostatic imbalance leading to metabolic stress [3].

Among the livestock used for economy, sheep are a source of meat, income, food security and for short term cash reserves. They are often termed as poor man's mobile bank in under Indian conditions [4]. Though they are several ways to raise the sheep viz- intensive, extensive and semi-intensive systems of rearing. During extensive system, seasonal fluctuations cause a frequent restriction both in terms of quality and quantity of nutrients [5]. The available grazing leads to not meet the nutrient requirements of the sheep and so the sheep have to face a situation called restricted feeding or underfeeding forcibly. Livestock subjected to a period of under feeding often exhibits a very high growth rate during subsequent re-feeding process [6].

The present review discusses the concept of feed restriction or compensatory growth and re-feeding or re-alimentation and their effect on the nutrient digestibility, performance, blood chemical parameters, carcass parameters in ruminants especially sheep in a methodological way.

2. Defining under feeding / feed restriction

The phenomenon of restricted feeding and again recoupment by the body tissues by a process of re-feeding is called Compensatory growth [7]. It was a practice by the West African countries to limit the feed intake to a level of maintenance of body requirements during lean seasons and feed the animals again *ad-libitum* to compensate for the growth loss [8]. A 40% restriction of *ad libitum* intake followed by re-feeding (re-alimentation) was practiced to induce compensatory growth (CG) to improve growth rate and produce leaner carcass meat in growing lambs [3].

Compensatory growth manifested is the ability of the animals previously restricted in the feed intake to out gain their better counter parts when given free access to good quality feed [5]. Many researchers have worked on this compensatory growth and have reported that there will be a change in the body composition during this restricted period and conflicting results have also been obtained. Some reports have indicated increase in body fat content [9, 10] and others have reported increase in the lean tissue of re-alimented animals [11, 12]. In other reports, body composition was not affected by a phase of feed restriction followed by re-alimentation phase [13]. Some contradictions could be due to different phases of restrictions and re-alimentation, different regimes of feed restriction, different animal physiologies and different breeds with different maturity age.

a. Conditions at which feed restriction can be implemented….

One of the possible strategies to reduce the cost of lamb production includes the imposition of feed restriction followed by compensatory growth [4]. Compensatory growth manifested is the ability of the animals previously restricted in the feed intake to outgain their better counter parts when given free access to good quality feed. Animals subjected to a period of under nutrition often exhibit a very high growth rate during subsequent re alimentation [14]. This phenomenon is called Compensatory growth. Others define compensatory growth may also be defined as a physiological process whereby an organism accelerates sometimes seen in animals following an extended period of slow growth or weight loss due to restricted nutrition. This is termed as a catch up programme by the body tissues that have lost the nutrients during feed restriction. This strategy has very important implication in tropical areas where the animals largely depend on grazing natural pasture to support animal production coupled with feed restrictions which occur due to seasonal variations in nutrient quality and quantity of available pasture materials [5]. It may not be mandate with animals that compensatory growth should be complete or partial or no growth because this catch up growth is a complex metabolic function and a number of mechanisms is involved. There are reports saying that compensatory growth may be influenced by genetic factor, age of the animals at which restriction was imposed, severity and duration of restriction, the quality of re-alimentation diet and duration of re-feeding [15, 16]. Restricted animals often compensate within the same period as their fellow animals which are unrestricted [11].

In tropical countries like India, scarcity of fodder resources occur in 6-7 months in a year resulting in standing hay and low quality feed that eventually culminates in the growth retardation of animals [17]. Compensatory growth may be associated with an increased feed intake [18], lower maintenance requirements brought about by feed restriction, an increased efficiency of nutrient utilization and changes in body composition. Maintenance energy requirements are usually measured by fasting heat production. Changes in body composition are estimated by slaughtering procedures or energy and nitrogen balances. The improved feed efficiency during compensatory growth is not so clearly measured. Similar to feed restriction there is another term called re-alimentation / re-feeding which is practiced after a considerable period of feed restriction / under feeding [7].

b. Research undertaken globally on Compensatory growth

Restricted feeding is one method which potentially improves the feed conversion efficiency and improves economy. Experimentation on beef cattle improved feed efficiency in growing and finishing beef cattle. The reason for an increased feed efficiency are attributed to an increased diet digestibility, reduced feed wastage with a lowered animal activity,decreased size of visceral organs during feed restricted which reduces the maintenance energy requirements for the organs during the feed restricted which reduces the maintenance energy requirements for these organs [19].

3. Growth performance

It was reported that implementing feed restriction during growing period and re-feeding ad libitum during re-alimentation (re-feeding) phase decreased the total dry matter intake and thus reduced the feeding costs in beef cattle. The process also affected the carcass quality by reducing the carcass fatness [2]. It was reported that energy intake during restriction phase resulted in lower weight gain as compared to the non-restricted feed fed animals. They also showed that the animals subjected to a 40% feed restriction recouped faster and showed improved FCR ($P<0.05$) in guzera formulas. Suryanarayana reported a decrease in average daily gain (ADG) and feed efficiency decreased as the level of restriction increased and the rate of gain in body weight was 20 and 43.8% faster for 75 and 60% restricted group, respectively, as compared to the group of animals fed *ad libitum* in a trial conducted with Forty Najdi ram lambs.

Suryanarayana and Siva Prasad conducted a trial with ninety-eight ewe lambs (14.9 kg ± 0.63) divided into four groups at random and were subjected to four feeding regimes to evaluate the effects of feed restriction on the body weight gain in a CRD model. The feed restriction was at four levels viz., 0, 20, 30 and 40 percent for T_1 (Control), T_2, T_3 and T_4 for the four groups, respectively. The duration of the trial was for 105 days containing preliminary (up to 18 kg) restriction (5 weeks) and re-alimentation (5 weeks) phases. The decrease is significantly ($P<0.05$) different among groups and the increase in weight gain for the first group was 6.54, 17.7 and 23.8 percent higher as compared to groups 2, 3 and 4, respectively, during feed restriction. The body weights recorded were significantly different ($P<0.05$) during re-alimentation phase. The increase in weight or compensatory growth for groups 2, 3 and 4 as compared to group 1 was in the order of 2 > 3 > 4 and it was 15. 6% and 13.4% higher for groups 4 and 3 as compared to group 2. It was concluded that the lambs can be fed with restriction up to 40% and the loss in weight can be recouped with the phenomenon of compensatory growth.

There are several reports saying that feed conversion ratio (FCR) was higher for maximum restricted groups resulted from a low level of feeding regime and there could be a probable reason in that the restricted feed restricted the energy

intake [2, 11]. It was demonstrated that the maintenance requirements [20] will be decreased during underfeeding. During feed restriction, the intake of nutrients will be decreased.

The point in discussing regarding the intake of nutrients in this context is that, a reduction in certain nutrient intake especially fiber results in a series of events in a cascade as less chewing by the animals, less buffering saliva secretion, a change in microbial population and a reduced acetate: propionate ratio and all these results in a decreased performance by the animals [2].

But during re-alimentation period it was reported that the animal continues to adjust to low feed ingestion [21]. The base energy metabolism continues to be low and increases slowly adjusting to the new feeding regime and so the utilization of energy and protein remains to be more efficient while the energy requirements for growth remains the same resulting in compensatory growth and weight gain of the feed restricted animals. The restricted energy intake during restriction phase resulted in lower weight gains as compared to the animals that were non-restricted. Re-alimentation permitted a return to normal weight gain [2].

Greater energy intake than necessary for maintenance caused a greater proportion of ingested energy to be available for growth and caused compensatory growth. Decreased maintenance cost, increased feed intake, increased efficiency of growth, genetic back ground and in some instances increased digesta load have been implicated as the key mechanisms in the compensatory growth phenomenon [22, 15, 23, 24, 25]

4. Nutrient digestibility

An experiment was conducted [26] in ninety six intact male sheep breeds of Sangasari and Afshari to assess the effects of restricted feeding on intake, digestion, nitrogen balance and metabolizable energy. It was concluded that sheep decrease their maintenance requirement as a result of feed restriction and further it was reported that the experimental conditions like length, severity of feed restriction, type of diet used and environmental conditions were more important than breed body size.A research work in ram lambs to assess the effect of different feed restriction regimen in the digestibility of various nutrients including cell wall constituents.They reported that the digestibility of CP increased with increasing level of feed restriction and similar in case with crude fibre digestibility.

It was reported by many workers that as the level of feed restriction increased the digestibility coefficients (%) increased for most of the nutrients [27]. The digestibility coefficient (%) of all nutrients showed an increasing trend as the feed restriction increased which could be due to a probable reason of more retention of the feed or low passage rate in the rumen, more enzymatic and in turn microbial action. When the feed is retained in the rumen for longer time, it facilitates the microbes to attach with the feed particles more efficiently. It was reported [28, 29] that dietary constituents have either positive or negative influence on the digestibility. Crude protein concentration has a positive effect on dry matter intake whereas fibre fractions of diets depressed dry matter intake of animals. Digestibility is dependent on dry matter intake (DMI). Since these two dietary nutrient factors are involved during restriction period, the digestibility coefficients (%) of all the nutrients showed an increased trend [6].

These factors contradict with the results obtained during re-alimentation phase. There is a positive relation between the digestibility of feeds and the intake. When the feeds are rapidly digested, the faster the digestive track is emptied and more space is available for the next meal. Some contradictions may be due to different restriction levels, different phases of restriction and re-alimentation and different breeds with different maturity ages [30].

5. Serum lipid profile

During restriction phase, as the level of restriction increased and the values of serum total proteins decreased mainly due to the decrease in globulin concentration [31]. It was reported that values of serum total protein were decreased ($P<0.05$) in sheep and goats due to restricted feeding, mainly due to a decrease in globulin levels of the feed restricted animals [31]. They also found that albumin increased insignificantly in sheep and remained almost same in goats.

It was reported that during feed restriction the cholesterol concentration is significantly influenced ($P<0.05$) by the percent of feed restriction. The cholesterol concentration was 15.3, 5.3 and 3.9 percent more for 10, 20 and 30 percent restricted animals as compared to the *ad libitum* fed animals. However, they found the maximum feed restricted group had higher ($P<0.05$) serum cholesterol and the remaining parameters like albumin, HDL, total protein, globulin showed a slow pick up. However, these conditions are based on severity and duration of restriction [2, 32].

6. Carcass parameters

Many workers reported the catch-up weight of fat deposits, visceral organs etc. during re-alimentation after a period of feed restriction [3, 12, 19, 33]

It was reported [19] that higher weight of the viscera especially liver for the maximum feed restricted group of animals could probably be due to the hypertrophy of the liver tissue upon re-alimentation after a phase of feed restriction [34] explained that the liver is the first organ to gain higher weights during re-alimentation as the energy was diverted mainly to replenish protein and glycogen reserves in the liver tissues. However, it is understood that the early maturing tissues have a priority to take up the limited nutrients from the blood stream and lose less weight during feed restriction and as suggested that [3] the general trend of tissue accretion indicates a different partioning priority of nutrient intake between carcass and non-carcass components of re-alimented lambs as indicated by an increase in weights and visceral fat.

It was reported by many workers that the early maturing parts (head, feet and visceral organs) have higher priority in usage of available nutrients in blood and are less effected than late maturing parts [23, 35].

In re-alimentation phase, the reactions were mostly due to the restriction responses of animals and the most affected organs with the greatest retardation, responded faster than those of less affected. These findings are supported by other reports [23, 35, 11]

7. Conclusion

In most of the sheep production system, lambs survive on the body reserves during feed shortage or feed restriction and replenish their body weights when adequate nutrition is restored by a process of compensatory growth. Many researchers say that that the sheep can be feed restricted upto 30% and this loss can be recouped with compensatory growth.

There are certain conditions where in the small ruminant rearing community should invariably go for feed restriction / under feeding. Annual and seasonal fluctuations of rain cause a periodic restriction in feed quality and quantity. Supplementary feeding could resolve natural feed restriction through conserved forages and concentrates. However, some results were found contradictory with those reported by other workers which may be related to the discrepancies of age, breed, and type of animals, length of recovery, severity and duration of restriction phase and along with the type of re-alimentation diet. It is directed that under the conditions of following economical measures and feed shortage, the feed restricted procedures can be better followed and could be upto a level of even 40% of the *adlibitum* feeding.

8. Acknowledgement

The authors acknowledge Sri Venkateswara Veterinary University officials to taking up some of the research works undertaken as mentioned in this review article.

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