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Breeds of sheep and goat and strategies to be followed in their selection for different production systems

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India possesses an enormous goat and sheep population which is the highest in South-East Asia. They are found throughout the length and breadth of the country. They do not look alike in body conformation and other characters. The differences among them are large as they have evolved under widely variable agro-ecological conditions in India. They show wide variation in phenotypic conformation, production parameters and other attributes. In the evolutionary time scale, groups of animal exhibited phenotypic and genetic coherence which is discernible from other groups. These groups were designated with different named for easy identification and communication and were called breeds. Thus, breed is defined as a group of animals with similar characteristics. A majority of sheep and goat population in our country do not conform to any breed characteristics and are designated as non-descript sheep and goat.

India is a rich repository of **goat genetic resources** with 24 well established breeds that have wide product diversity i.e. meat, milk and fiber (hair/pashmina). The breed habitat and utility of various goat breeds are given in table below:

Breed	**Habitat**	**Utility**
Sirohi	Semi-arid zone, Rajasthan	Meat and milk
Marwari	Semi-arid zone, Rajasthan	Meat and hair
Jakhrana	Semi-arid zone, Rajasthan	Milk and meat
Beetal	Semi-arid zone, Punjab	Milk and meat
Barbari	Semi-arid zone, Uttar Pradesh	Meat and milk
Jamunapari	Semi-arid zone, Uttar Pradesh	Milk and meat
Mehsana	Semi-arid zone, Gujarat	Milk and meat
Gohilwadi	Semi-arid zone, Gujarat	Milk and meat
Zalawadi	Semi-arid zone, Gujarat	Milk and meat

Kutchi	Semi-arid zone, Gujarat	Milk and meat
Surti	Semi-arid zone, Gujarat	Milk and meat
Sangamneri	Semi-arid zone, Maharashtra	Meat
Osmanabadi	Semi-arid zone, Maharashtra	Meat and milk
Kannai Adu	Sub-humid, Tamil Nadu	Meat
Malabari	Humid, Kerala	Milk and meat
Ganjam	Semi-arid, Orissa	Meat
Black Bengal	Humid zone, West Bengal	Meat and skin
Gaddi	Temperate, Himachal	Fibre and Meat
Changthangi	Temperate, Jammu & Kashmir	Pashmina and Meat
Chegu	Temperate, Himachal, Uttarakhand	Pashmina and Meat
Attapady	Kerala	Meat
Konkan Kanyal	Maharashtra	Meat
Berari	Maharashtra	Meat
Pantja	Uttarakhand and Uttar Pradesh	Milk, meat and hair

Goat breeds in major regional tracts

Our country can be considered into four regions with respect to distribution of goats, viz. North-Western and Central Arid/Semiarid region, Southern Peninsular region, Eastern region and Northern Temperate region.

North-Western Region: The climatic condition in this region is arid/ semiarid and comprises of Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Punjab and Haryana. The maximum numbers of goat breeds are found in this region. The breeds include Jamunapari, Barbari, Beetal, Jakhrana, Sirohi, Marwari, Kutchi, Mehsana, Zalawadi, Gohilwadi and Surti. Out of these, Jamunapari, Barbari, Jakhrana and Sirohi are found in Uttar Pradesh and are reared for milk and meat production.

Southern Peninsular Region: The climatic condition of this region is hot and humid in west coast and semi-arid in the central peninsula. The states of Tamil Nadu, Kerala, Karnataka,

Andhra Pradesh and Maharashtra belong to this region and include Osmanabadi, Sangamneri, Kannai Adu and Malabari goat breeds.

Eastern Region: This region comprises of Orissa, West Bengal, Bihar and north-east hilly states. The climatic condition is warm and humid in lower Gangetic basin, coastal plains and plateau regions while it is sub-temperate in hilly regions. The goat breeds found in this region are Black Bengal, Ganjam and Khasi (Assam hill goat). These breeds are mostly reared for meat purposes.

Jamunapari goat

Jakhrana goat

Barbari goat

Sirohi goat

Northern Temperate Region: Jammu and Kashmir, Himachal Pradesh and Uttarakhand states belong to this region and has extremely cold climate with heavy downpour in monsoon and moderate to heavy snowfall in winter. The goat breeds of this region are Chegu, Changthangi and Gaddi. The goats which produce precious pashmina fibers are found in the cold mountain deserts of this region.

Sheep play an important role in the rural agrarian economy as it provides gainful employment and income to a large number of rural poor especially backward, marginal and landless labourers. It

is perhaps the most appropriate species of livestock for utilization of available sparse vegetation and owing to their multi facet utility for wool, meat, skin, milk and manure which constitutes an important part of rural economy. Sheep is capable of converting the course roughages into valuable products meant for human use. Further, it has an important role to play in meeting the animal protein requirement for ever growing human population comparatively at lower cost. Indian sheep breeds have tremendous genetic potential for meat, wool, reproduction and adaptability, but due to non availability of required environment to the genotypes, these are unable to express fully in terms of productivity.

Sheep Genetic Resources

India ranks third in sheep population and account for 6.13 % of world population (FAO, 2009) with 71.56 million sheep to its record as of Livestock Census 2007 (DAHD, 2012). Out of 71.56 million sheep, 3.73 million is crossbred and 67.83 are indigenous. The distribution of sheep population in India is unequal in different states of the country. Andhra Pradesh ranks first in sheep population and alone possesses 25.5 million sheep (35.7%) of the country and followed by Rajasthan with 11.2 million (15.6%) and Karnataka with 9.5 million sheep (13.3%). Uttar Pradesh, being one of the largest states of the country, harbours 11.87 lakh sheep population and ranks 9th in the sheep population across the states. According to the FAO World Watch List (2000), there are 60 breeds of sheep in India. This list includes both well recognized and lesser known breeds along with some wild species, but details of 42 distinguished sheep breeds are available in the literature. These sheep breeds are well adapted to specific environment in specific agro-climatic region of the country. Out of 42 sheep breeds, 13 are found in North- Western region, 14 in Southern region, 8 in North- Temperate region and the rest 7 in Eastern region. Like this, highest sheep breeds are distributed in Southern region and most of them are mutton type with hairy coat, which is not generally shorn, or have very coarse fleece. The sheep breeds found in North-western region of the country are dual purpose i.e. wool and meat whereas breeds found in Southern and eastern region are meat type. Among all breeds, there are some breeds, which are famous for specific qualities like lustrous wool, soft wool, carpet wool, prolificacy and adaptation to harsh climatic conditions etc. Details of the sheep breeds classified on the basis of agro ecological regions *viz*. North temperate region, North Western arid and semi-arid region, Southern peninsular region and Eastern region are depicted below.

Breeds of Sheep in different Agro-Ecological regions in India and their major utility*

North Temperate	North-Western Arid and Semi Arid	Southern Peninsular	Eastern
Bhakarwal (CW)	Chokla (CW)	Bellary (MCW)	Balangir (MCW)
Changthangi (CW)	Jaisalmeri (MCW)	Coimbatore (MCW)	Bonpala (MCW)
Gaddi (CW)	Jalauni (MCW)	Daccani (M)	Chottanagpuri
Gurez (CW)	Kheri (MCW)	Hassan (M)	(MCW)
Karnah (AW)	Magra (CW)	Kanguri (M)	Ganjam (MCW)
Kashmir Merino(AW)	Malpura (MCW)	Kilakarsal (M)	Garole (MP)
Poonchi (CW)	Marwari (MCW)	Madras Red (M)	Tibetan (CW)
Rampur Bushair(CW)	Muzaffarnagari (MCW)	Mandya (M)	Kendrapara (MP)
	Nali (CW)	Mecheri (M)	
	Patanwadi (CW)	Nellore (M)	
	Pugal (MCW)	Nilgiri (AW)	
	Sonadi (MCW)	Rammand White (M)	
	Munjal(M)	Tiruchy Black (M)	
		Vembur (M)	

*Within parenthesis is the major utility of the breed: (AW) Apparel wool; (CW) Carpet wool; (MCW) Mutton and Carpet wool; (M) Mutton; (P) Prolificacy

Muzaffarnagari Sheep

Muzaffarnagari, the heaviest sheep breed of India, is primarily reared for mutton production. The home tract of the breed is in Muzaffarnagar and its adjoining districts of Western Uttar Pradesh namely Meerut, Bulandshahar, Saharanpur and Bijnor. Animals of this breed are also distributed in some of the parts of Delhi and Haryana states. Muzaffarnagari sheep in India is a rare genotype exhibiting very good adaptability and relatively higher prolificacy than other Indian sheep breeds. Muzaffarnagari is known for its faster growth rate and high feed conversion efficiency. But it produces less wool with inferior quality which is not suitable for carpet manufacture; hence efforts are being made at CIRG to improve this breed further for higher body weights through selective breeding.

Most of sheep breeds have low production potential since they were subjected to selection in the past for adaptability to the climatic stress and enzootic diseases, rather than improving the production potential. The low productivity of sheep is mainly attributed to poor exploitation of genetic potential of native stock, inadequate feed resources, nutritional deficiency, poor health monitoring, inadequate marketing and very low adoption of improved management practices. The actual potential of different sheep breeds is not yet known, as they have not been adequately evaluated in the optimum management conditions.

Selection Strategy

The ultimate objective of sheep and goat production is to maximize profit with available resources. Efficiency of selection of any productive system should always be considered under prevailing socio-economic, cultural conditions and utilization of local resources. In India, sheep and goats are reared by resource poor people on zero input, however, some resourceful farmers (10-20%) also maintain more productive sheep and goat flocks under semi-intensive/ stall feeding production system. There are three types of management systems with overlapping characters that are normally practiced in India.

Extensive Production System: This system is characterized by low input and low output system. It is integrated with arable crops, tree, shrubs, herbs etc. and there is minimum investment on housing, feed and health care. This system of sheep and goat production system can be further subdivided into:

(i) **Nomadic**: Irregular movement of sheep and goat and their keepers in search of feed with no fixed base.

(ii) **Transhuant**: Regular seasonal movement with return to a fixed base in a year. In strict sense vertical movement of sheep and goats flock from high altitude to low altitude in search of fodder during winter.

(iii) **Sedentary**: Animal movement is restricted to a short radius from permanent base. Bucks and rams are proportionally ten or few in number, normally stayed in flock throughout the year.

Sheep and goat keeper who followed extensive production system prefer lambing and kidding once in a year for an adjustment of seasonal availability of feed resources. It is difficult to carryout selection and breed improvement programme in nomadic and transhuant system. In that

system mass selection or phenotypic selection of breeding of male should be done for mating the same breed of goat and sheep.

Semi Extensive Production System: In this system, sheep and goat are allowed to graze for 5-8 hours in pastureland and further requirement are met through supplementation of concentrate. Local resources, crop byproducts and lopping from plants are utilized in better way in this production system. It is less expensive system as cohesive production is done as compared to intensive production system. Many benefits can be derived from enhancing crop livestock integration. This system is preferred more due to optimum utilization of biomass, human and financial resources. The production performance of Jakhrana goat was evaluated by researcher under semi intensive and extensive system of management in their home tract and high performance with respect to body weight of kids, milk yield and prolificacy were observed under semi intensive system. Sirohi goats showed that semi intensive system is good as compare to extensive system in respect to growth rate, feed efficiency and carcass quality. Studies were also conducted on Barbari and Jamunapari goat for comparing extensive, semi intensive and intensive production system and the result showed that growth rate (g/day) was maximum in intensive system followed by semi extensive system and lowest in extensive system.

Intensive System: It is characterized by high input and high output and usually practiced for high potential animals. It is associated with high investment on housing, veterinary care, housing, feed resources, labour and other infrastructure etc. It involves cultivation of fodder with zero grazing, usually low forage and high plane of concentrate diet. This system is very less practiced in India and mostly undertaken at institutional flocks and few commercial sheep and goat farmers. In semi intensive and intensive production system the selection of ram or buck can be done on the basis of their pedigree family if proper record is available or on the basis of phenotypic performance. Selective breeding plan should be conducted to take good results for improvement of breed. Breeding buck or ram should be replaced from the flock in every year to avoid adverse effect of inbreeding.

Genetic improvement of sheep and goat

Due to small population size, single buck/ram flock, lack of animal identification, low levels of literacy of farmers, unavailability of pastures and lack of health care in the field, the sustainability of genetic improvement programmes is not good. To solve the problem of small flock size and shortage of breeding rams, the use of **nucleus schemes** may be a better strategy for genetic improvement of sheep and goat in our country. Under Indian context where flock size is

small and resources are scare, the genetic improvement through nucleus scheme is generated in small fraction of the population (nucleus) and inbreeding should be kept under control. Record- ing of data is done in the nucleus only. Nucleus and multiplier flocks generate sires for distribution to farmers. The nucleus should be setup with the breeding objectives of the farmer in mind. The nucleus could be open or closed. In a closed nucleus, there is no upward migration of animals from the lower tiers to the nucleus, and all recording is confined to the nucleus. On the other hand, an open nucleus allows animals of high merit to be migrated up for breeding in the nucleus. Only females of high merit, and not males, from lower tiers are allowed to migrate up for breeding in the nucleus. Therefore, Open nucleus-breeding schemes may be recommended for genetic improvement of sheep in the tropics.

Future Approach for Genetic Improvement of sheep and goat

India is the host of 42 breeds of sheep and 24 goat breeds and many more breeds yet to be characterized as nowadays characterizations of breed is becoming more in demand. Due to small flock sizes and large sampling errors is the main hindrance in the evaluation of production performance in field conditions. In addition to this there is no breeding policy in our country to improve this important small ruminant species. For this purpose, it is essentially required to develop sound and sustainable region specific breeding policy and improvement programmes. The sheep genetic resources should be critically evaluated with respect to breeding tract environment, production traits, genetic architecture and production function of the breed. The use of genetic markers with quantitative information and their utilization through marker assisted selection and genotype assisted selection particularly for high chevon and mutton production, prolificacy, wool quality, milk yield and traits influencing adaptability to harsh environments, disease and parasite resistance is the need of the time.

Conclusion

Indigenous sheep and goat breeds evolved through natural selection have an immense production potential and hardiness. But due to large scale crossbreeding in the past and continuous indiscriminate breeding in the field, a majority of sheep and goat population has been converted into crossbreds. Indigenous sheep and goat breeds have immense genetic potential for production, reproduction and hardiness, but due to poor environmental conditions their optimum potential has not been expressed. Breeding strategy for sheep and goat improvement should not be prepared only on the basis of production but emphasis should also be given to level of prevailing environment (feed, fodder, resource and their utilization, sustainable production, health

infrastructure and marketing attributes) of a particular place. Breeding policies should be framed breed wise and area wise. Formation of breeder's cooperative/ societies should be encouraged. Up gradation of huge non-descript sheep population by improver breed should be seriously implemented. Data base of all important breeds in all regions should be collected along with production environment, marketing structure and socio-economics of farmers for framing area specific breeding policies. The sheep and goat breeds having unique importance continuously declining in number need immediate attention for conservation. Availability of potential purebred rams and bucks should be ensured for farmers and efforts should be made to check the slaughter/sale of high potential males by the farmers. Efforts should also be made to create a network for implementing ONBS and AI services in the field to provide the services of elite rams and bucks to the majority of females under field conditions.

Scope for goat rearing and its importance in social and economic upliftment of rural, marginal and landless farmers

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India is the second most populous country of world having 2.4 per cent of global geographical area, supporting more than 17.00 and 15.00 per cent of total world human and livestock populations respectively. The country vast resource of livestock and poultry, plays a vital role in improving the socio-economic conditions of rural masses along with the agriculture which supports 70 per cent of its population (Livestock census, 2012). Livestock are the best insurance for farmers against vagaries of nature like drought and other natural calamities. Indian economy is predominantly rural and agriculture oriented, where the declining trend in farm holding poses a serious challenge to the sustainability and profitability of the farming community. Livestock comprise an important productive asset and source of income for about two-third of India's farm households (Birthal, 2008).

Table -1: Livestock population of India

S. No.	Species	Population (In millions)
1.	Cattle	190.9
2.	Buffalos	108.7
3.	Sheep	65.0
4.	Goats	135.17
5.	Pigs	10.29
6.	Poultry	729.2

(Livestock census, 2012)

The supplemental income derived from rearing of livestock is a great source of support to the farmers facing uncertainties of crop production, apart from providing sustenance to poor and landless farmers. The livestock sector alone contributes nearly 25.6% of Value of Output at

current prices of total value of output in Agriculture, Fishing & Forestry sector. The overall contribution of Livestock Sector in total GDP is nearly 4.11%at current prices during 2012-13. Livelihood systems of poor rural households are often so fragile that a small misfortune can destabilize households for years. Strategies for coping with risk include informal mutual aid agreements and/or formal microinsurance schemes. In developing countries, insurance markets are usually underdeveloped. Nevertheless, if the development path is supported by strong structures and institutions, anonymous markets will, over time, replace informal insurance networks as they are more efficient.

The absence of off-farm investment possibilities further promotes investment in livestock production. Failure of an investment, especially when loan-funded, can leave a household in an extremely vulnerable position. Livestock death is considered to be a major factor contributing to poverty. Farmers using credit to purchase livestock face two risks at once: (1) loss of the livestock due to disease and subsequently (2) failure of investment. Livelihood strategies will differ according to whether people have to deal with gradual changes or sudden shocks and crises. Coping strategies (e.g. sale of livestock) seek to minimize the impact of livelihood shocks and are a short-term response to sudden or periodic shocks.

Poverty is largely, but by no means only, a phenomenon of the rural areas. Effective poverty reduction measures can only be successful if the livelihoods of the rural poor can be improved. Sheep and goats belong to the group of animals called small ruminants. Small-scale farmers keep small ruminants for both subsistence and economic reasons and, in either role, they generally improve household livelihoods, but they have the capability to do much more. Small ruminants contribute to landless, rural farming, peri-urban and increasingly to urban households by providing food, heat, income, socio-cultural wealth and clothing

Contribution of Goat has an overwhelming impact when it comes to the rural India. They are usually associated with the poorest of the poor and many a time the goat has been the only source of income for a family. That is why, it has rightly been called **"Poor Man's Cow" by Mahatma Gandhi.** Goat has been described as a poor man’s cow (or mini-cow) because of its immense contribution to the poor man’s economy. They not only supply nutritious and easily digestible milk to their children but also regular source of additional income for poor and landless or marginal farmers. Being small-sized animals, goats can easily be managed by women and children. Feeding, milking and care of goats does not require much equipment and hard work.

Capital investment and feeding costs are also quite low. Four goats can be maintained as cheaply as one indigenous cow. Goats can be successfully reared in areas where fodder resources are limited and milch cattle do not thrive. Returns on capital of up to 50% and recovery of 70% of retail price are possible in goat farming. In rural areas, goat farming plays a vital role in providing gainful employment.

India supports 16.1% of the world's goat population and 6.4% of its sheep (FAO Statistics, 2013), making it among the highest livestock holding countries in the world. Based on the latest GoI statistics (19th Livestock Census, 2012), the number of sheep and goats in the country is 65.06 and 135.17 million, respectively. The state with the highest number of goats is Rajasthan (21.6 million), followed by Uttar Pradesh (15.6 million) and Bihar (12.1 million). Sheep rearing is more frequently a feature of the arid and semi-arid regions of western India, the Deccan plateau and the western Himalayas. States with significant sheep populations include Andhra Pradesh (26.3 million), Karnataka (9.6 million) and Rajasthan (9.1 million). The total number of households and household enterprises, both rural and urban, which rear/own sheep and goats are 4.55 and 33.01 million respectively. Together, the goat and sheep rearing households constitute 15% of the total number of households in the country. Similarly, non-household enterprises and institutions which rear/own sheep and goats are 8,010 and 25,189 respectively.

Small ruminants not only contribute to the household livelihood and nutrition security, but are also a hedge against the losses in agriculture consequent upon the vagaries of nature, and the adversities faced by these families in the absence of adequate health and social security systems. Traditionally, sheep rearing has been the primary source of livelihood for shepherds, who often belong to distinct communities (for example the Raikas of Rajasthan, Dhangars of Maharashtra, Kurubas of Karnataka). Goat rearing, on the other hand, is a supplementary, support activity for other livelihoods, particularly agriculture. Sheep are reared in relatively larger herds (averaging 60-70) whereas goats are reared in smaller numbers, ranging from 1 to 10, on average. Goat rearing is also characterized by a greater involvement of women, and hence offers an opportunity for empowerment of women through goat-based livelihood improvement.

Statistics published by the Ministry of Agriculture indicate that around 70% of the goat and sheep in the country are reared by small and marginal farmers and landless labourers (refer table 1), and this is corroborated by field findings. Small ruminant rearing is therefore a priority

livelihood activity for resource poor farmers, and is often a key support activity for other livelihoods.

Table 1: Distribution of livestock according to size of the holding – all India (2006-07) (millions)

Category of holding	Numbers of livestock/ poultry		
	Sheep	Goat	Poultry
Marginal (<1 ha)	27.55	54.81	142.35
Small (1-2 ha)	14.77	18.77	41.33
Semi-medium (2-4 ha)	10.13	12.88	24.78
Medium (4-10 ha)	5.61	7.53	9.06
Large (> 10 ha)	2.39	2.74	4.05
ALL	60.4	96.7	221.6

Source: Department of Agriculture and Cooperation Input Survey 2006-07, MoA

Goat husbandry in India is essentially an endeavor of millions of small holders who rear animals on “Crop Residues” and “Common Property Resources”. The small holders produce milk, meat, fiber, skin etc for the community with virtually no capital, resource and formal training. More often goats are reared for production of meat, but they also serve as ready source for milk to meet the family requirement. In India, considerable growth has been recorded in production of goat meat and milk during the last decade.

Livestock rearing in the country has been primarily for livelihood security and not for commercial purposes, with ownership being more evenly distributed vis-à-vis land and other resources; animals are a hedge and insurance against natural calamities, droughts, etc., and animal husbandry is frequently one of the many occupations in a household’s livelihood strategy.

However, the commercialization of livestock is on the rise as a result of market developments and fiscal incentives, and an increasing demand for animal protein in the consumer market. A gradual shift is occurring towards intensively managed ram lamb/sheep units, particularly in the southern Indian states of Karnataka and Andhra Pradesh, which is being led and/or facilitated by animal health professionals, state veterinary departments and financial institutions.

Major challenges faced in development of livelihoods based on small ruminants rearing are described in the following paragraphs.

Veterinary care

- Characterized by failure of small holders to access essential livestock services, including preventive veterinary care; preliminary investigations suggest mortality rates as high as 30-40% in goats and goat kids.
- Vaccines for major diseases (such as PPR) are either not available in adequate numbers, or the cold chain supply systems are not adequately maintained, affecting the efficacy of the product.
- In most states, there is a virtual absence of para-veterinary and extension services at the village level; the government veterinary system reaches only up to the Block level and is inadequately staffed. Para-vets and community animal health workers, trained by both NGOs as well as under government programmes, have demonstrated their worth in last mile service delivery in many states across the country. However, questions around the sustainability and legality of the services provided by these trained para-vets and extension workers still persist.

Shelter and Housing

- Losses on account of predation and climatic variations are a major cause of mortality and morbidity, and could be avoided through appropriate housing and shelter, which is seldom accorded priority.
- Low-cost, eco-friendly and goat-considerate alternative models have been developed and are being propagated by SA PPLPP.
- GO-NGO collaboration is crucial to leverage advantages of government schemes for benefit of the smallholder livestock rearers, and this requires allocation of sufficient financial resources not only for the service delivery but also for community mobilization and sustainability of benefits.

Breed conservation and availability of bucks

- Given the structure of the market and its operations, the best quality bucks end up in abattoirs, resulting in non-availability of good quality breeding bucks and rams in sufficient numbers.

- There is a lack of good quality and reliable data on small ruminant numbers and breed populations, trends over time and the drivers of these trends. It is necessary that such data is collected and analyzed periodically to establish the reasons for the increase or decrease in the numbers of specific breeds. This will also help in identifying breeds that are at the greatest risk of extinction.
- The majority of sheep and goats in India belong to 'un-described' (usually referred to as non-descript) breeds or they are 'local' animals not necessarily belonging to a distinct, 'recognized' group or breed. The focus on 'breed improvement' through cross-fertilization with superior and recognized breeds needs to be complemented with appropriate measures for recognition of indigenous breeds, and conservation in their native breeding tracts.

Grazing and fodder resources

- Loss of designated grazing lands, closure of forest areas, and diversion of common lands for other purposes has intensified pressure on available resources, leading to their degradation. There has been an erosion of synergies between agriculture and animal husbandry due to an interplay of various factors, making small holder rearers' livelihoods more vulnerable.
- Reduction in grazing lands, encroachment of common lands, and increasing industrialization have adversely affected small ruminant rearing, which used to be a highly productive low-input system dependent on these lands for fodder and grazing resources.

Livestock markets

- Local livestock markets are auctioned by Panchayats/ local committees, and managed by contractors; there are hardly any government regulations and little intervention, if any, in the establishment, upkeep or management of these markets.
- Transactions in the livestock trade are non-standardised and one comes across numerous unfair trade practices because of the ad-hoc nature of the market. Animals are sold on the basis of a visual estimation of their weight, age and appearance; transactions remain unrecorded and unreported, resulting in loss of potential taxes/revenue to the government, which could go towards development of livestock market infrastructure.

- Small ruminant markets are structured in favour of intermediaries, to the disadvantage of the consumer, rearer and the by-products markets. The market has developed in a manner that clearly puts the rearer at a disadvantage; however it is not even a buyer's market. It will not be inappropriate to state that the meat market is ruled by traders, brokers and commission agents.
- The operational focus on meat to the exclusion of all other by-products obtained from small ruminants manifests in poor price realization for the rearer; except where operations have been modernized and mechanized, there is a lot of wastage, and in-efficient collection and utilization of by-products.
- There is virtually no value addition that takes place along the value chain from producer to consumer, even though the price of the commodity keeps increasing at each stage along the channel. In the meat industry, intermediaries' gains are on account of economies of scale and market location.

Advantages of goat farming / Utility of goats:-

1. The goat is a multi-purpose animal producing meat, milk, hide, fibre and manure. In hilly areas, goats are also used for hauling light loads.
2. Goats have very few demands of housing and management. They hardly need separate housing and happily share their homes with their owners or his other livestock.
3. Goats can be raised by landless agricultural labourers, ladies and children because they can thrive well on variety of leaves, shrubs, bushes, kitchen waste etc.
4. Goat farming can be a profitable occupation for a farmer and can fit well into mixed farming. Goats are cheaper to maintain, easily available and have a friendly disposition.
5. Goats are capable of adapting to various agro-climatic conditions ranging from arid dry to cold arid to hot humid. They can be raised in plains, hilly tracts, sandy zones and at high altitudes.
6. Goats are more tolerant to hot climate than other farm animals. Goats suffer from fewer ailments than other large animals.
7. Goats have got increased digestibility of crude fibre and can produce even on poor quality roughages.

8. Goats give more production per unit of investment. Goats are smaller in size and have a younger slaughter age.
9. Goat meat has no religious taboo and is relished by all sections of society. Goat meat has less fat and is more in demand.
10. Goats are called the foster mother of man, as their milk is considered better for human nutrition than other species of livestock.
11. Goat milk is cheap, wholesome, easily digestible and nutritious.
12. Goat milk is finer than cow milk i.e. the fats and proteins are present in a finer state and are more easily digestible, especially by children and invalids.
13. Goat milk has lesser allergic problems than other species of livestock.
14. Goat milk has higher buffering qualities and this enhances its value for patients suffering from peptic ulcers, liver dysfunction, jaundice, biliary disorders and other digestive problems.
15. Goat milk has higher phosphate content, which is beneficial for vegetarian communities.
16. Goat milk has a higher content of B-complex vitamins.
17. Goats can be milked as often as required, preventing milk storage problems and refrigeration costs.
18. Goat hide is used for the manufacture of leather products.
19. Goat hairs are used for the manufacture of rugs and ropes.
20. Pashmina shawls, Mohair and Kashmere carpets are in great demand and are sold at very high prices.
21. Goat manure is 2.5 times richer in nitrogen and phosphoric acid than cow manure.
22. Goats form an excellent animal for physiological and biomedical research.
23. Unlike large animals in commercial farm both male and female have equal values.
24. The goat meat (Chevon) is more lean (low cholesterol) and relatively good for people who prefer low energy diet.

Goat farming for poors

1. Goats can withstand heat stress and can endure prolonged water deprivation. They have additionally great adaptability to adverse climatic and geophysical conditions, where cattle and sheep cannot survive.

2. They can efficiently utilize poor quality forage and cover long distances looking for food. Their peculiar feeding habits make it easier to choose diets to meet their requirements.

3. Goats are the most prolific domesticated ruminant. Faster reproduction contributes to the genetic progress that can be achieved and enables their owners to recover quickly.

4. Farmers and pastoralists are increasingly relying on goats as means of survival and a way of boosting their income (Peacock, 2005). The increasing frequency of droughts, with long-term envi-ronmental degradation is causing pastoralists to change from cattle or sheep to camels or goats.

5. Overgrazing makes rangelands increasingly suitable for browsing species such as goats.

6. The widespread decline in services supplied by governmental agencies encourages farmers to move from keeping cattle to goats.

7. Goats provide their owners with a broad range of products and socio-economic services and haveplayed an important role in the social life of many people being used as gifts, dowry, in religious rituals and rites of passage (Peacock, 1996).

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Goat farming -A profitable and productive enterprise producing quality milk, meat, hair skin, wool, pelt, mohair and pashmina etc.

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Goat is considered as the first ruminant to be domesticated by human beings between 10000 and 6000 years before Christ (BC) in South-western Asia. Goat significantly contributed to the national economy by providing, meat, milk, skin, fibers, manure etc. Goats also contributed appreciably to nutritional security of rural livelihood by providing animal protein through meat and milk. In India, about 24 breeds of goats have been identified phenotypically and registered at National Bureau of Animal Genetic Resources, Karnal.

The goat population, during last decade remains almost similar; the population increased by 3.10% during the year 2003-2007, but decreased by 3.82% during the year 2007-2012, with present population of 135.2 million (19th livestock census, 2012). Goat contributed 5.05 million tonnes milk (3.67% of total milk production i.e.,137.685 million tonnes) during the year 2013-2014 (BAHS, 2014).

Goats are generally managed under extensive production system followed by semi intensive production system, where only night shelter is provided. However, now-a-days farmers are taking more interest for rearing under intensive production system for commercial purposes.

Goat rearing in India has certain limitations such as lack of genetic improvement programme, lack of health care facilities, limited feed and fodder resources and marketing problems etc. In addition, inefficient and inappropriate production systems along with poor strategies for improved natural resource management and inadequate support have led to low productivity of small ruminants. The level of adaption of breeding, feeding and nutrition and health related techniques by the farmers are not satisfactory (Devendra, 2001).

Goat farming has multifarious added advantage as it required less housing facility , less management and labour, higher prolificacy, improve the soil fertility, easily managed by women and children goat export market in skin, high quality clothing can be manufactured by mohair and pashmina, provide transport power in high altitude, to control bush and undesirable forbs, high dry matter and fibre digestibility managed under integrated system in small holder (Kumar, S. 2007).

Classification of goat on the basis of utility

Meat & Skin	**Meat Milk & Skin**	**Meat Pashmina& Skin**	**Milk Meat& Skin**
Black Bengal	Barbari	Chegu	Jamunapari
Ganjam	Sirohi	Changthangi	Beetal
Kannai Adu	Surti	Gaddi	
	Mehsana	Gohilwadi	
	Osmanabadi	Marwari	
	Jhakhrana	Sangamneri	
	Pantja		

(ICAR. 2008)

Medicinal values of goat milk-

- Goat milk is finer than cow milk i.e. the fats and proteins are present in a finer state and are more easily digestible, especially by children and invalids. Goat milk has lesser allergic problems than other species of livestock.
- Goat milk is used as a ayurvedic medicine for personas ailing with asthma, cough, diabetes etc.
- Goat milk has higher buffering qualities and this enhances its value for patients suffering from peptic ulcers, liver dysfunction, jaundice, biliary disorders and other digestive problems.
- Goat milk has higher phosphate content, which is beneficial for vegetarian communities.
- Goat milk has a higher content of B-complex vitamins.
- Goat milk is suitable for preparing various milk products.
- Goats can be milked as often as required, preventing milk storage problems and refrigeration costs.
- Goat milk has 9 minerals more in number than any other milk used for human consumption.

Utility of goat meat

Goats are the main meat-producing animals in India, whose meat (chevon) is one of the choicest meats and has huge domestic demand.Goat contributed 0.97 million tonnes meat (15.56% of total production i.e., 6.235 million tonnes) during the year 2013-2014 (BAHS, 2014).Due to these fast socio-economic changes in the recent past, a rapid shift has taken place in the dietary habits in favour of non-vegetarian diet. Goat meat has high demand in India which accounts Rs. 380-450/kg presently

Advantage of goat meat

- It contains lower value of saturated fats, cholesterol and high value of unsaturated fats thus it is safe for the heart and reduces the risk of cardiovascular disease and other chronic problems.
- Unsaturated fats found in it improves the good blood cholesterol levels, provides relief from inflammations and etc.
- It contains lean proteins in high amount, low saturated fat thus helps in controlling weight and reduces the risk obesity.
- Proteins found in it acts as a hunger suppressing agent and keeps the stomach full for longer time thus helps in controlling weight.
- It contains lots of vitamins and nutrients which help in burning fat.
- It prevents from anemia during pregnancy to both mother and baby by increasing the blood hemoglobin level in mother and enhancing blood supply to the baby as it contains high iron level (3mg iron/100g of goat meat).
- It prevents from other iron-deficiency diseases, reduces the risk of birth defects among new born babies, neural tube defects and etc.
- It contains B group vitamins, selenium and choline which is very beneficial to be prevented from cancer.
- It helps in improving sex power among men as it contains torpedo and bile which enhances the ability of male sexuality.
- It helps in iron recovery among women during menstruation and provides relief from the menstrual pain.

- It provides better nourishment to the skin and makes it healthy, soft, supple, glowing and smooth.
- It provides relief from the skin problems like psoriasis, eczema or acne and other problem by nourishing the skin.
- It also provides relief from the dry skin and rashes problems by making the skin soft and supple.
- It reduces the risk of infections, type 2 diabetes and other diseases if eaten regularly.
- It contains low sodium level and high potassium level thus safe food for the heart and prevents from the high blood pressure, risk of stroke, kidney diseases and etc.
- It contains niacin vitamin which involves in promoting the energy metabolism.
- It provides better nourishment to the bones, teeth and hairs thus prevents from osteoporosis, joints pain, tooth ache and hair loss.
- It helps in improving the power of immune system and prevents from various infections.
- It helps in maintaining the functioning of thyroid gland and prevents from the early ageing as it protects from the free radicals.
- It normalizes the blood sugar level thus keeps blood sugar level under control among diabetic patients.
- It enhances the memory power among kids by helping in proper brain development.
- Goat meat is called as chevon and so chevon leg soup is very famous, delicious and healthy for the health especially bones. It is rich in calcium and helps in bone building and teeth strengthening. It enhances producing new body cells thus delay the aging. It is good for weight watchers as it is rich in protein which keeps stomach full longer

Goat manure

Manure are the excreta of the animals and bedding materials of the animals. Goat manure is great for fertilizing to the fields. An average goat produces over a ton of manure every year, and the feces are in pellet form, which makes them easy to handle. Goat manure is a good source of NPK possibly other minerals as well. Goat manure helps maintain the soil fertility.Goat urine is equally rich in both nitrogen and potash, and is more valuable than that of any other animal. Goat manure fetches ready cash to the owner. He usually leaves the goat to graze on stubbles in the field and is paid by the farmer for his field being thereby manured. It is said that one hectare of

land receives a sufficient dressing of manure if 4800 goats are folded there for a night. Goat manure is 2.5 times richer in nitrogen and phosphoric acid than cow manure.

Goat skin

The outer coverings of small domestic animals and wild animals are called skins. Skins are smaller in size, thinner in substance and lighter in weight than hides. The maximum numbers of goat skins are produced in India due to an annual removal of goat of approx. 45%. The finest quality skins for the leather industry are obtained from the Black Bengal goat, and are exported to many countries, particularly to the USA, where they are mostly used in the shoe industry. Goat skins are of two types viz. Amritsar and Calcutta. The former are used as lining for shoes and the latter are used for shoe uppers.The importance of goat leather is well known in spite of the fact that their availability is less than 10% of total leather production. The classic glazed kid leather is among the best in high quality shoe leathers, having a steady position in the area of orthopedic women's shoe upper. This is because one can use the skin almost in its full thickness on the shoe uppers of less than 1.0 mm. this is due to the specific structure of the goatskin, it is tight fibred and has a very tough grain layer, providing an outstanding form-stability and therefore an excellent support for the foot.

Uses of goat skin

Leather is used for car & furniture upholstery, luggage, wall painting, gloves, hats, coats, dress, handbags, wallets, bookbinding's & numerous other products. In the world of sports, leather is essential-cricket, soccer & rugby ball are made by leather. And then there are such items as boxing gloves & head guards, football, boots, saddles & harnesses, ski & riding boots, leather gloves & leather covered steering wheels help racing drivers to keep their under precise control. Protective motorcycle racing leather has helped to reduce serious injures in accidents. The biggest use of leather is in the manufacture of shoes.

Utility of goat pashmina

Pashmina can also be defined as the undercoat fiber derived from Cashmere goats with a diameter of 30 microns or less. Pashmina has derived its name from the Persian word meaning *soft gold* or *the king of fibers* (*Anon.*, 2005). It is well known for its fineness, warmth, softness, desirable and aesthetic value. It is most luxurious fiber which is much softer than superfine merino wool of the same diameter with the result it commands much higher price. It has occupied a unique position among the fibers of animal origin because of its warmth, lightness, handle and its better ability to absorb dyes and moisture. On equal weigh basis, it is having 3

times more insulating capacity as that of wool (Von Bergen, 1963). The term Pashmina is also known as *Cashmere, kashmir, pashm, tiflit, tiftik, tivit, tibit*. In India, Pashmina is obtained from Ladakh region of Jammu and Kashmir, Lahul and Spitti valley of Himachal Pradesh, Uttar Kashi, Chamoli and Pithargarh districts of Uttranchal. The Pashmina obtained from Jammu and Kashmir is known as *Changthangi Pashmina* whereas that obtained from H.P and Uttranchal is known as *Chegu pashmina*.

Total pashmina production in India during 2005-2006 was 50 tonnes, of which *Changthangi* breed contributed 80 per cent . Goat fibre with less than 19 µm diameter is classified as cashmere but the fibre from Changthangi breed has average diameter of 10-14 µm, which is considered best and warmest in the world.

The production of Pashmina in the world has increased tremendously over last decade or so as it has increased from 4500 tons / year in 1990 to 8000-10000 tons/ year in 2004 (Dubeuf *et al*., 2004). Out of 40 tons of Pashmina produced in India, Jammu and Kashmir alone produces 32 tons of Pashmina worth Rs 1.8 crore (Singh, 2004). The Annual Pashmina production per animal in China and Russia has been reported to be ranging from 700 grams to 1000 grams but in India it is far lower and is ranging from 100 grams in Chegu goats to about 250 grams in Changthangi goats (Singh, 2004).

The production of Pashmina depends on number of factors, among which main factor is number of hair follicles per unit body surface. Pashmina production is more in males than females due to the difference in body size. Lactation is having an effect on fiber yield. There is an apparent variation in the fiber length of Pashmina from different body regions in case of both male and females. As Pashmina grows as undercoat and acts as protective mechanism in Pashmina goats, so the sub zero winter temperature also has an effect on the growth of Pashmina fibers. Pashmina fibers are having little felting property. The fiber is slightly weaker than wool and is more susceptible to wetting (Ryder, 1984). The strength of Cashmere fibers is about 10% below finest sheep wool and 40% below Mohair (Von Bergen, 1963).

Harvesting of Pashmina

Pashmina fibers can be collected during spring moulting season when animals naturally shed their winter coat. On the basis of weather conditions and region, the goats start moulting over a

period from Feb to late May. In India combing is the major way of harvesting Pashmina. Since combing and manual separation is labour intensive so combing is sometimes replaced by shearing (Miller, 1986). Shearing followed by mechanical dehairing has become a common practice in Australia and New Zealand (Aglink, 1984) but in Iran the process of shearing was combined with laborious manual dehairing (Von Bergen, 1963). In India combing/shearing followed by laborious manual dehairing was a common practice but has now changed to combing/ shearing followed by machine dehairing on the modified cotton cards.

Utilization of Pashmina

Pashmina is utilized for the development of aesthetic products like Knitwear in Scotland, woven fabrics as blends in Italy and Switzerland. After spun into yarns, pure Pashmina can be knitted into jumpers, hats, gloves, socks and other clothing or woven into fabrics than cut and assembled into garments such as outer coats, jackets, pants, pajamas, scarves, blankets and other items. However in India, majority of Pashmina is utilized for preparation of shawls in Kashmir valley. The shawl preparation is hand woven only and involving labour in sorting, spinning and weaving on specified handlooms.

Goat mohair

It is produced by Angora goat and similar to the wool in chemical composition, but differ in mohair fibre are smoother surface and non-insulating used for summer cloth. It is more luster than wool and also 2 to 2.5 times stronger than wool. Mohair is also known as Diamond fibre. Mohair is warm in winter as it has excellent insulating properties, while remaining cool in summer due to its moisture wicking properties. It is durable, naturally elastic, flame resistant and crease resistant.(*Black, William 1900).*

Utilization of Mohair

Mohair is used in scarves, winter hats, suits, sweaters, coats, socks and home furnishing. Mohair fiber is also found in carpets, wall fabrics, craft yarns, and many other fabrics, and may be used as a substitute for fur. Mohair is a very soft yarn when compared with other natural and synthetic fibers.

Sheep wool

Wool production begins with several basic concepts. Along with the fiber diameter, fiber length, and the amount of vegetable matter and any other foreign material in the fleece affect wool

quality. Fiber diameter varies by breeds of sheep and is used to determine the purpose of the wool. Wool made up of smaller diameter fibers or fine wool is used for clothing while wool made up of larger diameter fibers or coarse wool is used for carpets and rugs. Below are more details about wool production and wool quality.

1. Wool Yield

   As wool comes off the sheep it is called grease wool. This is because the lanolin in the wool gives it a greasy feel and appearance.
2. Fiber Diameter

   Fiber diameter is probably the most important factor for determining the quality of wool and its value. As the fiber diameter increases, it changes the way wool is used.
3. Crimp

   Crimp is another wool characteristic highly related to fiber diameter.
4. Vegetable Matter

   Vegetable matter in wool comes from feed particles as well as burs, seeds, twigs, leaves, and grasses.
5. Fiber Length and Strength

   The staple or fiber length affects how the wool can be used.
6. Fiber Color

   The whiteness of wool is very important if the fibers are not expected to be dyed or will be dyed a light color.
7. Cotted or Felted Fleeces

   Occasionally, the wool fibers may become matted or felted together.

Improving Wool Quality

Wool quality can be affected by genetic and environmental influences. Genetic influences would be to select sheep with higher quality wool, while environmental influences might include nutrition, sheep management, and shearing management.

Classification of Indian sheep breeds according to their utility

Garment wool (apparel wool)	Carpet wool	Meat & Carpet wool	Meat
Kashmiri merino Nilgiri Hissardale Karnah	Chokla, Nali, Pattanwadi, Gaddi, Rampur Bushair, Bhakarwal, Poonchi, Gurez, Changthangi	Muzzafarnagri, Jalauni, Deccani, Bellary, Ganjam, Sahahbadi, Chotanagpuri, Coimbatore, Marwari, Jaisalmari, Pugal, Malpura, Sonadi, Bonpala	Nellore, Mandya, Hassan, Mechari, Kilakarsal, Vembur, Maadras red, Tiruchi Black, Ramnad white

(ICAR. 2008)

Pelt breeds

Karakul is the most important sheep breed used for production of high quality pelts and is spread in many countries e.g. in Russia, Afghanistan, Namibia, South Africa, Iran, and Rumania . Other sheep breeds used for pelt production are Gotland, Icelandic sheep, Grey Shiraz and Zandi.

These sheep are bred primarily for lamb pelts used for garments. At birth and for a few days there after, the lamb pelts have characters that make them suitable for use as furs. Karakul is often spoken of as a “fur-bearing sheep”. This property of the lamb pelts and the hardiness of the sheep are the two most useful features. The majority of karakul lamb pelts are produced in Bokhara (USSR), Afghanistan, Southwest Africa, Iran and Iraq. The best pelts come from Bokhara, where the sheep is a fat-tailed, coarse carpet wool type of breed. Karakul is very well adapted to the extreme climatic conditions and sparse vegetation resources. The lamb pelts are produced through the slaughter of lambs within 24-48 hrs of birth or through killing of unborn lambs removed by slaughter/abortion of mothers at around 130-140 days of pregnancy.

Pelts from sheep are to a great extent by-products in lamb production. Statistics presented by the Food and Agriculture Organization of the United Nation (FAO) indicates a total world production of almost 540 millions sheepskins in 2008 (FAOSTAT, 2011).

Contribution of Women in sheep & goat Husbandry

Women make essential contribution to the agricultural and rural economics in all developing countries . Their roles vary considerably between and within regions and are changing rapidly in many parts of the world, where economics and social forces are transforming the agriculture sector. Women make 60-80 % of the agriculture labor forces (FAO 2011). Estimate of the time contribution of woman to the agriculture activities in India is 32%, data foe west Bengal and Rajasthan reports women's share as from less than 10% to more than 40% respectively in both areas younger's women contribute a higher share of the total time provided in agriculture by their age group than older women do theirs (FAO 2011).

Conclusion

Sheep & Goat farming has huge scope and demand in India as purchasing power of majority of people is increasing. Goat provides nutritious milk, meat, mohair, pashmina with good fertilizing manure, whereas sheep provides meat, wool, pelt & faeces with high fertilizing capacity. Hence small ruminant rearing has a great promise as source of income and employment and livelihood security of resource poor rural people throughout the country in general and the arid and semi arid regions in a particular. However, there is a need for appropriate policy and institution for transfer of need based technologies, linking with smallholders with the market, value addition and safeguards mechanism in face of increased competition due to globalization and climate change.

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Housing for small ruminants

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Appropriate and adequate housing is an absolute necessity for goat farming. It is important that goats are adequately sheltered to protect them from adverse environmental and harsh conditions. Goat keepers can lose up to 50 % of their kids due to diseases and complications caused by poor and unhygienic housing. Goats need shelter and are usually afraid of rain. Shelter is also necessary to protect goats especially kids from predators like dogs, wild animals and thieves. The adult goats suffer reduced production and productivity due to bad weather.

Types of Houses

The type of goat house to be selected varies with: -

1. Goat Farming System
2. Size of herd
3. Resources available.

Goat houses may be built using cheap materials, which are locally available. Different groups of goats have special housing requirements. These are:

- Breeding males.
- Pregnant Does in the last stage
- Goat kids.
- Sick goats

Principal Features of Goat Houses

The key features however include:

- Siting
- design
- type of floor and
- roof

Recommended specifications

1. Permanent Housing: 1.5 m^2 (1.22 x 1.22 m) per goat with an exercise yard and space for feed and water troughs
2. Night Housing: 1.0 m^2 (1 x 1 m) per goat
3. Kidding pen: 3.0 m^2 (1.73 x 1.73 m) per doe

4. Permanent buck pen: 3.0 m^2per buck with an exercise yard and space for feed and water troughs

Design of the house depends on: -

- Purpose.
- Specialized needs
- May be permanent or temporary.
- Made of mud, bricks, or timber.
- Should have adequate ventilation.
- Floor must be easily cleaned.
- Roof and a wall must be strong.

Layout design of goat house

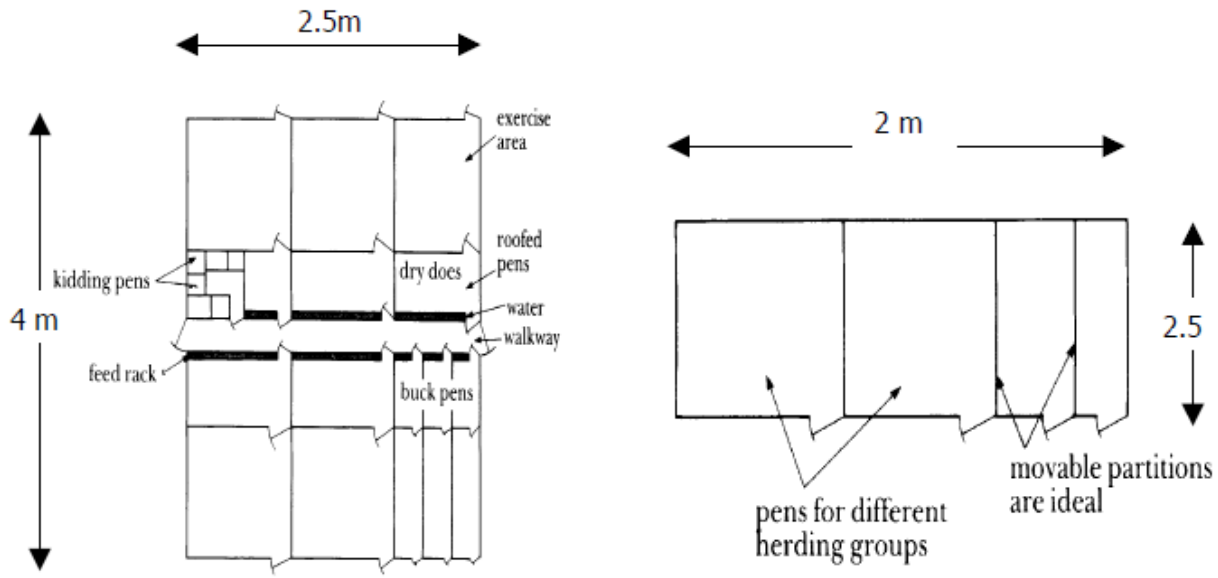


Figure 1 Lay out design for 5 goats (1 male & 4 females) permanently housed and for 3 goats (1 male & 2 females) housed at night only

Dimensions

For permanently housed goats, if you have 5 goats, the requirement is for 1.5m^2 per goat, therefore 5 x 1.5 = 7.5 m^2. See figure 37a (immediately above), the dimensions are 4 x 2.5m =

$10m^2$. This will be sufficient to house 5 goats, using the recommended spacing, but the more space the better.

For goats housed during the night only, Figure 37b is for 3 goats, the recommended spacing is 1 m2 per animal. Therefore for 3 goats $3m^2$ is required, in Figure 37b (immediately above), the dimensions are 2 x 2.5 = $5m^2$. This will be sufficient to house 3 goats.

With goat housing you need to plan for the future. What reproductive rate do you anticipate? If for example with a high level of husbandry, the does produce twins, therefore in the first breeding year 4 does x 2 kids each = 12 animals. If all these are kept, with the male being replaced = 13 Goats total. If they are permanently housed – 13 x 1.5m = $19.5m^2$ (at least) = A house with the following minimum dimensions – 4.5 x 4.5m plus an exercise yard and space for feed and water. The dimensions will be 6m x 6 m = $36m^2$.

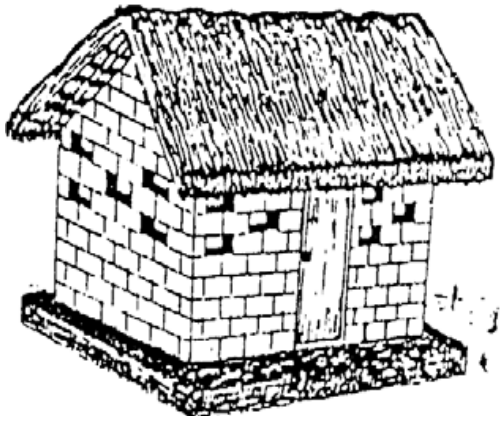
Floor

1. Houses can be set on the ground or stilted.
2. Ground level housing may have a floor of rammed earth / clay or concrete.
3. Mud floors must be compacted to allow easy cleaning.
4. Stilted floor must have be raised to at least about 1.5 - 2m off ground.
5. Wooden slats must have a separation gap of 1.5 - 2cm to allow manure to fall through the ground.
6. Avoid making big slats, which trap the goats' legs.

Roof

1. All goat shelters/ houses must have roofs.
2. Roofs are made from corrugated iron sheets, papyrus, grass or polyvinyl material (kaveera).
3. Roofs must slope to allow water run off and must not leak.
4. A veranda or platform constructed around the house prevents rainwater from entering the house or damaging the foundation.

Brick House



Advantages

1. Structures are usually permanent
2. Not easily demolished by animals

Disadvantages

1. Bricks are expensive
2. Houses are often of poor ventilation,
3. Floor needs special attention and may not be easily cleaned

Mud House

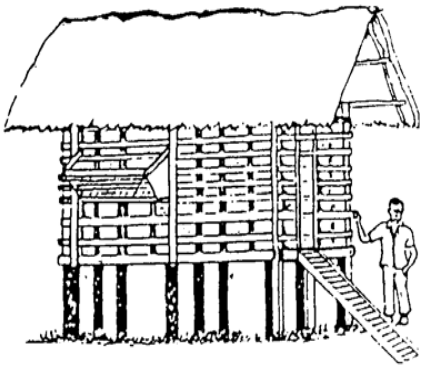
Advantages

1. They are cheap to construct
2. Are semi permanent.
3. Materials are cheap and locally available

Disadvantages

1. Often ventilation is not adequate
2. Floor is difficult to clean.
3. Most mud houses also have grass-thatched roofs, which easily leads toleaking during rainy seasons

Stilted house, slatted floor



Advantages

1. Can house a large or small number of goats
2. Adequate ventilation
3. Cleaning is easy and not labour intensive
4. Urine and faeces can be collected for other purposes
5. House is durable
6. Stilts protect goats from large predators

Disadvantage:

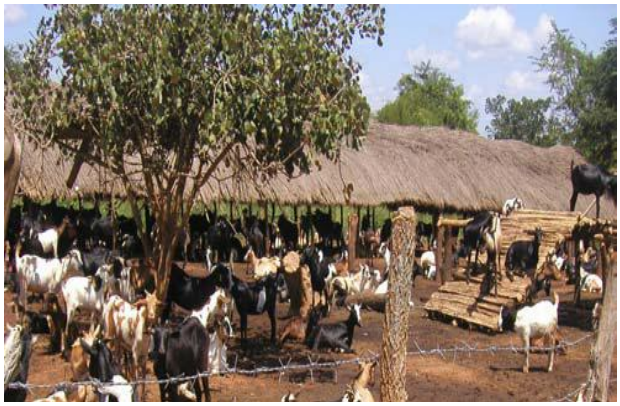
1. Expensive to construct: since material use is high

Some recommended specifications for animal space

- Kid 0.3 m2 (0.55m x0.55m) per animal
- Doe (non pregnant)1.5 m2 (1.22mx1.22m) per animal
- Doe pregnant 1.9m2 (1.37mx1.37m) per animal
- Buck 2.8 m2 (1.67m x1.67m) per animal

Goat houses made from local Materials

Goat houses made of local materials are more than adequate. The principle requirement is to keep goats dry during rain showers. Thatched houses show the minimum required – a roof only with ground floor.



Thatched house for goat with ground floor

The above figure shows a further level of development, by raising the goat house above ground level, means urine and dung falls through the slats, making the collection easy. The walls may be simple, made from eucalyptus poles, widely spaced to keep the goats confined, yet well ventilated.

General tips on goat housing

- If the goats do not get enough space for movement in the house, their activity is restricted and this has a subsequent effect of reduced goat productivity.
- Congestion in the house makes goats susceptible to respiratory diseases.

- The goat house should be cleaned everyday because the accumulated droppings make a good environment for multiplication of infectious agents and parasites that cause diseases.
- Young goats are very susceptible to parasites found in the faeces and urine whereas the adults suffer skin and foot infections from dirty houses.
- People should not share houses with animals.

Management of Sheep and Goat

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Management and production are closely allied terms that are often used interchangeably.A system of production is characterized by the emphasis placed on, the manner, scope, and scale of providing the inputs of breeding, feeding, disease control, marketing and management.

Management Practices:

Management refers to the day to day care of the flock, including routine operations, basic planning and the overall business aspects of the proceeding.

Size of Flock:

Only conditional limits of flock size can be specified. There is often a difference between the flock-ownership and flock-size while grazing. Thus, it is a common practice in both nomadic and sedentary flocks to combine the animals owned by a number of different people in order to reduce the required number of herders.

While grazing, a flock of 100 to 500 head under nomadic conditions and 25 to 50 head in connection with sedentary farm holdings are judged optimal.

Flock Mobility:

Seasonal movement is most often based on traditional land-use practices and locally established grazing customs, within a given locality. These patterns are usually in response to environmental conditions. Flock mobility varies from completely sedentary to entirely nomadic.

Transhumance is an intermediate form of migration that usually entails regular seasonal movement from a fixed base to pasture at some distance, and return.

Management and housing

Two basic production systems are widely recognized.

Under extensive production methods, animals obtain most of their feed requirements from grazing and spend the major part of their life in open.

Intensively produced flocks obtain bulk of their sustenance from feeds other than grazing, they spend much of their time in relative confinement. These systems further can be classified as-

Traditional system

Goat raising is mainly in the hands of the weaker sections of the community which either do not possess land or their landholdings are so small that crop cultivation does not provide remunerative employment all the year round. Further, in the major goat rearing areas especially in north western districts of Rajasthan, grazing and stock watering resources are available only for a few months in a year, compelling shepherds to lead a nomadic life .

The system of constant migration is one of the main reasons for the high percentage of illiteracy among these sections of the people. Even children of the family have no chances of education because they are also constantly on the move and are employed by their family for grazing the goat flocks.

Due to lack of education these goat owners are not able to appreciate and adopt improved goat husbandry practices brought to them by extension workers. Goat management has thus remained in a neglected state. Migration and grazing practices have an impact on the present status of goat husbandry in the country.

Extensive system

This system is practiced in large tracts of Deccan Plateau where there are hills and large areas of land unable to be cultivated. Goats are taken out of grazing by women and children in the morning and brought back in the afternoon. This is the cheapest system and practiced over all parts of India where grazing land is available. This is also practiced by nomadic tribes who move for pasture to pasture along with the season with their herds. The nomads keep watch dogs with their herds to protect them and to prevent them trespassing in unwanted areas.

Advantages of this system are that it is cheap and provides the production and disposal process simultaneously. The disadvantages are mainly that the animals raised on the system are poor producers besides having poor genetic capabilities, and are exposed to continuous stress.

The diversity in extensive management system from use of goat in control of certain weeds in some areas to the migratory flock system depends on the agro-climatic conditions of the region. In this system the goats are grazed round the year on natural vegetation with some additional hay or concentrate during lean periods of the year.

Semi intensive system

This system is widely practiced by small and marginal farmers and village poor. The nature and extent of this system depends on the type of crops grown and their suitability to goats. Goats are left to graze/browse on the crop residue when the same has been harvested.

The advantages of this system are increased fertility of the land by droppings and urine of these animals, control of wasteful habits, good growth rate, easier management and possible increased crop yields. Goat keepers keep herds of goats which they take to other farmers fields when a crop has been cut. The farmers pay them in cash or kind for the manure and urine they drop in the field while grazing.

A modified form of this system is tethering where the animal is held by a rope about 2-3 meters long, and other end being tied to a tree or post. The animal grazes and browses in the area accessible through the length of the rope. This system is popular with farmers who keep only a few goats. It permits utilization of grass, fodder and bushes in a limited area and keeps a control on the animal and saves labour.

What is needed is to maintain a balance between the number of goats and other livestock and the quantity of feed which is available for the combined population during the lean periods. This will ensure protection to the ecosystem in different agro-climatic zones of the country.

Intensive system

If the agro-climatic conditions are such that the land is mostly under prennial cropping and the grazing land is available during inter-cropping periods, the only choice is to adopt intensive management system. Such areas are suitable for milch breeds.

The pressure of increasing population of human and animals further justify adoption of intensive management system for livestock, in general and goat, in particular to ensure control and degradation of the environment.

Handling and care of animals

Kidding does

The doe should be put in the pen a few hours before parturition. She becomes fussy about 2 or 3 hours before actual kidding. The udder becomes engorged with milk, the belly appears shrunk and the flanks appear rather hollow. The tail head is raised higher than usual as the ligaments of either side relax. There is thick, white, starchy discharge which soon changes to a more opaque substance.

The water-bag appears first. Soon afterwards, within 15 minutes, it breaks and the feet of the kid appear with the head resting on them Since the doe is fussier and noisier than any other domestic animal during kidding, it is not necessary to care for her unless she is obviously in trouble. In case of undue delay in the appearance of the kid after the bursting of the water-bag, the position of the kid may have to be adjusted. If twins or triplets are to be born there is usually a short period of rest between the appearance of kids.

Kids

The first few days of life of kids are rather vital in the management of kids. With multiple births weaker kids often require special attention particularly at the time of suckling. It is a good practice to clean the udder with KMnO4 solution each time, prior to suckling. Overfeeding and underfeeding are both deleterious to the health of the kid(s). It becomes essential to detect and isolate the kid suffering from diarrhea or other ailment and to place the cases under the attending veterinarian. Healthy kids become playful within 72 hours and they require soft bedding and clean grassy paddocks. The kids are very susceptible to cold and special attention is required to monitor the shed temperature with simple Maximum–Minimum thermometer and to impose correction of ambient temperature to about 18o C in winter.

Pregnant does

A temporary increase in milk yield after mating is considered to be an indication of pregnancy, but the first sign that a doe is in-kid is the cessation of the periodical return of oestrus. During the first 3 months of pregnancy there is little alteration in the shape of the in-kid does. The head of the kid can sometimes be felt from 6 to 8 weeks. An old doe or a young doe which is to give birth to one kid may be very misleading in appearance and show no sign of pregnancy. Six to 8 weeks before kidding, young does commence to show udder development, but this is by no means a sure sign of pregnancy as they will frequently show such development and even have milk in the udder when they are not in- kid.

Dry does

No extra care is required for these animals. Regular grazing for 8 to 10 hours on a good pasture is sufficient to maintain their weight/condition.

Fattening stock

Complete separation of kids from their mothers is called weaning. The practices and problems of weaning and care of weaners vary from place to place. The management of weaners play an

important part in good goat husbandry because these weaners will be the future breedable animals. The following steps will greatly help in proper care and management of weaners.

(i) Weaning should preferably be done at 90 days.

(ii) Avoid malnutrition, as it will result in stunted growth and susceptibility to worm infestation.

(iii) Provide supplementary feeding and good clean pastures.

(i) Drench them regularly against various gastro-intestinal parasites as these are very prone to worm infestation.

(ii) Vaccinate them against enterotoxaemia, struck and black-quarter diseases.

(vi) Do not graze weaners in burry and seedy type of pastures which may cause skin irritation to lambs, damage to wool and cause ophthalmic diseases.

(vii) Provide them shelter against vagaries of climate and predation.

(viii) They should have easy access to fresh and clean water and nutritious green pastures.

Male kids

Immediately after birth, the nose of the kid should be cleared of nay entangling membranes or mucus to prevent suffocation, and the navel swabbed with tincture of iodine. The kid, if healthy and strong, would stand on its legs and make for its mother‘s teats. Failure to reach the teats, however, is of no consequence. The kid should be taken away from its mother in birth. Colostrum should be the first food to be given to kids; it clears the stomach and develops immunity in them. The kids should be placed on either pan or bottle-feeding. Use of baby bottles and nipples or baby feeders that lessen air swallowing would be better. Nipples and bottles should be kept thoroughly cleaned. Pan-feeding is fast and efficient. Lukewarm milk (95°F/36°C) should be placed in a shallow pan and the lip of the kid slowly dipped into it. Bottle feeding may cause distension of the abdomen, and pan-feeding distension of the abdomen and scouring. During the first 2 or 3 weeks kids should be given 0.9 to 1 litre of milk 3 times a day. If the milk is costly, milk substitute can be used when kids are a couple of weeks old.

They should be allowed free access to any kid-starter meal. Space for exercise is an important item for the playful kids. Milk can be given twice a day later, but should be discontinued when the kid is 3 to 4 months old. Excessive milk feeding will produce exceptionally nice-looking does, but having improper stomach development. These does will be low milk producers.

Teaser bucks

The number of vasectomised bucks used is 1% of the original number of does i.e. for 5,000 does 50 teasers and even when there are only 1,000 does left in the mob, 50 teasers should still be used. All vasectomised bucks are tested for brucelosis.

Two teams of teasers are used and alternated every 3rd day. The time to chage teasers is when a large percentage of the does that are presented for insemination have creamy vaginal mucus. This indicates that estrous has terminated and this means that teasers did not detect estrous at the onest, either because there were too many does or they had lost interest.

Breeding Bucks

Buck kids, unless from highly pedigreed does or from does with good performance records are rarely worth retaining. They should be castrated shortly after birth or within 2 weeks. Male goats are fertile when quite young and if left with young females are capable of breeding and causing early kidding. Goats for slaughter should be raised on milk for the first 6 weeks. They can be sold or slaughtered when 3 months old for meat, which is considered excellent.

The buck, to be in good condition and well suited for breeding, should be kept on range, and made to cover 3 to 4 km each day. Bucks often become sluggish and slow breeders for lack of adequate exercise, because they are kept confined in small enclosures. For giving exercise, they may be yoked to small carriages used for hauling light loads.

A buck is very active during the breeding season. The buck‘s hooves should be regularly attended to as otherwise foot-rot or lameness may develop. Bucks should always be kept separate from the does. They become unduly restive or excited and waste more energy when kept with does.

Grazing and feeding systems

Rotational Grazing

The fodder crops should be included in the grain or commercial crop rotation programme. The practice of keeping the lands fallow for wheat, paddy, gram etc. should be discontinued and fodder crops like sorghum, pearlmillet, cowpea and clusterbean should be introduced in kharif in the rotation. The fodder crops should also be sown with grain or commercial crops in such a way that they do not affect the production of grains. Alongwith sorghum and pearlmillet, the legumes like cowpea, dolichos, clusterbean, clitoria, black gram and green gram, may very easily be grown as companion crops. The legumes will not only provide nutritious fodder for goats without adversely affecting the grain yield but will also improve the soil fertility through

nitrogen fixation which in turn will be available to the grain crop. It is essential that the programme and multiplication of seeds and planting materials of recommended fodder crops should be followed.

Silvipasture Grazing

Establishment of silvipasture improves quality of nutrient available ensuring its supply round the year. Experiment conducted at CSWRI has indicated that the hoggests are able to achieve 30 kg at yearling age whereas under grazing on natural pastures with some supplementation with grass and cultivated fodder hay it was 25 kg. Similar studies conducted on does in advance stage of gestation and lactation indicated that pasture intake was not adequate for them requiring supplementation to harvest desirable production traits. Another study with weaner kids on 3 and 2-tier silvipasture indicated that kids were able to achieve 22 kg body weight at 6 months of age without concentrate supplementation.

Supplementary Feeding

Fattening of kids

Post-weaning growth is primarily affected by hereditary factors, plane of nutrition, prevailing meteorological conditions, animal‘s ability to adapt to the environment and managemental stresses. In agriculturally advanced countries post-weaning phase of growth is mainly used for fattening and finishing purpose, whereas, in our intensive meat production strategies, the active growth is completed by 5 to 6 months of age depending on the weaning age of kids.

Dry does

No extra care is required for these animals. Regular grazing for 8 to 10 hours on a good pasture is sufficient to maintain their weight/condition.

Flushing is conditioning of does for breeding. If the does are in low plane of nutrition prior to breeding, additional supplementation for about one month has beneficial effect in bringing the does into oestrus. Even without additional supplementation when there is lush green pasture, there is flushing effect. Supplementation of about 250 g of concentrate could bring about flushing of does quite well. If the plane of nutrition of the animal is good prior to breeding, flushing is not at all required.

Pregnant and lactating does

If the does are flushed and good grazing is available, no additional supplementation is necessary during early pregnancy up to about 14 weeks of gestation period. During advanced pregnancy (last 6 weeks) however, extra feeding is essential. During this stage, there is also depression in

the intake capacity and feed digestibility. Hence highly digestible feed need to be fed during this stage.

Care During Pregnancy Period:

- Housing of pregnant ewes should be in separate enclosure.
- Provide green leguminous fodder ad lib.
- Avoid taking them for a long distance for grazing.
- Give extra allowance of nutrients to provide enough protein, energy, water and minerals.
- Keep houses clean and well ventilated.
- Avoid high temperature in houses of pregnant animal as it leads to birth of immature and weak lambs.
- Provide enough clean and safe drinking water.
- Keep them free of parasites.
- Avoid dipping of sheep in advance stage of pregnancy.
- Keep them comfortable.
- During pregnancy the ewes should have gain in body weight 4 to 6 kg depending up on the breed.
- If ewe loses weight in pregnancy period then she will give birth to weaker lambs with more death rate.
- Avoid all kinds of stress during this period.

Bucks

When the bucks are to be maintained they should be only for breeding purpose, otherwise they should be sold for slaughter. In some places in the field, farmers keep large number of bucks in their flocks only for getting the hair clip. Some farmers have also religious sentiments not to slaughter their bucks. This practice should be discouraged. Generally if good grazing is available, bucks do well on grazing alone and no additional supplementation is required. During breeding season, concentrate supplement should be provided. In the absence of concentrate, supplement with good legume hay should be provided in the quantity twice the recommended concentrate allowance. During non-breeding season if the bucks lose weight, fodder supplement should be provided. About 5 to 6% DCP in the fodder/pasture is adequate to maintain the animal during non-breeding season.

Management of Breeding Flocks:

Good management of the reproductive cycle is fundamental to a successful sheep year. By good management the breeding plan is carried out effectively.

Selection:

Selection of the individuals for breeding flock must go on all year round. Since the stud ram represents half of the breeding flock from the genetic stand point, great care should be exercised in his selection. One ram to each 20 to 25 ewes should be kept, depending up on the local environment.

Mating or Breeding Season:

This is the time when the ewes are exposed to the stud ram. The period may be uncontrolled, when the ram is available to the ewes all year round, or seasonal.

This controlled mating varies from running the ram with the ewes continuously for 50 to 60 days, putting the ram with ewes at night, or confining the ram and bringing on-heat ewes to him for service.

Uncontrolled mating will usually give a higher lamb drop than seasonal mating, but also a higher lamb mortality due to some lambs coming when feed supplies are short or during unfavorable weather.

In general, the larger the sheep enterprise and the more attention paid to the animal, the greater is the advantage of seasonal mating. In controlled mating , ram is placed with the ewes for about 2 hrs daily and the mating observed. Another method of checking mating involves swabbing the ram's brisket with pigment or paint so that mark is left on the rump of each ewe served.

Flushing:

Breeding ewes should be provided with special grazing or feeding starting a fortnight before is to begin; this can be done only where mating is controlled.

A ewe that gains in body weight just prior to and during the mating season is likely to produce more lambs of better weight. Overall lambing can be expected to increase 5 to 10% where flushing is carried out. The breeding flock should be treated for internal and external parasites before starting the flushing period.

Flushing should be done two weeks before mating. Provide good quality roughage(oat, dub, cow pea etc.). Provide 125 to 200 gm of concentrate for flushing. During pregnancy the ewes should gain 4 to 8 kg in body weight.

Benifits of flushing:

- To prepare the ewes for pregnancy.
- Stimulates ovulation rate.
- To get lambs of better weight.
- To get higher lambing percentage.

Goats are bred either by natural mating or through artificial breeding. Bucks of the indigenous breeds donate good quality semen under proper management conditions throughout the year. However, the bucks of temperate breeds if not protected from high temperature, high humidity and high solar radiation will not produce good quality semen during hot dry and hot humid seasons. Females of tropical breeds cycle throughout the year. Temperate breeds which are affected by hours of day light and breed with declining day length. They come in heat in autumn from August to November, although some may breed up to February.

Natural Breeding (Individual, Pen and Flock Mating)

The natural breeding is done by either flock mating, pen mating or hand mating. In flock mating system, breeding bucks are usually turned out in the flock during the mating season at the rate of 2 to 3 per cent of the does all through day and night. It is most widely practiced in the flocks of all farmers. Semi flock breeding or pen breeding is done to conserve the energy of bucks and give them rest. In this, the bucks are turned out for service with the flock in the pen during night and confined and stall-fed or grazed separately during the day time. Hand mating is practiced when exotic purebred sires are used, or when it is considered desirable to extend the services of buck over much larger flocks. Goats in heat do not manifest behavioural symptoms. Hence, the teaser bucks are employed for detecting the does in heat. These does are then taken out of the flocks and bred to the designated sire of the flock. In pen and hand mating systems and when teaser bucks are used for heat detection, some dye mixed in grease or simple linseed oil is smeared on the brisket of the buck. This makes it possible to record the date when the does is bred and also to remove them from the breeding flock. The colour of the dye should be changed every 16 to 18 days so that the repeaters can be discovered, if the bred does have not been removed from the flock. This is termed as marking of does by breeding buck and marked does are considered as bred.

Artificial Insemination

It is because of this that the possibility of artificially inseminating females exist. From 4 to 8 does may be inseminated from one service of a buck although as many as 30 to 40 have been reported, but the degree of success was not given as 0.1 to 0.2 cc of semen is sufficient for the purpose when there is a heavy concentration of sperm in the semen. Great numbers of sperm are of course needed as they are microscopic in size, and the reproductive tract of the female through which they must migrate to come in contact with the egg, also microscopic, is very large indeed in relation to the size of the reproductive cells. Apparently, most sperm do not survive much more than 18 to 24 hours in the reproduction tract of the doe. Russian research workers have reported impregnating from 300 to 400 does in one season with the semen collected from a single buck. They also reported that 90 per cent of the does so inseminated became pregnant. This is a far greater number than could be bred to one buck using natural methods. From 40 to 60 does is generally considered a reasonable/maximum for a buck in one season.

For the purpose of artificial insemination, artificial vaginas are used for the collection of the semen, although it may be recovered in some quantity from the vagina of a doe. Semen can be preserved for several days with suitable media and low temperature and has been transported long distances and used successfully in experimental tests. The semen is diluted for use and is injected into the vagina or deposited at the base of the cervix through a glass or plastic tube. Two inseminations at about a 12 hour interval, beginning soon after the onset of heat, are often recommended.

Although little use has been made of artificial insemination in goat except in an experimental way, some of the advantages and disadvantages are known. The chief advantages are that the usefulness of a superior sire may be greatly extended, the number of bucks needed for a large flock is reduced, and a flock of considerably greater uniformity should result. Disadvantages include the need for extra equipment and labour, some of which must be skilled in the work, the need for one or more ‗teasers' to identify which does are in estrus, and the frequent handling of the does during the breeding season.

Heat detection methods

Visual signs of approaching estrous are, a swelling and redness of the vulva and restlessness or nervousness indicating a desire for company, but the most obvious sign is ridding and in turn being ridden. The breeding occurs only during estrous although the buck is capable of breeding at any time. Overnight teasing and drafting riddled does off in the morning is quite manageable

for small lots, but when large numbers have to be inseminated, it takes lot of time as does cannot be presented for A.I. at proper time during estrous. Under the circumstances the bucks have to be worked too frequently to provide necessary semen. When large number of does are to be handled, harnessed vasectomised bucks are released with the does at about 5 p.m. and the mob turned into paddock.

Marked does are either inseminated to get the labour force acquainted with procedure and a few bucks checked and trained or these are put aside and brought back into the mob at the end of the cycle. Generally the drafted does are inseminated on the acceptable type of estrous mucus. Obviously those does which are drafted late in estrous are rejected.

Restraint of does for insemination

With the help of two attendants, does can be inseminated at the rate of 100 per hour, if the operation is streamlined, using fresh neat semen. Various methods of holding does have been used:

(a) Does held upside done in a cradle.

(b) Does placed on a battery of bails on a raised platform.

(c) Does held on a rail, as for marking.

(d) The operator working in a pit and a doe manoeuvred up to a hock bar at the edge of it.

Lambing:

- This is the most critical period in the life of both the ewe and lamb, and poor management at this time may undo previous good work.
- It may be undertaken on pasture or in confinement, depending on circumstances. The former practice is most common in Tropics and of course the only available under most extensive production systems.
- A practical method of lambing out the ewes under average Tropical flock conditions is to identify each day those ewes judged ready to lamb and hold them in camp or at house holds until the event occurs.

Symptoms of Lambing:

- Lag behind in movement in group.
- Get separated from the flock.
- Vertical movement of tail.
- Scratching the ground with forelegs.

- Restlessness: Changing position by sitting and standing alternately.
- Emergence of water bag from vulva
- On set of contraction.
- Appearance of part of lamb.

Care of New Born Lamb:

- Ensure that nose and mouth are free of membranes and mucoid fluid immediately after birth.
- Place the lamb in a clean and sheltered place.
- Clean the mucus from the body of the lamb and make it dry.
- Let the ewe also lick her lamb for:
  (a) Cleaning and removal of mucus from lamb's body.
  (b) Establishing the affinity between lamb and ewe.
- Immediately after birth, the lamb's navel cord should be cut leaving 3 cm from the body and treated with tincture of iodine to prevent invasion of bacteria.
- Mark the lamb and give permanent number and record age and number of ewe, sex of lamb and date born.
- Weigh the lamb and record it (normal birth weight varies from 2.5 to 3.5 kg in Indian sheep).
- Make sure that lamb gets first milk.
- If the lamb has not begun to nurse 15 to 20 minutes after birth, it should be assisted to do so by placing the ewe's teat in to the lamb's mouth and milking a few streams of milk in to it.
- Protect the lamb from getting chill by wrapping in jute or blanket.
- The greatest losses in productivity in most flocks are due to mortality of lambs during first 48 hrs or first week of life.
- Protect your lambs from cold or heat stress, small carnivores etc.

Care of Ewe after Lambing:

- Dispose off placenta thrown by ewe.
- Sealed orifices of teats be cleared by removing greasy plug by hand.
- Provide separate clean area in night enclosure.
- Feed lightly on hay or fresh forages with little amount of grains.

- Provide free access to water at all times.

Raising Orphan Lamb:

- To raise lamb whose lamb has died.
- For adoption to strange lamb by foster mother, some of the following measures should be followed:
  (a) Rubbing the foster mother's milk on the rump of the lamb and nose of the ewe.
  (b) Identify such ewe(s) that have lost their lambs closer to orphan lamb.
  (c) Putting the whole skin of the dead lamb over the body of orphan lamb.
  (d) Patience helps in getting ewe to accept an orphan lamb.
  (e) An attempt by ewe to lick an orphan lamb is an indication of success.

Raising Orphan Lambs By Hand:

- Feed small quantity of milk frequently, i.e. 30 gm milk at 2 hrs interval for two days.
- Increase the quantity of milk with age and weight/ size of lamb and its appetite.
- Increase the interval between feedings.
- Make use of nipples and clean bottle.
- More troubles are noticed from overfeeding than from underfeeding. Therefore do not feed too much at one time.

Pre-weaning:

- This covers the nursing period in the life of the lamb. It may vary from 2 to 5 months, depending on the intensity of production system and the extent to which milking is practiced.
- A strong healthy lamb at birth starts growing immediately and the cheapest, most efficient gains in body weight are made during the pre-weaning period.
- The best pasture available should be reserved for the ewes with growing lambs.
- Under intensive conditions, when some of the ewes are milked or where fat lambs are desired for early slaughter, creep feeding of lambs is advantageous. The lambs are hand fed usually by placing feed, e.g. grain, oil crop meals and other concentrates in a creep where the only the lambs have access to it.

Identification:

- The common practice of notching or punching holes in the ears used by most nomadic shepherds in an economical measure for identification of lambs.

- Tattoos are also satisfactory, but are expensive and special instrument is required.
- Ear tags, either of metal or plastic, with stamped numbers or letters.
- Hot iron brands, made locally from heavy wires or thin metal rods, works well when applied to the long ears of desert-type hair sheep.

Castration:

- Surplus male lambs should be castrated with in the first month of life.
- Several methods can be generally recommended; knife, emasculator, and elastrator.
- The knife should be sharp and used in combination with appropriate disinfectant. The lower one third of scrotum is severed and testicles are with drawn.
- The emasculator is a special clamping device that crushes the testicle cords, stopping the blood flow and causing the testicles to atrophy.
- Castration by use of the elastrator is also bloodless and involves placing a tight rubber band around the neck of the scrotum with testicles below. Scrotum with enclosed testicle atrophy and slough off.

Purpose:

- To stop indiscriminate mating.
- To remove surplus males for market preference.
- To make males more docile.
- To make mutton of superior quality.
- It is important in treatment of orchitis, other ailments like tumour, accidental injuries.

Time:

- Any part of the day, preferably on sunny day in the morning.
- Optimum age: With in a month (preferably 3 weeks of age).

Docking:

- It is very important to cut off the tails of long-thin tailed wooled sheep as a sanitary measure and to reduce the incidence of blowfly strike.
- Operation can be performed with a knife, chisel, elastrator, emasculator, or docking iron.
- The docked ewes are easier to shear, have much cleaner udder, and can be more easily serviced by the ram, as compared to those with intact tail.
- It may be performed at any day or time but preferably on sunny day and at about 10 days of age of lamb.

Post Weaning Management:

- These practices are ill defined in many tropical flocks, chiefly because weaning is often left to the ewes.
- The lambs should be removed from their mothers in an orderly manner at 2 to 5 months of age.
- This permits hand-milking of the ewes, if desired, or drying off and recovery for the next breeding season.
- In the post weaning period the ewes can be grazed on poorer pasture, reserving the better feed for the weaned lambs.

Replacements:

- Both male and female lambs should be tentatively identified, and separated by sex before the age of sexual maturity.
- Under intensive production methods where first breeding is desired at 10 to 12 months of age, special grazing and or supplemental food should be provided.
- Replacement stock should be maintained in a good state of health and grown at a moderate rate of development.

Meat Production:

- Lambs surplus to breeding replacement requirements can be used for meat production.
- If demand is strong in nearby market outlets, the larger, fatter lambs should be disposed of early in the post weaning period, especially where feed supplies are short and internal parasites a major threat to lamb health.

Dipping:

- To eradicate ectoparasites.
- To prevent spread of sheep scab.
- To ward off attack by sheep blow flies.
- To remove waste materials and dung from fleece.
- To get clean wool.
- The sheep are to be dipped usually once or twice in a year.
- In India, little attention is paid to dipping sheep, though vermin menace is more here and in other Tropical countries.

- In India, sheep can be dipped immediately before the post winter shearing and or before post autumn shearing.
- When there is high incidence of ectoparasites, sheep can be dipped one month after shearing too, when fleece has grown long enough to retain dip solution and also to allow cuts and scratches, incidental to shearing, time to heal.

Precautions:

- Ewes in advanced stage of pregnancy should not be dipped. Should it be necessary to do so, they should be handled gently in small lots.
- Avoid dipping on rainy days as the dip may be washed off the fleece.
- Some times a dip solution with oily bases that can be emulsified in warm water is used so that it will not be washed out by rain; the process being called as " water proofing dips".
- Always water and dip sheep before dipping so that sheep will not drink dip solution.
- Do not dip sick animals, sheep with open wounds, very young lambs and stock being sent for slaughter.
- Dip on a day which is neither too hot nor too cold.
- Complete each day's dipping by about 4 pm so that the last sheep to go will have some hrs to dry, before night falls.
- Have the preparations for dipping completed on previous day, as for as possible and commence dipping early in the morning.
- Allow sheep 15 minutes in a draining pen after dipping. The draining pen should drain back in to the bath to avoid wastage of dip solution.
- The rams should not be dipped during breeding season for fear of injury to penis and scalding of thighs.
- Follow manufacturers instructions thoroughly for preparation of dip as well as its disposal. Used dip solution should not be allowed to pollute water.
- The soiled and dung stained wool on the crutch of sheep(on buttocks and inside of thighs) should be removed with hand shears before dipping.

Common Chemicals to Be Used In Dips:

- Lindane dip: 0.031% gamma isomer concentrate for young stock, and 0.05% for adult stock.

- DDT dips: 0.5% DDT. To get this concentration mix 20 kg of 25% DDT wettable powder or 10 kg of 50% DDT wettable powder in 1000 litres.
- Pyrethrin Arsenic Sulphide powder dips: 0.2% total arsenic.
- Nicotine and Tobacco: 0.1% nicotine or soak 15 kg of tobacco leaves in 500 liters of water.

Methods:

- Sheep can be dipped by hand bath method or by swim bath.
- Hand bath is used for small flocks. A tank made of wood or galvanized iron about 1.2×1.0×0.5m is used for this purpose. Sheep should be kept in the dip for two minutes or according to dip makers instructions; its head should be immersed at least once. It is then lifted on to a draining board, where the surplus dip is squeezed from its fleece back in to the bath. Two men dip the sheep and one catches them.
- Swim bath is used for large flocks of sheep. It is quicker, since two or three sheep may be in the bath at a time. The sheep, lowered into the deep end of the dip, swim through and up the ramp into the drying pen. While swimming through the dip may be guided and helped along by a man with pole having a fork-shaped end. The head must be immersed once.
- The measurement of dipping tank depends on the number of sheep kept; but in general they are 1.5m deep, 1.5 to 2.0m long at bottom and 1.0m wide. They are usually made of concrete, at the ground level or slightly raised. At one end is situated a collecting pen and at the other end a draining pen. The draining pen should have a gradient towards the dip tank.

Pouring:

- Some times a small quantity of dip is poured on along the back, sides and belly. It is used only for special individual treatment of sheep affected with scab or when they are badly affected with maggots and, in consequence, have a broken skin and, so cannot be dipped.

Spraying:

- This comprise spraying a weak fly repelling dip solution over back and side of animals packed fairly tightly together in a pen. Spraying should be in the form of fine mist. Spraying at regular intervals is very effective in controlling ticks especially in Tropical countries.

- In developed countries fly-repellent solution is sprayed into a roomy tunnel (by means of a series of nozzles), through which animals are forced to pass. Such tunnels are simple to build.
- Smaller quantities of insecticide solutions are required for spraying. Method of preparing these solutions is the same as that of dip solution.
- Depending on the size of the flock and equipment available, liquid insecticide may be applied with a power sprayer, a hand sprayer , a sponge or brush. About 8 to 10 liters of solution are required for spraying each animal effectively.

Modern semen evaluation techniques to augment production in small ruminants

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Brief overview of frozen semen in animal reproduction

Frozen semen technology has been the pillar behind artificial insemination and one of the major strengths of assisted reproduction. The discovery of liquid N_2 and different extenders has made it relatively easy for the preservation of liquid semen. Frozen semen technology has been used as a method for dissemination of superior germplasm and also going to cater the increasing demands of meat, milk and other animal product in future. Some of the major advantages of the frozen semen are-

- Long term of storage of superior quality of sperms.
- Faster propagation of germplasm.
- Prevents the loss of semen in excess.
- Increase possibility of inseminations by using semen from a bull.
- Ease in transport and avoid country or border as a limitation for best semen.
- Animal cloning and stem cell technology are dependent on frozen semen.
- Up gradation of local breeds with superior sperms.

The mammalian sperm is a deceptively simple, and terminally differentiated cell. Although it seems to have a limited array of functional features, in essence to deliver an intact haploid genome to an oocyte at fertilization. Despite the extensive knowledge on spermatology, a definition of what constitutes a “good” spermatozoon (i.e. a male gamete with high fertilization potential) remains elusive. Besides the already mentioned species-specific differences, the fact that ejaculates from the same male may vary according to several factors, and that they are always very heterogeneous, containing both functional sperm and defective cells, is the main obstacle for proper analysis. However, there are several aspects of sperm biology that can be monitored, and which can give clear indications on the potential fertility of a given sample.

Furthermore, the analysis of sperm structure and function may be adjusted and complemented according to specific needs, be they clinical, teaching or research; and several methods can be chosen according to both the purpose of the assay, and the available resources.

Since the advent of AI, researchers have sought laboratory assays that would accurately predict the fertilizing potential of a semen sample. This goal, however, has proven difficult to achieve. This difficulty arises from the complex nature of the problem, dealing with the complexities of the spermatozoon itself, with our ability to evaluate fertility, and with our ability to manage the females to be inseminated. Part of the complexity dealing with the spermatozoa, comes from the fact that each spermatozoon is a multi compartmental cell that must possess many different attributes to be able to fertilize an oocyte. Each spermatozoon must possess:

- Motility: To carryout transit in the female reproductive tract
- Active mitochondria to supply the energy necessary for motility and other metabolic functions
- Intact acrosomal membranes that are capable of undergoing capacitation changes thereby permitting the acrosome reaction to occur, but only at the correct moment that is during fertilization.
- Receptors that permit the cell to bind to the zona pellucida and to the oolemma;
- Plasma membranes that permit fusion with the oolemma
- A nucleus that is capable of proper decondensation, nuclear reorganization, and genetic performance to maintain zygotic and embryonic development.

WHY FROZEN SEMEN AND AI IN GOATS?

- Faster propagation of superior germplasm.
- Conservation of native and pure breed.
- More kids per year.
- To enhance the goat production.
- Eliminate or reduce the cost and bother of maintaining bucks.
- Increase the rate of genetic improvement through maximal use of superior sires.

- Increase the number of does to which a buck could be bred.
- Reduced disease transmission.
- Estrous synchronization allows several does to be bred the same day.
- Easy transport of genetics.

MAJOR CONSTRAINTS OF AI IN GOATS:

- Poor diluents with limited information regarding their standardization in bucks.
- Egg yolk coagulating enzyme.
- Inhibitory effects of seminal plasma proteins.
- Poor adaptability of buck semen to ultra low temperature.
- Costs for equipment and liquid nitrogen
- Increased labor for estrus detection and insemination
- Lack of standard protocols for packaging and quality control
- Potential for spread of undesirable traits

The success of AI in goats mainly dependent on-

- Fresh vs. frozen semen
- Number and timing of inseminations
- Insemination method
- Quality and quantity of semen
- Semen handling practices
- Management of animals to be inseminated
- Proper detection of estrus in does.
- Proper mode of insemination.
- Feeding and nutritional status of does.

Sperm Compartments and Their Functional Significance

A functional sperm is composed of three main regions: the head, the mid piece, and the tail. The head contains the nucleus, in which sperm-specific DNA binding proteins, called protamines, have replaced histones. The presence of protamines allows for tighter chromatin packaging, and, together with the loss of most of the typical cell organelles and cytoplasm that takes place during spermiogenesis, this is thought to have a role in reducing cell volume and increasing the sperm's aerodynamic properties, thus potentially facilitating fertilization. It should be noted that these characteristics are also widely believed to render the sperm transcriptionally inactive, or at least translationally impaired. Overlaying the nucleus is a large secretory vesicle, the acrosome. This vesicle contains hydrolitic enzymes thought to aid in sperm penetration through oocyte-protecting layers, namely the translucent glycoprotein-based *zona pellucida*.

Release of acrosomal contents, an exocytotic process dubbed the acrosome reaction, must only take place in the vicinity of an oocyte, and the lack of an acrosome in any other circumstance signals that the sperm will likely not be fully functional. However, before the sperm can undergo the acrosome reaction it must be primed by a series of poorly understood maturation steps involving tightly regulated intracellular signaling and protein phosphorylation (characteristically on tyrosine residues), which comprise what is called sperm capacitation. The sperm tail (or flagellum) is paramount for sperm motility, and is comprised of an axoneme containing a typical 9+2 microtubular arrangement, consisting of nine doublet pairs of peripheral microtubules, arranged in circle around a central pair.

Other protein structures (the outer dense fibers and fibrous sheath) are arranged around the axoneme, adding strength and resistance to the tail. The sperm midpiece, as its name indicates, apparently connects the head and the tail, although it in fact consists of a variable number of mitochondria wrapped helically around the anterior portion of the flagellum. It has been assumed that the role of these mitochondria might be to provide ATP for sperm movement through oxidative phosphorylation. However, it is also possible that the necessary ATP is produced mostly by glycolitic pathways throughout the flagellum, with mitochondrial ATP required only in specific circumstances. It is also very important to note that there are many species-specific differences, and what holds true for one species may not translate well (or at all) to another.

Acrosome and its Functional Significance in Frozen Semen

In order to fertilize an oocyte, a spermatozoon must first become capacitated and bind to the zona pellucida of the oocyte. Capacitation is a process in which many changes occur within the spermatozoon including but not limited to; cholesterol efflux from the plasma membrane, increases in intracellular calcium, bicarbonate, potassium, protein phosphorylation, and a decrease in intracellular pH. In the best case scenario, a spermatozoon reaches the site of fertilization and completes capacitation at the time the oocyte is present. However, cryopreservation results in a loss of lipids from the sperm membranes and a rearrangement of lipids and proteins within the membrane, which results in a ‘‘precapacitated’’ spermatozoa, resulting in a reduced fertilizing lifespan for the spermatozoon. Therefore, assays to evaluate sperm capacitation can be used to evaluate the normalcy of spermatozoa after freezing and thawing, as well as to monitor techniques designed to induce sperm capacitation for assisted reproductive technologies.

Since there are many aspects of sperm capacitation many assays have been developed which monitor one or more parts of the capacitation process. Changes in membrane fluidity can be measured, using the probe merocyanin 540, as capacitation occurs. Similarly, changes in intracellular calcium levels using chlortetracycline, Indo-1 AM or fluo-3 AM, changes in protein phosphorylation or the ability of sperm to undergo an acrosome reaction when challenged with various acrosome reaction-inducing compounds can be assessed as sperm undergo capacitation.

Sperm Mitochondria and Its Functional Significance

Several fluorescent probes have been used to evaluate sperm mitochondrial function. Mitochondrial probes are actively transported into actively respiring mitochondria, therefore, the more active the mitochondrial respiration, the more probe is accumulated. Rhodamine 123 was initially used to evaluate sperm mitochondrial function, but can only differentiate between respiring and non-respiring mitochondria. More recently, JC-1 has been used to assess spermatozoal mitochondria function. At low concentrations, JC-1 remains in the monomeric state and fluoresces green. However, at high concentrations, JC-1 forms aggregates that fluoresce orange. Therefore, JC-1 has not only the ability to distinguish functional from non-functional mitochondrial, but permits different levels of mitochondrial function to be determined by intensity of mitochondrial ‘orangeness’. In support of sperm motility being a measure of

mitochondrial function, the percentages of sperm with functioning mitochondria is highly correlated to sperm motility, regardless of whether rhodamine 123 or JC-1 is used to evaluate mitochondrial function.

Sperm DNA Evaluation and its Functional Significance

The genetic integrity of the spermatozoan is essential for normal embryo development. A high level of DNA fragmentation in sperm cells may represent a cause of male infertility that conventional examinations - sperm concentration, motility analysis, morphology assessment - cannot detect. Results reported in the scientific literature show regardless of the assisted reproductive technology used, elevated levels of DNA fragmentation above the critical threshold will significantly compromise the possibility of a successful pregnancy.

1. High sperm DNA fragmentation does not appear to affect fertilisation or the first or second embryo cleavage stages
2. High sperm DNA fragmentation can affect embryo cleavage once the paternal genome is switched on, and subsequent blastocyst development
3. DNA fragmentation levels are closely correlated with IUI, IVF and ICSI miscarriage and pregnancy rates
4. DNA fragmentation is significantly higher in frozen semen
5. Animals with poor semen parameters are more likely to have high DNA fragmentation
6. High sperm DNA fragmentation is also found in animals with normal semen parameters

Freeze thaw process induces a high amount of oxidative stress to the sperms causing induction of DNA fragmentation. This instead makes the sperms prone to apoptois and thereby a reduction in the sperm quality. That is why sperm DNA evaluation is a key process in frozen semen analysis. This can be achieved by-

- Comet assay of the sperms.
- Sperm chromatin assay
- TUNEL assay of the sperms.
- Detection of apoptotic like changes in the sperms through the evaluation of caspases and various death ligands.

Major Setbacks of Cryopreserved Sperms

- Cold stress to the sperms
- Formation of inter and intra cellular ice crystals
- Free radical generation and oxidative stress to the sperms.
- Capacitation like changes in the sperms
- Acrosome damage and loss of functional intact acrosome
- Loss of membrane integrity and there by osmotic stress to the sperms
- Cholesterol loss from the membrane causing reduction in the fluidity of the sperm membrane
- Chromatin crosslinking, protein denaturation and lipid peroxidation of sperm plasma membrane.
- Induction of cell death in sperms leading to apoptosis.
- Loss of functional proteins from the sperms and a consequent loss of motility and fertility in the sperms.
- Abnormal sperm motility and altered ion channels of the sperms.
- Reduction in seminal attributes after freezing.
- Enzyme leakage causing loss of sperm function.
- Reduced metabolic activity of the sperms.
- Protein tyrosine phosphorylation causing precapacitation in the sperms.
- Induction of acrosome reaction in the sperms.
- Altered ionic equilibrium in the sperms.
- Deprotamination in the sperms and hence there is a loss in the chromatin compaction.
- Reduction in the viability of the sperms.
- Damage to the sperms at cellular and molecular level causing overall loss of sperm competence for the process of fertilization.

Major Sites of Sperm Dysfunction During Freezing and Thawing

Freezing and thawing of the semen target primarily four structures of the sperms leading to reduction in the sperm quality. These sites are

- Sperm Plasma membrane and its molecular alteration in terms of ion channels and cholesterol.
- Sperm acrosome inducing precapaciation like changes along with acrosome reaction.
- Sperm nuclear DNA causing or inducing the sperm DNA fragmentation, deprotamination.
- Sperm mitochondria and alterations in the mitochondrial function along with compromised sperm motility.

Logic behind the evaluation of frozen semen:

- Freezing process induces a large number of irreversible changes in the sperms which make the sperms incapable of fertlisation.
- Generation of free radicals and oxidative stress to the sperms substantially reduce the sperm quality.
- Multiple alterations occur in the sperms both at cellular and molecular level leading to a dramatic loss in post thaw sperm quality.
- Multiple sites of sperm damage are possible during freeze thaw process as a consequence there will be a reduction in the sperm fertilizing ability.
- Cold stress, stress associated with freezing and alterations in sperms are still not understood at molecular level and hence a number unknown causes are defined for the reduction in the sperm quality.

Advanced Tests for Semen Evaluation- Need of the Hour

Routine laboratory tests cannot evaluate the inherent competence of the sperms to bring out successful fertilization. The increase in trend of molecular abnormalities at cellular and subcellular level again makes it very difficult to predict the male fertility in terms of sperm functional competence. Routine laboratory procedures are also failed to determine the future

consequence of embryonic development and hence it is essential to evaluate the sperm competence by using advanced techniques. The primary advanced techniques are-

1. Use of fluorescent probes to detect intact acrosome, intact plasma membrane and viable sperm population.
2. Targeting sperm flagella by using CASA to monitor sperm motility competence.
3. Targeting sperm mitochondria to evaluate sperm energetic as well as sperm ageing.
4. Targeting sperm DNA and protamine to evaluate the organization of sperm DNA for successful fertilization as well as embryonic development.
5. Sorting of sperms to differentiate between normal and apoptotic sperms so as to enhance semen quality.
6. Evaluation of sperm ion channels, a new venture to understand minute to minute regulation of sperm functions.
7. Evaluation of membrane architecture in terms of cholesterol content as well as functional significance in bringing out acrosome reaction and capacitation.
8. Targeting the residual cytoplasm of sperm to know their functional significance.
9. Targeting sperm sub populations with less activity to understand sperm dynamics.
10. Targeting molecular surface architecture of sperms to understand sperm functions.

Evaluation of Frozen Semen and its Significance

Correlations between laboratory results and fertility are inconsistent between studies. Part of the reason for this is that sperm must possess many attributes to fertilize an oocyte, not merely one or two or even three attributes. Secondly, for most attributes, there is not a continuum from a minimum to a maximum that affects fertility, but instead spermatozoa must possess a sufficient amount of each attribute to fertilize an oocyte. Therefore, when evaluating a specific sperm attribute, we can postulate which samples are likely to have poor fertilizing capacity, but are unable to determine if a particular sample will be fertile.

Over the past 75 year, researchers developed laboratory assays for many of the attributes spermatozoa require to fertilize an oocyte, but there are likely many sperm attributes necessary to fertilize an oocyte that are unknown. There may also be problems inherent in a specific assay

that may limit the usefulness of the data obtained. Using that assay. In addition, because each spermatozoon requires many attributes to fertilize an oocyte, an assay measuring only a single attribute will fail to detect spermatozoa defective in a different attribute, and therefore, overestimate the number of fertile spermatozoa in a semen sample.

Unfortunately, because these assays evaluate a population mean for each attribute measured, combining results from two or three different assays on the same sperm population does little to determine the 'true number of fertile sperm' in a population. To achieve this, we would need to assess all the attributes necessary for fertilization simultaneously on each individual spermatozoon.

Problems also exist in defining and measuring fertility. Fertility can be described as the percentage of females from which embryos are flushed after insemination, the percentage of females that are pregnant a defined number of days after a single insemination or multiple inseminations during a single heat cycle or several heat cycles, or the percentage of females that deliver a live offspring after insemination (again single or multiple inseminations over one or many heat cycles). Each of these is a very different response and each reflects a different aspect of maternal input that is not likely to be detected in a semen assay. In addition, for fertility data to be useful, it must accurately reflect the true fertilizing potential of the semen used.

All together above mentioned events mediate a time dependent irreversible damage to the sperms and as a consequence to this there is a reduction in sperm quality. The sperm looses the functional competence to bring out fertilization. These cellular and molecular changes are not assayed through the routine semen analysis and hence require sophisticated assays and imaging to evaluate the sperm functions. Following are some of the assays which are employed to evaluate the sperm functional competence in terms of sperm fertilization.

- Fluorescent based evaluation of sperm viability by employing PI or EBr.
- Evaluation of sperm acrosomal integrity by employing FITC-PSA staining.
- Evaluation of sperm mitochondrial activity by JC I staining.
- Evaluation of sperm DNA integrity by employing various techniques namely Comet assay, TUNEL assay, Sperm chromatin structure assay (SCSA).
- Evaluation of sperm motility through CASA.

Optimization of Conception Rates in Bovines in Sepcific Reference to Frozen Semen Evaluation

Optimization of conception rates in bovines can be achieved by both male and female factors. Following are some of the parameters which can be incorporated to enhance the conception rates in the bovines and in specific reference to frozen semen.

- Proper evaluation of semen samples by using multiple automatic and visual methods.
- Evaluation of sperm basic and sub cellular parameters.
- Proper evaluation of sperm motility by using CASA.
- Evaluation of sperm DNA integrity/Chromatin structure.
- Employment of highly sensitive fluorescent based staining of sperm components.
- Proper care of the sperm during freezing and thawing.
- Prescreening of sperms for the process of freezing.
- Selection of best quality of semen along with best ejaculates for preservation.

Concluding remarks

No doubt that frozen semen is the best choice for artificial insemination but simultaneously one cannot avoid the abnormalities induced by freeze thaw process. This ultimately compromises the fertility response when used and hence time demands to opt for multiple advanced tests for quality evaluation of sperm samples. Employment of various staining (fluorescent) will effectively solve the issue for semen evaluation along with incorporation of automation will substantially improve the semen for artificial insemination and the consequence thereof. Relatively few of these assays are conducted on every semen sample, and it is unreasonable that many of these assays should be conducted on every semen sample, due to time and expense. However, these assays might be performed on selected semen samples from males that are exhibiting low fertility to determine more precisely what spermatozoal attributes are compromised. Steps may then be taken to attempt to correct the deficiency, if possible. Unfortunately, it is very unlikely that results from any single laboratory assay will effectively estimate the fertilizing potential of a semen sample. However, laboratory assays are important, as they can help to eliminate poor samples from being used for artificial insemination and to

determine what spermatozoal defects are present in samples with poor fertility. Several laboratory assays have been developed that evaluate several spermatozoa attributes simultaneously on the same spermatozoon. Such assays increase the likelihood of more accurately identifying sub-populations of fertile sperm in a sample and are more powerful than conducting single assessments of the same sperm attributes on different sub-samples of the semen sample, which may only still measure two or three attributes. In conclusion, besides employing routine semen analysis tests, one should employ specialized sperm assays to get best quality sperms for fertilization. Along with this, optimization of freezing with the selection of best extenders will enhance the quality of frozen semen opted for artificial insemination purposes.

Techniques for differentiation of sheep and goat meat with the meat of other animals

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In recent years, interest in meat authenticity has increased due to consumer's consciousness on meat quality and its origin as well as fraudulent substitution of inferior quality meat into superior. It is also important to validate the meat in case of vetrolegal cases arise in field conditions. Meat authentication and meat species speciation also have relevance in quality control management in meat industry, food safety and human health, conservation of laws; safeguard the religious sentiments, consumer's satisfaction, fair trade, economic importance, etc. Analytical methods used in meat authentication and speciation are diverse and ranges from simplest one to most modern methods. Modern methods require diverse range of equipments and techniques and have more reliability while simple methods can perform easily but has certain limitations.

Common techniques adopted for meat species speciation are physical techniques (differentiation in colour, consistency, odour, marbling, presence of other body parts along with meat etc.), anatomical techniques (the typical dental formulations, identification on the basis of vertebrae, ribs number present on the carcass etc.), histological techniques (muscle fiber diameter, muscle fiber density, pattern of the muscle fibers etc.), chemical techniques (determination of carotene, glycogen , refractive index, iodine number etc.), biological techniques based on serological or immunological phenomenon (precipitation test, complement fixation test (CFT), enzyme-linked immunosorbent assay (ELISA), electrophoresis techniques etc.). Today various molecular techniques are also prevailing which are mostly variables of polymerase chain reactions.

1. Physical methods: The physical methods of fraudulent substitution detection are mainly based on characteristics of flesh and fat of different species.

A. Meat characteristics:

Meat	Colour	Consistency	Odour	Marbling
Beef	Dark red with slight brownish tinge	Firm and cut surfaces are shiny	-	Present
Buffalo meat	Dark red	Firm	-	Absent
Veal	Pale grey to greyish red	Firm	-	Absent
Chevon	Light red and paler than mutton	Very firm	Goaty odour	Absent
Mutton	Dark red	Firm and dense	Ammonical	Absent to scanty
Pork	Greyish white to dark red	Very soft	Urine like	Present
Poultry meat	White	Firm	-	Absent
Horse meat	Dark red with bluish tinge	Firm with prominent fascia	-	Absent
Camel meat	Red	Fairly firm	-	Absent
Dog meat	Dark red	Firm	Disagreeable and repulsive	Slightly present
Rabbit meat	Pale, grey to grey red	Firm	Pronounced	Absent
Venison	Dark red to brownish red	-	-	Absent or very less

B. Fat identification:

Fat	colour	Consistency	Fat type	Bone marrow characteristics	Remark
Beef	Yellowish white	Firm	Intramuscular fat	Pure white to reddish yellow	-
Buffalo fat	Pure white	Slightly firm	No Intramuscular fat	-	-
Veal	Reddish yellow to white	Loose and greasy	No Intramuscular fat	Pink red	-
Chevon	Pure white	Hard , firm and brittle	No intermuscular fat	Firm and slightly red	-
Mutton	Pure white	Hard , firm and brittle	Abundant intermuscular fat	Firm and slightly red	-

Pork	White	Soft and greasy	Subcutaneous but intramuscular also	Pink red and soft	On boiling it turns to whitish grey.
Poultry fat	Yellow	Loose	Mostly subcutaneous	-	-
Horse fat	In young- light gold to yellow In mature - white	Soft and greasy	No intramuscular fat	Waxy, yellow, greasy and soft	On exposure to air turns to blackish
Dog fat	White to whitish grey	Oily and greasy	Slight intramuscular	-	-
Rabbit fat	Whitish yellow	Loose	Fat is absent in muscle and confined to body cavity	-	-

2. Anatomical methods for carcass differentiation:

On the basis of anatomical structure of the carcass we can easily differentiate some closely related animal carcasses. Some of the basic structural differences in closely related animal species are as follows:

A. On the basis of dental formula:

*Cattle and buffalo $2\ \frac{(0033)}{(4033)} = 32$

*Sheep and goat $2\ \frac{(0033)}{(4033)} = 32$

*Pig $2\ \frac{(3143)}{(3143)} = 44$

*Horse $2\ \frac{(3133)}{(3133)} = 40$

B. On the basis of vertebrae and their characteristics:

Type of vertebrae	Cattle	Sheep and goat	Horse	Pigs	Chicken	Rabbit
Cervical	7	7	7	7	15-17	7
Thoracic	13	13	18	14-15	7	12
Lumber	6	6	6	6-7	L+S fused 14	7-8
Sacral	5	4	5	4		3-4
Coccygeal	18-20	16-18	15-21	20-30	5-6	14-20

Characteristics	Horse	Cattle	Sheep	Goat
Superior spinous processes of first six dorsal vertebrae	Well developed	Less developed	-	-
Transverse processes of last three lumbar vertebrae	Articulate with each other	No articulation	-	-
Lateral border of sacrum	-	-	Thickened in form of roll	Thin and sharp

C. On the basis of number of ribs and their degree of curvature:

Characteristics	Cattle	Sheep	Goat	Horse	Pig	Chicken	Rabbit
Number of ribs	13	13	13	18	14-15	7	12
Degree of ribs curvature	Less curved	-	-	Markedly curved	-	-	-
Thoracic cavity	Smaller	-	-	Longer	-	-	-

Thorax	-	Barrel shaped	Laterally flattened	-	-	-	-

D. On the basis of specific characteristics of long bones:

Characteristics	Sheep	Goat	Horse	Cattle
a. In fore quarter				
Scapula	Short and broad, superior spine bent back and thickened	Distinct neck, straight and narrow spine	-	-
Radius	1.25 length of metacarpus	Twice the length of metacarpus	-	-
Ulna	-	-	Extends half of the length of radius	Extends full length of radius and articulates with carpus
b. In hind quarter				
Femur	-	-	Third trocanter present	Third trocanter absent
Fibula	-	-	Extends 2/3rd length of tibia	It is small point projection

E. Sex determination on anatomical basis: sex of the meat species can be identified on the basis of gonads and udder. The presence of developed gracilis and bulbocavernosus muscle (erector and retractor penis muscle) indicates the male carcass. Sex can also be detected by seeing the size of pelvic cavity.

F. Histological methods: On the basis of muscle fibre length, diameter, density and pattern we can identify the meat species. Muscle fibre diameter of buffalo meat smaller is smaller than ox meat while number of fibres per mm^2 is more than ox. The striation of muscles in buffalo is more angular as compared to ox while it is horizontal in poultry meat. In poultry, muscle fibres are thinner and density values are greater than other species.

3. Chemical methods: To determine the meat species, various chemical tests are of immense use in which we can identify different meat constituents and body fat parameters to reach on a particular conclusion.

Tests	Beef	Cara-beef	Mutton	Chevon	Pork	Horse
Glycogen (%)	0.5-1.0	0.5-1.0	0.5-1.0	0.5-1.0	0.5-1.0	2.28
Intramuscular fat (%)	2.6	0.9	13.3	3.6	4.4	Nil
Linoleic acid (%)	0.1	0.1	0.1	0.1	0.1	1-2
Carotene (mg/g fat)	0.14-0.22	Nil	-	-	-	-
Refractive index	40	-	41.5	41.5	51.9	53.5
Iodine value	38-46	-	35-45	35-45	50-70	71-86
Vitamin-A	Present	Absent	Present	Absent	Absent	-

1. **Biological or serological or immunological techniques**

a. Ring Precipitation Test: RPT is a qualitative test in which antigen antibody reaction takes place. Finally at a point of interaction between antigens and antibodies a ring formation occurs which shows the positive results. Test is not suitable for identification of heat treated meat and sometimes gives false +ve results and formed ring diffused shortly.

b. Double Immunodiffusion Test: DID is also based on the same principles as RPT. However, in DID compliments are used to holds the bands for longer period of time and to enhance their visibility. Meat can be identified both qualitatively and quantitatively. Meat adulteration upto 5% can be detected and cooked meat at 80°C for 10 min can

easily be identified. Howver, test is time consuming (2-3 days) and also gives false +ve result in closely related species.

c. Overnight Rapid Identification Test: There are various types of test kits are available to identify the meat species from the mixture of meat. These tests are Overnight Rapid Beef Identification Test (ORBIT) or Poultry Rapid Overnight Field Identification Test (PROFIT) or Multispecies identification field test (MULTI-SIFT) or Dot-blot technique. In these tests three disks, i.e., blank, disk with beef or poultry antigen and disk with bovine or poultry antiserum are generally used. The sample fluid is filled in blank disk and directly placed in precast agar gel and allow it to incubate overnight and then observed for precipitation development. Multispecies identification can also be performed using Multispecies identification field test (MULTI-SIFT). In Dot-blot technique binding of antigen from the sample takes place in a membrane (nitrocellulose or cyanogen bromide activated nitrocellulose) with a specific antibody. These tests are not suitable for quantitative analysis.

d. Enzyme Linked Immunosorbent Assay (ELISA): ELISA is a most common technique and rapid technique in which results can be obtained within 2-3 hrs. Larger number of samples can be handled at a time and closely related species identification can be performed. Adulteration upto 2% and Pressure cooked meat at 133°C for 20 min. can be identified.

e. Electrophoresis techniques: In electrophoresis, separation of proteins takes place by their differential migration through supportive medium under influence of electric field. The formed bands thus visualized by enzymological, chemical and immunological means. The common techniques are Polyacrylamide Agar Gel Electrophoresis (PAGE), Sodium Dodecyl Sulphate Polyacrylamide Agar Gel Electrophoresis (SDS PAGE), Counter Immuno-electrophoris etc. It is rapid and more sensitive test for meat species speciation.

f. Isoelectric Focusing: IEC technique is basically utilized the principle of protein migration in pH gradient. Species specific bands generated in test can be identified on the basis of location, density and area of bands. Fresh as well as 100°C cooked meat can be identified by this technique but it is not a suitable method for closely related species and frozen meat.

g. Chromatographic techniques: Cation exchange chromatography and high performance

liquid chromatography are the most common types of chromatographic techniques used for meat speciation. In cation exchange chromatography, separation of haemoglobin followed by filtration with cellulose acetate paper is done and finally diode array detection is performed at 416 nm. Meat species can be identified based on the characteristics peak patterns of cation exchange chromatography.

2. **Molecular techniques:**

Molecular techniques used for meat speciation are mainly based on Polymerase Chain Reaction (PCR). It is highly selective and specific test to find out the species of meat in a mixture of meat sample. It is a highly sensitive technique and closely related meat species can easily be identified. The variants of PCR used for meat speciation may be categorized as PCR sequencing, DNA barcoding, Species specific PCR, Polymerase chain reaction-Restriction fragment length polymorphism (PCR-RFLP), PCR-RFLP lab-on-a-chip technology, Species Identification by Randomly Amplified Polymorphic DNA (RAPD), Species Identification by using Forensically Informative nucleotide sequencing (FINS), Real time PCR, Taq Man assays etc.

To get better results and accurate authenticity, it is utmost important to select the proper technique for meat species speciation. The selection of technique is mainly based on the situation of meat speciation. The simple techniques may be effective if carcass and whole body parts are available for examination while molecular technique may be used in case of cooked meat, meat products and deteriorated meat samples.

Advances in exploiting goat meat and its products

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Goat is extensively distributed around worldwide (Webb *et al* 2005). There approximately 880 million goats around the world, out of which India has 140.5 million goats population (15.96%) comprising of 23 breeds that are adapted efficiently in various agro-climatic zone all over the nation. The cumulative meat production from sheep and goat in India is 0.876 MT (FAO 2012). The goattery farming contributes 14,453 crores to the agricultural economy of the nation out of which meat share 6851 crores. Goat meat contributes 10.41% of total meat production in India. The goat meat production has doubled (9.3%-18.3%) during the last decade. Goat meat is a good source of protein and is considered as red meat. The popularity and utilization of goat meat varies within and between region/communities. Consumer preference of goat meat is almost universal depending on cultural traditions and social and economic conditions (Webb *et al* 2005).

On a global meat production and consumption, goat meat consumption is less than beef (Madruga and Bressan, 2011), but goats undoubtedly serve as a staple source of red meat to non-vegetarian (Webb et al., 2005), particularly in developing countries. It is estimated that 98% of the goat population is in developing nations where more than 30 breeds exist that are under-utilized (Devendra, 2010). In India, goat meat is preferred over mutton (Sen et al., 2004). However in India most of the goats are slaughtered in unorganised way outside the market with little measure of hygiene. Thus development of a scientific protocol for small size modern abattoir is the need for the production of wholesome meat.

Processing and value addition to goat meat products and by-products is urgently required. Goat meat quality assurance needs to be ensured. Similarly Entrepreneurship program for processed meat sector development needs to be initiated and encouraged for goat meat. Meat products with functional benefits such as hypo-cholesterolemic, anti-carcinogenic, anti-ageing effects are being preferred by consumers and it is possible to pass on these health benefits to the consumers through development of functional goat meat products. In this area of functional goat meat, research will be conducted towards production of functional meat products to either enhance their bioavailability from their natural source or create novel foods via the addition and/or

fortification of isolated or enriched fractions of bioactive compound. Development of new functional products such as antioxidant enriched, omega-3 fatty acids enriched, low cholesterol goat milk products, herbal products, low calorie indigenous goat foods and minerals and vitamins fortified functional products and low cholesterol foods will be evaluated.

Meat Processing

Goat meat is sold mainly as whole carcasses/primal/sub-primal/retail cuts or as bone-in cubes (Kannan et al., 2001) to consumers (Pinkerton, 2002). Value is added to raw chilled meat by changing the form or utility. Meat properties and preservation are transformed by single or amalgamation unit-processing technique. Primary processing process such as tenderization, grinding, flaking, freezing, and case-ready fabrication and packaging, whereas examples of additional processing like curing, smoking, marinating, injection, emulsifying, forming and cooking (Pearson and Gillett, 1996). Value-added meat product areas also would include irradiated goat meat products for microbial safety, precooked products for convenience and nutritionally enhanced meat for healthfulness.

Ground meat

Products are popular minimally processed products, with ground meat accounting for 45 to 50% of retail meat sales in the United States (NCBA, 2001). Ground meat can be made by comminuting through a grinder plate or through bowl chopper to achieve the desired size reduction of meat (Aberle et al., 2001). James and Berry (1997) documented that the shear force was lower in comminuted goat meat patties prepared with grinding than with bowl cutter chopping. Ingredients may also enhance the physico-chemical properties or functionality of comminuted meat. Addition of 10 ppm α-tocopherol acetate into ground goat meat improved the water holding capacity, sensory attributes (odour), colour stability, retard lipid-oxidation. The incorporation of 15 to 50% oat bran to ground goat meat was observed to decrease moisture, fat, protein, Na, Zn, cholesterol, cooking loss, and shear force and to increase unsaturated fatty acids and fiber in formulated patties. There were least composition and texture changes with incorporation of 15 or 20% oat bran than control patties (Dawkins et al., 1999). Oat trim and oat gum were added to ground chevon at 0.5, 1, and 2%to provide meat products with added fiber and textural enhancement.

Cooked Goat Meat

Meat that is cooked and stored at refrigeration temperature is vulnerable to lipid-oxidation, known as warmed-over flavor (Cross et al., 1987). Refrigerated cooked goat meat developed lipid oxidation more rapidly than other cooked meats (Lamikanra and Dupuy, 1990). The cooking yield and tenderness of goat leg chops were not different between broiling and microwave cooking; however broiled chevon chops were darker in colour and lower in fat content. The cooking yield and hardness value for patties cooked to an internal temperature of 75°C were slightly higher than pan-frying and broiling (James and Berry, 1997). Higher cooking losses were recorded in leg cuts, intermediate in shoulder/arm cuts, and lowest in loin/rib cuts (Kannan et al., 2001). Freezing of broiled goat meat patties packed in polyethylene bags, thawing, and reheating did not greatly change in sensory attributes. However, meat deboned at 3 to 4 h postmortem has lower cooking yield of broiled patties than chilled meat (Padda et al., 1988). Oxidation of fat in cooked goat meat patties increased during storage in aerobic packaging at refrigeration, however it increased very slowly in cooked patties stored at −20°C (Rhee et al., 1997).

Sausages

Sausage products may be classified by texture, ingredients, curing, smoking, casing type, size, and appearance (Aberle et al., 2001). Uncured, seasoned sausages added with 25 or 50% goat meat (50-75% pork) had visual colour, juiciness and off flavour similar to that of pork sausages, however goat meat sausages had comparatively higher colour and off flavour scores. Incorporation of sodium acid pyrophosphate in sausage decreased cooking losses and improved visual colour compared with controls during the initial days of retail display (Reddy et al., 1987). Goat meat sausage had somewhat lower fat, lower cohesiveness, same gumminess and chewiness as beef and pork sausages, indicating that goat meat could be used in formulation of low fat sausages without influence on textural attributes (Gadiyaram and Kannan, 2004). Smoked sausage added with 0 and 3.5% soy protein concentrate was comparable in flavour, texture, and overall acceptance in a consumer sensory panel (Cosenza et al., 2003). Fermented chevon sausage (25% fat) with 0.5% rosemary as a natural antioxidant had decreased lipid oxidation and higher untrained sensory panel acceptability than control fermented chevon sausage during 70 d of storage in vacuum packages at room temperature (Nassu et al., 2003). Emulsion based meat products such as frankfurters and bologna require extraction and solubilisation of myofibrillar

proteins to form a stable matrix with emulsified fat and chilled water (Acton et al., 1983). Goat meat water-soluble proteins had higher emulsifying capacity than sheep, chicken, and pork proteins. Melted sheep and goat meat fat formed unstable emulsions due to its poor dispersion of the excessive quantities of saturated fat, but sheep and goat meat sausages may be used in place of other meats (Chattoraj et al., 1979). Higher fat levels in chevon emulsion sausages gave lighter colour, less firm texture, lower elasticity and springiness, and less intense smoky and seasoning flavour.

Acceptability of goat meat

Goat meat is highly preferred in India due to its unique palatability. Unlike pork and beef consumption, chevon consumption has no spiritual taboo. Religious, psychological and sensory responses (product appearance, price, aroma, flavour, tenderness, juiciness, nutritive content) determine the consumers' liking or disliking (Aberle 2001). Flavour has a huge influence on the sensory attributes of meat products, as well as its overall acceptability. Smith *et al* (1974) compared sensory quality of chevon with pork, beef and lamb at comparable maturity and fatness and reported that chevon had comparable more juiciness and flavour scores, but lesser tenderness. Chevon had a distinct flavour and aroma when compared to other meat.

Table-1: Nutritive values of goat meat (Webb et al., 2005)

Parameters	%
Moisture	69.4
Protein	22.8
Fat	10.5
Ash	0.95

Conclusions

Various meat processing and preservation technique can be used to produce chevon products, with better product consistency, uniform cutting and fabrication practices and categorization of raw meat. Goat meat have better emulsification, textural, and flavor properties that would be

useful in lower fat or processed meat products manufacturing, however lipod-oxidation of cooked goat meat and the specific product type influence storage. Consumer overall acceptability of goat meat and goat meat products is very high and dependent on consumer culture as well as desires.

Table-2: Goat meat products with incorporation of non-meat ingredients

Sr.no.	Name of products	Added ingredients	Reference
1.	Goat meat patties	Soy paste and soy granules	Das et al., 2008
2.	Chevon patties	Jackfruit	Verma et al., 2015
3.	Goat meat nuggets	Broccoli powder	Banerjee et al., 2012
4.	Goat meat nuggets	Bael pulp residue	Das et al., 2014
5.	Goat meat nuggets	Almond	Rajkumar et al., 2012

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General management of infectious goat diseases and vaccination Schedule

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Goat plays a significant role in providing supplementary income and livelihood to millions of resource poor farmers and landless labourers of rural India. In the last few years, goat production in the country has gained momentum in the form of commercially viable enterprises. In global scenario, India ranks on top in goat population in world. The demand for meat, milk and fiber is increasing progressively in the country and is expected to further rise in future in view of sizable increase in per capita income. Livestock diseases are foremosthurdle in profitable animal husbandry hence their control needs particular attention.Goat production is facing diverse challenges and multiple constraints necessitating continued research efforts and development of cost effective technologies. Outbreak and re-emergence of diseases lead to considerable economic losses, therefore, to control them is of a paramount importance in present era of bio-security as well as for safe food production. Control of PPR, Goat pox, ET, helminthoses, JD, brucellosis, FMD and blue tongue needs special attention and constant vigil to minimize economic losses.

1.Neonatal diseases:

Neonatal mortality is vital to the economic goat husbandry and is critical for the fast growth of small ruminants in the country. Several studies have shown that on an average 20% of the kids are lost every year. Based on this mortality rate, the estimated total deaths would be around 10–12 million kids each year. The variable mortality rates for small, medium and large categories of goat keeping are 32.8, 32.1 and 15.8% in kids.With present assigned value kid and adult goat, the total mortality losses due to diseases in goats at national level would be around Rs 11460 million per annum. The losses caused by morbidity have been accounted for overall economic losses and may sometimes exceed losses caused by mortality. Colibacillosis and septicemiaare generally taken as the most common cause of mortality in juvenile kids in India along with other infectious organism like Cryptosporidium*parvum*, rotavirus, *Clostridium perfringens* and *Salmonella* species.

1.1. Colibacillosis:. Diarrhea is documented as a very frequent cause of kid mortality throughout the world. Colibacillosis is a disease of very young animals usually 2-10 days old. The bacterium *Escherichia coli* (*E. coli*) isan important causative agent. This is a common inhabitant of the gastro-intestinal tract in non-pathogenic and pathogenic forms. Pathogenic serotypes, however; some of these are capable of gaining entrance to the body (septicemic form) through the intestinal wall, others remain in the intestinal tract and liberate a toxin which is absorbed by the body and causes generalized disease and diarrhea (enterotoxogenic form). The mortality due to diarrhea has been recorded as high as 60%; with enterotoxigenic strains of *E. coli* being principally involved. In a study at CIRG,all 178 isolates showed 100 % Congo red binding activity. The identification of shiga toxin producing *E. coli* (STEC) or verotoxin producing *E. coli* (VTEC) was done by PCR amplification of stx-1 and stx-2 genes. Out of 178 isolates of E. coli from the diarrheic neonatal kids, 3.93 % (7/178) were identified as STEC. The common serotypes of *E. coli* responsible for neonatal diarrhea in kids were identified as O36, O26, O59, O29, O43, O91, O82, 9 and O171, out of which, the most common were O36, O26 and O59.This is most common at 1 to 4 days of age. The common signs are anorexia, loss or decreased appetite, off feed, bloody stools, feces, hematochezia, ataxia, incoordination, staggering, falling, dehydration, fever etc. In a study at an organized farm, in clinical colibacillosis in Barbari kids overall morbidity, mortality and case fatality rates werefound to be 60.8%, 14.6% and 24.0% respectively. It wasdemonstrated that younger group (0-7 and 8-15 days) is more prone to diarrhea as compared to the age group 16-22 days. A number of *E. coli* strains have been identified and characterized in animals. Serotyping revealed mainly O2, O78, O1, O86, O21, O8, O147 and O45 serotypes of *E. coli*. Dam-hood vaccination with prevalent *E.coli* strain is an effective alternate to reduce the economic losses due to this neonate clinical problem. In an experiment at CIRG in pregnant goats of the Barbari and Jamunapari breeds, which were vaccinated with two doses of vaccine subcutaneously on 120th and 140 daysof parturition against the natural form of enteric colibacillosis. A higher incidence of diarrhea was observed in non- vaccinated kids. Effective hygiene and sanitation is also helpful to reduce the load of infection in the environment, thus prevents colibacillosis.

1.3.Rota and corona viral gastroenteritis: Lambs and kids are infected with group A rotaviruses. Rota virus has been reported from diarrheic kids in different case studies. Rotavirus generally causes diarrhea in lambs and kids at 2 to 14 days of age. Of the 120 diarrheic fecal

samples processed, 34 samples showed positive for GARV. Among the seven groups of Rotaviruses in Human beings and animals, three groups viz., GARV, GroupB Rotaviruses (GBRV) and GroupC Rotaviruses (GCRV) were reported in ruminants. The GARV is one of the major pathogens that are associated with acute neonatal diarrhea (AND) in ruminants. The incidence of AND caused by GARV recorded in the current study is 28.33%, which may be considered moderately serious. However, the pathogenicity studies have to be undertaken through field trials and system biology of viral-host interaction to establish the GARV in neonatal goat kids. In addition, a total of 80 samples were assayed by OSRT-PCR for confirmation of BCV. With the total samples processed, 19 samples were positive for BCV. Therefore, the incidence of BCV in the current study was observed at 24%. Young animals become very depressed and dehydrated. Rotavirus is treated with supportive care. Vaccinating ewes and does with bovine rotavirus vaccines before they give birth will increase passive immunity.

2.0. **Diseases of growing kids:**

2.1. Enterotoxaemia: It is an infectious disease of ruminants that results due to absorption of certain bacterial toxins being formed in the intestine by soil borne anaerobic microbes,*Clostridium perfringens* that produces fatal toxins. Five types of *Clostridiums*pp(A,B,C,D,and E) are important, which cause different disease entities in different age groups. It is impossible to manage a herd of good dairy goats without experiencing some incidence of enterotoxaemia. The disease is characterized by sudden and acute abdominal pain, distress in the form of kicking and rolling on the ground, lack of coordination, continuous changing of sitting posture, constipation followed by blackish color diarrhea. The acute course of disease lasts 4-26 hours and usually ends in death. The diagnosis of enterotoxaemia in goats is based on sign of acute death. Fecal examination andculture,reveal a predominant population large gram positive rodtypical to*C.perfringens*.Definitive diagnosis, however, can only be made in the laboratory. Intestinal contents should be preserved by adding 1 ml of chloroform to 10 ml of contents which have been collected in glass within 12hours of death for detection of epsilon toxin. Recent research with sheep and cattle on the sensitivity of *Streptococcus bovis*, the initiator of acute acidosis, to various antibiotics gives hope that powerful aids in the prevention of enterotoxaemia may be available for goats. Infection may spread through contaminated faecesand soil; therefore, hygienic conditions should be maintained at the farm. Effective

protection can be achieved by treatment with an appropriate toxoid. However, actively immunized goats provide good passive protection to their kids through colostrum till they become immune-competent. Enterotoxaemia vaccination followed by annual repetition is recommended as mandatory vaccination. Sudden change in feed and fodder should be avoided.

3.0. Other major economically important diseases:

3.1. Peste des petits ruminants: Peste des petits ruminants (PPR) which is also referred as goat plague, has always been noticed as a highly contagious disease of small ruminants and characterized by classical signs of alimentary tract disorders and respiratory tract disorders exhibited mainly in form of fever, necrotic stomatitis, lacrimation, pneumonia, fetid enteritis and high mortality. Most outbreaks in India occur after transportation of unvaccinated goat, resulting in severe set-back to of central /State sponsored programme of improvement in livelihood security through goat farming. PPR has been reported from various parts of Uttar Pradeshthroughout year. PPR seems to have become endemic in our country. In some instance, PPR has been observed simultaneously with Goat Pox and Blue Tongue. It has become a major constraint in the development ofsmall ruminant productivity among small holders by causing high mortality in young stock. Morbidity rates of 40% and mortality rates of 50-80%. In face of outbreak, quarantine, slaughter, and proper disposal of carcasses and contact fomites, decontamination, and restrictions on importation of goats from affected areas are important measures. A monoclonal antibody-based competitive enzyme-linked immunosorbent assay is commonly used to detect the presence of serum antibodies. Freeze dried PPR vaccine is recommended at the age of 3 months and confer the immunity for atleast for 3 years.

3.2. Goat pox. Goat Pox caused by GPV is highly host specific, infecting only goats but there are strains that may cause disease in both sheep and goats.Short distance aerosol transmission from nasal secretions and saliva is an important method of spread and transmission is most likely to occur by direct contact when animals are herded together at watering places, yards and markets. Environmental contamination of such sites is also important because of the resistance of the virus to inactivation.Goat pox is a serious disease with high mortality rate of 50% or high, characterized by skin eruption on whole body. In India, goat pox is frequently observed in West Bengal, Bihar, Maharashtra, Orissa, Rajasthan and adjoining areas of these states. This disease is now appearing in some areas of the UttarPradesh. In Mathura district , one confirm outbreak was reported. Goat pox is an acute to chronic disease of goats characterized by generalized pox

lesions throughout the skin and mucous membranes, a persistent fever, lymphadenitis, and often a focal viral pneumonia with lesions distributed uniformly throughout the lungs. Infection results in solid immunity. There is no specific treatment to this diseases but antimicrobial therapy helps in recovery. Goat pox vaccine is recommended in prevalent areas of country.

3.3. FMD (Foot and Mouth Disease): It is an acute febrile highly contagious viral disease of cloven-footed animals, is characterized by vesicular eruptions in the epithelium of buccal cavity, tongue, muzzle, feet, teats, and udder. In kids, there is focal degeneration of cardiac muscles, which leads to death. Most of the time, this disease is subclinical in nature in goats. The disease imposes considerable economic losses due to reduction of milk, meat, and heavy kid mortality. In India, type O, A and Asia-1 has been found prevalent.Definitive diagnosis is based on isolation of virus from suspected cases of FMD. There is no specific treatment of FMD beyond supportive care including confinement, soft &palatable food, administration of antibiotic and analgesics and topical antiseptic washing. FMD is controlled by restriction of livestock movement, isolation or slaughter of infected animal, ring vaccination around outbreak and regular vaccination. Several types of vaccines have been tried to combat FMD. Recovered animals are immune to the homologous virus only. Immunity is broken not only by different serotypes but also by the variants of same serotype. Now polyvalent vaccines are available in market.

3.4. Paratuberculosis (Johne's disease): The disease is caused by *Mycobacterium paratuberculosis*. It is one of the most important chronic wasting diseases of adult goat, mostly in intensively managed goat farm. The susceptible animals pick up infection by contaminated food and water, from contaminated feces or when animals are overcrowded and sanitation is poor. Affected animals show a continuous fall in body weight even with normal appetite, hide bound condition, rough coat, intermittent diarrhea (may or may not) followed by death. On necropsy, important lesions are thickening and corrugation of mucosa of ileo-cecal valve and enlargement of mesenteric lymph nodes. At CIRG,highly pathogenic 'Indian Bison type' has been isolated, characterized at genomic level. A test kit has been developed by CIRG (ELISA, fecal microscopy and IS900 PCR) for early detection and available to consumers. Screening of various goat farm at UP, reported the high bio burden in goats and sheep.No successful treatment. Killed vaccine has been developed by CIRG Mathura, for both preventive and therapeutic for JD in all livestock species. It is commercially available with Bio Vet, Bangaluru.

3.5. Brucellosis: It is an acute or chronic contagious disease of goats, caused *by B. melitensis*. It causes abortion in the late pregnancy, retention of placenta,metritisand mastitis in goats and infertility, orchitis, osteoarthritis, synovitis in males. The disease can be diagnosed by tube agglutination test and specific ELISA . CIRG has developed DOT ELISA based test kit for detecting Brucellosis caused by *B. melitensis,* which is available for sale from CIRG Mathura. The prevalence rate reported in goat varies from 5.0-15% and higher rate is reported in organised farming system. Antibiotics like streptomycin, oxytetracycline or enrofloxacin can be tried. The susceptible animals should be segregated from healthy flock and slaughtered. Specific vaccine against *B. melitensis* is currently not available in India but Cotton strain 19 vaccines can be used to provide protection. Frequent sero-screening program in goat flock should be implemented. Strict and proper disinfection of contaminated area by fumigation or by sprinkling of lime should be taken up. The culling of sero reactors from healthy group should be implemented. Apply "test and slaughter" policy, if feasible.

4.0. Emerging threats:

4.1. Caprine arthritis-encephalitis: Caprine arthritis-encephalitis (CAE) is an economically important viral disease of goats, caused by caprine arthritis encephalitis virus (CAEV), a lentivirus, which infects its hosts persistently for life. The disease is characterized by encephalitis in kids and arthritis, indurative mastitis and occasional interstitial pneumonia in adult goats. The encephalitic form affects usually kids of 1-6 months age and is characterized by hind limb paresis which may progress to pathetic tetraperesis, blindness, head tilt, tremors, opisthotonos, torticollis and death. The arthritic form affects older goats of over one year of age and is characterized by crippling arthritis, indurative mastitis and rare interstitial pneumonia. The disease lingers for years and animal finally die, terminally exhausted and complicated by secondary infections.

CAE was first diagnosed in goats in 1974. Since that time, it has been diagnosed in North America, Europe, Kenya, Peru, Australia, New Zealand and India. There is single authentic report on the prevalence on CAE in Indian goats, reporting 18% seropositive cases out of 1134 goat sera screened from Ajmer-Avikanagr-Ramsar, Agra-Mathura and Bhopal-Itarasi zones.The investigators also examined 2000 goats physically and found 13 clinical cases confirmed on the basis of characteristic clinical, gross and histopathological features of carpal and other joints, synovial membrane and mammary tissues, isolation of CAE virus from clinical samples in GSM

cell culture and PCR of gag sequences . Earlier data recorded in the proceedings of conferences/workshops showed a solitary case of CAE viral genome demonstration by PCR in a Barbari goat and a report of about 2% seropositive reactors from Rajasthan. Since CAE has now been recognized worldwide as a source to inflict heavy economic losses to goat industry on account of poor meat and milk production and culling of infected animals, the problem is further aggravated by the fact that all efforts to develop effective vaccine against CAE have failed.In a CAE investigation carried out at CIRG, Makhdoom, a total of 360 sera samples collected from various parts of the country screened by cELISA, 12 goats were found seropositive to CAE virus infection, with an overall prevalence of 3.33% (unpublished data). Periodic serologic testing, raising CAE free kids, administration of heat-treated goatcolostrum or pasteurized goat milk or commercial milk replacers are the primary steps to control this disease.

Control of goat diseases, mainly PPR,ET, Goat Pox,FMD,helmonthosis and ectoparasitic load are important in all management systems and assumes prime importance in the crucial time of shifting of animal agriculture from extensive to intensive i.e. commercial system of management in Uttar Pradesh. Strategic control and eradication of economically important diseases will result in enhancing goat production in the country.

Control of disease can be achieved only in a phased manner by the application of large-scale immunization of all the susceptible livestock using a potent vaccine.

Annual Health calendar for vaccination and deworming in goats, recommended by CIRG Makhdoom Mathura.

Vaccination Schedule

Name of disease	**Initial Vaccination**		**Annual vaccination**
	Ist Injection	**Booster Injection**	
1. Peste-des-petits ruminants (PPR)	At 3 months age and above	Not required	Confers immunity for 3 years
2. Enterotoxaemia (ET)	At 3- 4 months age and above	3-4 weeks later of Ist Injection	Every 6 months interval
3. Foot & Mouth Disease (FMD)	At 3-4 months age and above	3-4 month later of Ist injection	Every 6 months interval

4. Goat Pox (GP)	At 3-4 months age and above	3-4 weeks later of Ist Injection	Annual vaccination
5. Hemorrhagic Septicemia (HS)	At 3-4 months age and above	3-4 weeks later of Ist Injection	Annual vaccination

Deworming Schedule

Name of Infestation	**Age group**	**Period of drug Administration**	**Recommendation as feed mix , if any**
1. Coccidiosis	2 – 6 months	Any coccidiostat for a week period	Monensin @20 gram / 100 Kg feed from 2- 5 months of age
2. Endoparasitic infestation	After 3 months onward	Pre & Post monsoon every year	Additional dose may be given in heavy parasitic load
3. Lice infestation	Any age	Pre & Post winter	As & when required
4. Tick infestation	Any age	Monsoon months	As & when required

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Common viral disease of small ruminants

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Small ruminants are resistant to many diseases. However when we rear more number of animals in one place and insufficiency of pasture facilities, intensive system of rearing leads to spread of many diseases. This causes reduced production potential and more mortality which in turn causes economic losses to the farmers. Hence identification of diseases and its prevention is most important.

Foot and Mouth Disease

It is a Fast spreading disease, caused by apthovirus, clinically characterized as high fever 40-41^{0}C, low appetite, drinking much water at the beginning, the mouth is swollen, close tightly and has crackling sound, 2-3 days after, vesicles appear on mouth, foot, leg and udder. Clinically sheep and goats have mild infection and clinically not much evident and they acts as maintenance host for spread to other animals. Lameness is usually the first clinical sign of FMD infection in sheep and goats. This is followed by fever and vesicular development on the interdigital cleft, heel bulbs, coronary band, and mouth. Vesicles may also form on the teats of lactating animals and rarely on the vulva and prepuce. Secondary infections result in reduced milk yield, chronic lameness, and predisposition to other viral infections, including sheep/goat pox and peste des petits ruminants. The reddish nodes appear on broken vesicle. Injuries may result in inflammation and secondary diseases. Because this is a viral disease, to date there is no effective cure, Annual vaccination is the best measure to prevent FMD disease, A twice-yearly vaccination buffer zone in livestock proximal to endemic wildlife reserves may additionally help decrease outbreak.

Bluetongue

Infection with bluetongue virus (BTV) is common in a broad band across the world, where *Culicoides* mosquitoes are abundant. Fine-wool and mutton breeds of sheep mostly affected. Bluetongue virus is the type-species of the genus Orbivirus in the family Reoviridae. The course of the disease in sheep can vary from peracute to chronic, with a mortality rate of 2%–90%. Peracute cases die within 7–9 days of infection, mostly as a result of severe pulmonary edema

leading to dyspnea, frothing from the nostrils, and death by asphyxiation. In chronic cases, sheep may die 3–5 wk after infection, mainly as a result of bacterial complications, especially pasteurellosis, and exhaustion. Mild cases usually recover rapidly and completely. The major production losses include deaths, unthriftiness during prolonged convalescence, wool breaks, and reproductive losses. Vascular endothelial damage, resulting in changes to capillary permeability and subsequent intravascular coagulation, results in edema, congestion, hemorrhage, inflammation, and necrosis. additional clinical signs may be seen, such as edema of lips, nose, face, submandibular area, eyelids, and sometimes ears; congestion of mouth, nose, nasal cavities, conjunctiva, and coronary bands; and lameness and depression. A serous nasal discharge is common, later becoming mucopurulent. Some affected sheep have severe swelling of the tongue, which may become cyanotic (‘blue tongue”) and even protrude from the mouth. Current recommended serologic techniques for detection of BTV antibody include agar gel immunodiffusion and competitive ELISA.

There is no specific treatment for animals with bluetongue apart from rest, provision of soft food, and good husbandry. Complicating and secondary infections should be treated appropriately during the recovery period. Prophylactic immunization of sheep remains the most effective and practical control measure against bluetongue in endemic regions. Attenuated and inactivated vaccines against BTV are commercially available in some countries. Three polyvalent vaccines, each comprising five different BTV serotypes attenuated by serial passage in embryonated hens' eggs followed by growth and plaque selection in cell culture, are widely used in southern Africa and elsewhere, should epizootics of bluetongue occur. Control of vectors by using insecticides or protection from vectors may lower the number of *Culicoides*bites and subsequently the risk of exposure to BTV infection. However, these measures alone are unlikely to effectively halt a bluetongue epidemic and should be regarded as mitigation measures to be used alongside a comprehensive and vigorous vaccination program.

Sheeppox and goatpox

Sheeppox and goatpox are serious, often fatal, diseases characterized by widespread skin eruption. Both diseases are confined to parts of southeastern Europe, Africa, and Asia. The clinical picture is similar in sheep and goats but less severe in goats. Fever, Eyelids become swollen, and mucopurulent discharge crusts the nostrils. Widespread skin lesions develop and are most readily seen on the muzzle, ears, and areas free of wool or long hair, vesicles and pustules

are not evident clinically. Infection results in solid and enduring immunity, live attenuated virus vaccines induce longer immunity than inactivated virus vaccines. Live, attenuated, lumpy skin disease virus also can be used as a vaccine against sheeppox and goatpox.

Scrapie

Classic scrapie, a natural disease of sheep and goats, is seen worldwide except in Australia and New Zealand. It is one of the transmissible spongiform encephalopathies (TSE), related to bovine spongiform encephalopathy caused by prion protein (PrP^{C}). The classic disease is naturally transmitted during lambing from infected dams via ingestion of infected placenta or allantoic fluids by flock mates and newborn lambs. Signs of hypersensitivity are often elicited by rubbing or scratching the sheep's back, which induces the sheep to throw its head back, make chewing motions and lick at the air, or compulsively nibble at the limbs below the carpus. A complete necropsy should be performed on any sheep dying mysteriously, including submission of the brain for immunohistochemical (IHC) testing for scrapie. The IHC test is used as a confirmatory test and is considered to be the gold standard worldwide. For disinfection, instruments should be soaked in 2.5N NaOH or a disinfectant shown to be effective against abnormal prions.

Ovine pulmonary adenocarcinoma (Jaagsiekte)

A contagious, viral, neoplastic disease of the lungs of sheep and more rarely of goats. It has been reported from Europe, Asia, Africa, and South and North America. Caused by beta retrovirus called, Jaagsiekte sheep retrovirus (JSRV). Transmission occurs predominantly through the aerosol route by inhalation of infected respiratory secretions, although the virus may also be transmitted via colostrum and milk. The tumors produce clinical signs when they become sufficiently large or numerous enough to interfere with respiration. Affected sheep lose weight and show increasing respiratory distress and panting. Crackles are audible over a much larger area than the distribution of OPA lesions determined ultrasonographically. Coughing is not prominent, and infected animals are afebrile unless secondary infection develops. During the advanced stages of clinical disease, the tumor mass may occupy up to 60% of lung parenchyma. Clinical disease ends in death after many months but sometimes within 1–2 days due to secondary pasteurellosis. Chronic weight loss, dyspnea, crackles, and copious amounts of serous nasal discharge from accumulated lung fluid in an adult sheep that is afebrile are highly

suggestive clinical signs of OPA. No specific treatment or vaccine is available. Affected sheep must be culled as soon as clinical suspicions are confirmed by ultrasonographic examination of the chest.

Ovine progressive pneumonia (maedi-visna)

Ovine progressive pneumonia and maedi-visna are chronic diseases of sheep caused by lentiviruses (family Retroviridae) Progressive pneumonia virus and maedi (meaning "dyspnea") virus induce chronic progressive pneumonias that present with similar clinical signs. Visna (meaning "wasting") is the term used in many parts of the world to refer to the neurologic form of the disease in sheep, resulting initially in unilateral pelvic paresis, progressing to paralysis. Transmission occurs most commonly via the oral route, usually by ingestion of colostrum or milk that contains virus, or by inhalation of infected aerosol droplets. Signs rarely occur in sheep <2 yr old and are most common in sheep >4 yr old. The disease progresses slowly, with wasting and increasing respiratory distress as the main signs. Coughing, bronchial exudate, depression, and fever are seldom evident unless secondary bacterial infection occurs. The encephalitic form of visna causes head tilt and circling, whereas the spinal form causes unilateral pelvic limb proprioceptive deficits progressing to paresis and eventually to complete paralysis. Ultrasonographic examination is very useful to differentiate these various types of pneumonias in the live animal. Listeriosis, scrapie, cerebrospinal nematodiasis, and space-occupying lesions should be considered when the neurologic form (visna) of the disease is seen. Currently, there is no practical, effective treatment, and no vaccines are available. Therefore, the only means for control and prevention is serologic testing and removal of positive animals.

Nairobi sheep disease (NSD)

Nairobi sheep disease (NSD) is a tickborne viral disease of sheep and goats caused by *Nairovirus*, family Bunyaviridae, characterized by fever and hemorrhagic gastroenteritis, abortion, and high mortality. The African field rat (*Arvicathus abysinicus nubilans*) is a potential reservoir host. It is transmitted transovarially and transstadially by the brown ear tick, *Rhipicephalus appendiculatus*. Clinical signs begin with a steep rise in body temperature (41°–42°C [105.8°–107.6°F) that persists for 1–7 days. Leukopenia and viremia usually coincide with the febrile phase. Diarrhea usually appears 1–3 days after the onset of fever and worsens as infection progresses. Illness is manifest by depression; anorexia; mucopurulent, blood-stained,

nasal discharge; occasional conjunctivitis; and fetid dysentery that causes painful straining. Pregnant animals frequently abort. Agar gel immunodiffusion, complement fixation, and ELISA can be valuable for detection of antigen in the infected tissues or tissue culture. No specific antiviral agent is available for treatment. Unaffected animals in the flock may be treated with acaricides (eg, pyrethroids in a grease, cypermethrin "pour-on" products, various dip preparations). Longterm tick control is not cost effective in endemic areas. A single dose of the modified-live vaccine produces rapid immunity; however, revaccination is necessary to maintain full protection. Two doses of the inactivated vaccine are required to elicit good protection. Neither of these vaccines is produced commercially.

Rift Valley fever (RVF):

Peracute or acute, mosquito-borne, zoonotic disease in Africa, Madagascar, and the Arabian Peninsula caused by *Phlebovirus* and is a typical Bunyavirus. Outbreaks are usually associated with periods of abnormally heavy rainfall or, in some cases, with localized flooding due to dam building or flood irrigation. The incidence of RVF peaks during the late rainy season. People are readily infected through blood aerosols from infected animals during slaughter, or by exposure to infected animal tissues, aborted fetuses, mosquito bites, and laboratory procedures. Therefore, veterinarians, farm laborers, and abattoir workers are particularly at risk. People can also act as amplifying hosts and introduce the disease (via mosquitoes) to animals in uninfected areas. Clinical signs of RVF tend to be nonspecific, rendering it difficult to recognize individual cases. Affected animals are listless and reluctant to move or feed and may show signs of abdominal pain. Mortality in young lambs is high (90%–100%), and animals usually die within 2–3 days. Adult sheep are less susceptible, with 10%–30% mortality; the incubation period is 24–72 hr, and animals show a generalized febrile response, lethargy, hematemesis, hematochezia, and nasal discharge, although infection may also be inapparent. The virus can readily be isolated from tissues of aborted fetuses and the blood of infected animals.

The viral titer in these tissues is often high enough to use organ suspensions as antigen for a rapid diagnosis in neutralization, complement fixation, ELISA, agar gel diffusion tests, or staining of organ impression smears; however, these tests should be supplemented by isolation in suckling mice or hamsters injected intracerebrally or in cell cultures such as baby hamster kidney (BHK21), monkey kidney (Vero), chicken embryo–related (CER) and mosquito cells, or primary kidney and testis cell cultures of lambs. Immunization remains the only effective way to protect

livestock from RVF. The mouse neuro-adapted Smithburn strain of RVF virus can readily be produced in large quantities, is inexpensive, and induces a durable immunity 6–7 days after inoculation. It should normally not be used for protection of pregnant animals. More recently, a naturally attenuated avirulent isolate of Rift Valley fever, clone 13, has been used in a commercially available vaccine. It is not advisable to use live attenuated vaccines in nonendemic countries. Possible future recombinant DNA vaccines and viral strains with deletions of the major virulence genes should offer a better alternative.

Peste des petits ruminants (PPR)

Acute or subacute viral disease of goats and sheep characterized by fever, necrotic stomatitis, gastroenteritis, pneumonia, and sometimes death. Goats and sheep appear to be equally susceptible to the virus, but goats exhibit more severe clinical disease. ausal virus, a member of the *Morbillivirus* genus in the family Paramyxoviridae, PPR has been reported in virtually all parts of the African continent, except for the southern tip; the Middle East; and the entire Indian subcontinent. In the last 15 yr, PPR has rapidly expanded within Africa and to large parts of Central Asia, South Asia, and East Asia. Transmission is by close contact, and confinement seems to favor outbreaks. Secretions and excretions of sick animals are the sources of infection. cute form of PPR is accompanied by a sudden rise in body temperature to 40°–41.3°C (104°–106°F). Affected animals appear ill and restless and have a dull coat, dry muzzle, congested mucous membranes, and depressed appetite. Early, the nasal discharge is serous; later, it becomes mucopurulent and gives a putrid odor to the breath. Necrotic stomatitis affects the lower lip and gum and the gumline of the incisor teeth; in more severe cases, it may involve the dental pad, palate, cheeks and their papillae, and the tongue. Diarrhea may be profuse and accompanied by dehydration and emaciation; hypothermia and death follow, usually after 5–10 days. Bronchopneumonia, characterized by coughing, may develop at late stages of the disease. Pregnant animals may abort. Morbidity and mortality rates are higher in young animals than in adults. A presumptive diagnosis is based on clinical, pathologic, and epidemiologic findings and may be confirmed by viral isolation and identification. Historically, simple techniques such as agar-gel immunodiffusion have been used in developing countries for confirmation and reporting purposes. However, PPR virus cross-reacts with rinderpest virus in these tests. Virus isolation is a definitive test but is labor intensive, cumbersome, and takes a long time to complete. Currently, antigen capture ELISA and reverse transcription-PCR are the preferred laboratory tests for

confirmation of the virus. Local and federal authorities should be notified when PPR is suspected. PPR is also an OIE-reportable disease worldwide. Eradication is recommended when the disease appears in previously PPR-free countries. There is no specific treatment, but treatment for bacterial and parasitic complications decreases mortality in affected flocks or herds. An attenuated PPR vaccine prepared in Vero cell culture is available and affords protection from natural disease for >1 yr.

Contagious ecthyma (Orf, soremouth)

Contagious ecthyma is an infectious dermatitis of sheep and goats that affects primarily the lips of young animals. The disease is usually more severe in goats than in sheep. People are occasionally affected through direct contact. Soremouth condition is caused by a Pox virus that requires a break in the skin to enter the body. Clinical signs of a soremouth infection include scabs or blisters on the lips, nose, udder and teats, or sometimes at the junction of the hoof and skin of the lower leg. Soremouth results in loss of condition, depressed growth rates, increased susceptibility to other diseases, and death by starvation, since affected animals are less willing to eat while the infection persists. The condition will resolve on its own, but can be treated topically with iodine/glycerin solution. It is important to not use a brush or other utensil to rub or abrade the area of a sore mouth lesion as it will spread it further on the face or other tissue (Hopkins and Gill, 2008). The live vaccines for soremouth will cause soremouth lesions at a specific location on the body chosen by the handler. A hairless area of the animal, such as the inside of the ear, under the tail, or inside of the thigh, is scratched, and the vaccine is applied to this area.

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Bacterial diseases of goats

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The most common bacterial diseases affecting small ruminants in India are pneumonia, brucellosis, footrot, dermatophilosis, caseous lymphadenitis, anthrax and clostridial infections such as blackquarter, tetanus, malignant oedema and enterotoxaemias. Colibacillosis and salmonellosis are also encountered particularly under the intensive production systems.

1- PNEUMONIA

Pneumonia refers to the inflammation of the pulmonary parenchyma usually accompanied by the inflammation of bronchioles and often pleurisy and, it is characterized by respiratory embarrassment or sometimes toxaemia. Upper respiratory infections are accompanied with respiratory abnormalities and very often they descend to pneumonia.

Aetiology

The aetiologic classification of bacterial pneumonia is complicated by the fact that many types of bacteria may be isolated from the same pneumonic lesions. However, *Pasteurella spp* are the most common bacteria isolated from cases of clinical pneumonia in goats and sheep. *P. haemolytica* biotype A is the commonest isolate from pneumonic pasteurellosis although *P. haemolytica* biotype T and *P. multocida* may also be encountered. Other bacteria isolated from pneumonic lungs of goats and sheep include *Corynebacterium pyogenes, Streptococcus* spp, *Staphylococcus aureus, Proteus mirabilis, Pseudomonas aeruginosa* and *Escherichia coli.* Bacteria and mycoplasmas are commonly involved together in the pathogenesis of pneumonia in goats and sheep.

Epidemiology

It is considered to be one of the most important causes of losses in the small ruminant industry.

Some of the bacteria commonly isolated from pneumonic lungs such as *Pasteurella* spp, *Staphylococcus* spp, *Streptococcus* spp and *Corynebacterium* spp are normal flora of the

respiratory tract. Predisposing factors such as poor ventilation in animal houses, inclement weather, exhaustion during transport, severe parasitism are important in the epidemiology of pneumonia. Kids and lambs are more susceptible than adults.

Pathogenesis

The main route of transmission of pneumonia and other respiratory infections is by inhalation of infective aerosols. The pathogenesis of the disease depend on the presence of virulence factors in the bacterium, host immunity and presence or absence and severity of the predisposing factors. *P. haemolytica* possess adhesive fimbriae, secrete proteolytic enzymes and a cytotoxin, all of which enhance its establishment on the respiratory system. The fimbriae facilitates attachment on the mucosa, proteolytic enzymes break down the mucosal barrier and impair the mucocilliary function of the respiratory tract thus facilitating colonization and, the cytotoxin cause lysis of respiratory tract cells. The presence of other pathogens in the respiratory tract such as para-influenza- 3 virus and adenoviruses disrupt the phagocytic mechanisms and lower the host immunity thus favouring proliferation of pasteurellae.

Clinical features

Acute, subacute and chronic pasteurellosis may occur. Acute pneumonic pasteurellosis is characterized by laboured breathing, coughing, nasal discharges, lacrimation, anorexia, depression and sometimes pyrexia if there is a systemic involvement. Exercised animals exhibit tachypnoea and dyspnoea. Some of the acutely affected animals may die without showing any clinical signs. The subacute and chronic diseases are mainly characterised by unthriftiness.

Pathological features

The gross pathological features of pneumonic pasteurellosis include oedema, haemorrhage, congestion, emphysema and red or grey hepatisation of the lung tissue. The lesions are found predominantly on the cardioventral aspects of the lung although other areas may also be affected. Tracheal froth, adhesive pleuritis and enlargement of bronchial and mediastinal lymph nodes are common features. A serofibrinous or fibrinopurulent exudate may be expressed from the bronchioles of the cut lung surface. Other features include presence of gelatinous exudate over the pericardium and straw coloured exudate in the pleural cavity and in the interlobular spaces resulting in distension of the interlobular septa. Pulmonary abscess and adhesive fibrinous pleuritis and pericarditis are features of the subacute and chronic syndromes. Abscesses may be

encountered in regional lymph nodes. At histopathology, acute pneumonic pasteurellosis is characterised by dilation of the alveolar capillaries which are engorged with blood and mucus. The lumina of the bronchi, bronchioles and alveoli contain a serofibrinous exudate which is mixed with neutrophils, macrophages and desquamated epithelial cells. There may be diffuse alveolar necrosis, oedema of the interlobular septae and necrosis of the bronchial mucosa. Gram-negative bacteria are abundant around the necrotic foci. Thrombosis of the blood and lymphatic vessels is also evident. Abscessation, organisation and fibroplasia of the affected tissue are evident in the subacute and chronic syndromes.

Diagnosis

A tentative diagnosis of pneumonia can be achieved by consideration of the epidemiological, clinical and pathological findings. In *Pasteurella* spp infections, Gram- or methylene blue-stained smears from the lungs reveal Gram-negative Small coccobacilli which may show bipolar staining. The bacteria can be isolated from the lung lesions, pleural exudates and mediastinal lymph nodes by culturing on sheep or ox blood or MacConkey agar. The cultures are incubated aerobically at 37 °C for 24-48 hours. In MacConkey agar *P. haemolytica* produces pin-point red colonies surrounded by a narrow β-haemolytic zone. *P. multocida* colonies are larger, non-haemolytic and, may be mucoid and produce a characteristic sweetish odour. *P. multocida* does not grow on MacConkey agar. In septicaemic cases a large number of organisms can be isolated from the liver, spleen, kidneys, heart blood, pharyngeal and oesophageal mucosa. Intraperitoneal mice inoculation with suspensions of the organisms from affected tissues elicits a clinical disease with large numbers of the bacteria in tissues. Acute pneumonic pasteurellosis should be differentiated from contagious caprine pleuropneumonia (CCPP) and other mycoplasmal pleuro-pneumonias, aspiration pneumonia and septicaemic colibacillosis. CCPP does not affect sheep and can be confirmed by isolation and identification of the causative *Mycoplasma* spp. Aspiration pneumonia is commonly associated with gangrenous lesions which are not common features of acute pneumonic pasteurellosis. Chronic pneumonic pasteurellosis can be differentiated from abscesses caused by *C. pseudotuberculosis* and *Actinomyces pyogenes* by isolation and identification of the causative bacteria while verminous pneumonia can be confirmed by demonstration of eggs or larvae in the bronchi, bronchioles and alveoli. Ovine progressive pneumonia can be differentiated from chronic pneumonic pasteurellosis by

histopathological examination. Pneumonia caused by other bacteria can be confirmed by bacteriological tests.

Treatment and Control

P. hemolytica is sensitive to oxytetracycline at 20 mg/kg given parenterally. The treatment should be repeated after 4-6 days because relapses may occur. Penicillins are also used although some strains of *P. haemolytica* are not responsive to Penicillins. Ampicillin, sulphadimidine and trimethoprim-sulphonamide combinations have also been found to be effective. There is no effective vaccine against bacterial pneumonia because of the diversity of aetiologic bacteria and serotypes but in some countries, vaccination of lambs and kids with vaccines prepared from local strains of *P. haemolytica* have been used. Control of pneumonia in a herd can be achieved by isolation and treatment of the affected animals. Avoidance or minimization of predisposing factors such as overcrowding, long distance trekking and inclement weather can greatly reduce the incidence of pneumonia in a herd or farm.

2- BRUCELLOSIS

This is a disease caused by infection with bacteria of the genus *Brucella* and it is characterized by abortion in late pregnancy and subsequent high rate of infertility. Then disease is zoonotic and occupational causing undulant or Malta fever in man.

Aetiology

Brucellosis in goats and sheep is normally caused by a Gram-negative coccobacillary rod, *Brucella melitensis* although *Brucella abortus* may also cause clinical brucellosis. *Brucella ovis* is a cause of epididymitis of rams but it has also been associated with abortions and infertility. *B. melitensis* infection causes a fulminating disease in man (undulant or Malta fever) which is characterized by intermittent fever, malaise, fatigue, night sweats, muscle and joint pains whereas, *B. abortus* causes a mild disease. Osteomyelitis is a common complication in human brucellosis.

Epidemiology

The source of infection is the infected doe or ewe and *Brucella* spp tend to be abundant in the placenta, placental fluid, uterine exudate and aborted fetuses. The bacteria may persist in the uterus for about 5 months after abortion. Inhalation is the most important route of infection in

goats and sheep but infection may also be acquired through ingestion of infected material and by penetration of the bacteria through the conjuctival mucosa. *In utero* transmission may occur. The infective discharges can contaminate the environment very rapidly causing grazing animals to ingest massive numbers of the organisms. *B. melitensis* is known to be the most pathogenic of the *Brucella* spp and is more contagious than *B. abortus.* Overcrowding of animals in houses, communal grazing areas and water sources and, poor hygiene favour the rapid spread of the disease. The unrestricted movement of animals and personnel can facilitate the transmission of brucellosis between herds. Man can be infected through handling of contaminated materials, consumption of infected meat or milk or accidental inoculation with the live attenuated Rev *B. melitensis* vaccine.

Pathogenesis

After infection, *Brucella* spp multiply in macrophages and neutrophils of the regional lymph nodes causing lymphadenitis. This is followed by bacteraemia and subsequent localization of the bacteria in various organs. The gravid uterus is the primary target organ but the organisms also lodge in the mammary tissue and supramammary lymph nodes. *Brucella* spp produce an exotoxin which is enables it to establish and cause lesions.The consequences of the infection are determined by the virulence of the bacteria, resistance and reproductive status of the host. The presence of erythritol, steroid hormones and other substances in the uterus, placenta and foetal fluids favours the proliferation of *B. melitensis.* Spontaneous recovery usually occurs in animals which were infected when not pregnant.

Clinical features

Abortion storm in late pregnancy is the principal manifestation of brucellosis. An abortion storm involving about 60 % of the pregnant does in the farm or herd is common. Other features include reduced milk yield and birth of weak kids or lambs which become asymptomatic carriers. An acute septicaemic form of brucellosis may occur and is characterised by fever, depression, weight loss and sometimes diarrhoea. The presence of bacteria in the mammary tissue may cause mastitis. Epididymitis, orchitis, synovitis, hygromas, osteoarthritis, lameness and infertility are usually observed in male animals. *B. abortus* infection has been associated with neonatal deaths in lambs in Nigeria. *B. ovis* infection in rams causes inflammation of the scrotum which is manifested by oedema, enlarged and hard palpable epididymis and, obliteration of the groove

between the testis and epididymis. In the advanced stages of the disease the testis become atrophic. The infection in ewes is characterized by abortion, stillbirths or birth of weak lambs.

Pathological features

The pathological features of *B. melitensis* infection are mainly localised to the genital organs. Greyish-white necrotic areas are observed in the placenta and there is a brownish red exudate between the allantochorion and the endometrium. Acute endometritis is a common feature. Abscesses may also be present in the spleen and other parenchymatous organs. Histopathologically, there are necrotic foci around the placentomes and granulomatous foci may be encountered in the costochondral junction. Thickening and fibrosis of the tunicae, granulomata or caseation necrosis of the testis and infiltration of the semen with inflammatory cells are the main features associated with *B. ovis* infection in rams. The semen is characterised by reduced total sperm count, morphologically abnormal sperm cells which also have poor motility. In the affected ewes, there is purulent exudate in the uterus, necrosis of the uterine surface, thickening of the placenta and raised yellowish-white or whitish areas in the intercotyledonary area. The aborted foetus is oedematous.

Diagnosis

The clinical history, endemicity of the disease in the area and clinical signs may be suggestive of the disease. The disease can be confirmed by demonstration of the bacteria in smears made from the vaginal discharges, placenta, colostrum and the abomasum of the aborted foetus using the modified Ziehl-Neelsen stain (MZN) or Koster method. In MZN-stained smears the bacteria appear as red intracellular coccobacilli. Brucellae can be isolated from the abomasal contents and lungs of the foetus; mammary glands; supramammary, retropharyngeal, parotid and mandibular lymph nodes and, seminal vesicles by culturing on 5-10 % blood or selective serum agar. After incubation for about 15 days at 37°C pinpoint, smooth, glistening, bluish and translucent colonies appear. The colonies become opaque as they age. Farrels' medium and Albimi Brucella medium are selective enriched media for isolation of *Brucella* spp. The serological methods used in the diagnosis of brucellosis include serum agglutination test, Rose Bengal plate test, ELISA, agar gel immunodiffusion and complement fixation test. The complement fixation test is considered to be the most specific and most sensitive method for the diagnosis of brucellosis in small ruminants. The milk ring test, Coomb's test and whey complement fixation test are used to

detect the infection in milk. Cross-reaction occur between *B. melitensis* and *B. abortus* but not with *B. ovis.*

Brucellosis should be differentiated from other causes of abortion such as toxoplasmosis, Rift Valley fever, chlamydiosis, campylobacteriosis, listeriosis, salmonellosis and *Coxiella burnetii* infections. Hepatic necrosis is a characteristic feature of RVF and is distinguishable histologically. The other causes of abortion can be confirmed by demonstration of the causal organisms through bacteriological or other microbiological tests.

Treatment and Control

Treatment of the affected animals in usually not undertaken and such should be culled in order to reduce the sources of infection. Regular testing of animals, restriction of movement of animals and personnel between herds and purchase of animals with known health and reproductive records can prevent introduction and reduce the spread of the disease. Pasteurisation of milk is recommended in order to reduce incidence of the disease in man. All the infected materials should be incinerated and the contaminated premises disinfected. A test and slaughter policy can only be effective if it is preceded by a well organised educational programme to the livestock owners and assurance for compensation. Vaccination with a live attenuated *B. melitensis* Rev 1 strain vaccine confers strong immunity but it causes abortion if used in pregnant does and ewes. It is recommended that kid and lambs should be vaccinated at 3-8 months while adults should be vaccinated 2 months before breeding. A formalin-killed adjuvant vaccine 53 H 38 has been in use in pregnant animals elsewhere.

3- FOOTROT

Footrot is a contagious infection of the feet characterised by inflammation of the skin-horn junction, under-running of the horn, ulceration and necrosis of the sensitive laminae of the foot and severe lameness. The disease is associated with production losses and sometimes mortality due to starvation.

Aetiology

Footrot in goats and sheep is caused by a large Gram-negative rod-shaped bacterium, *Bacteroides nodosus* which is commonly associated with *Treponema penortha. Fusobacterium necrophorum* and other aerobic or anaerobic bacteria may be isolated together with *B. nodosus*

from the footrot lesions. Three serotypes A, B and C of *B. nodosus* exist. Serotypes A and B cross-react while serotype C is antigenically distinct.

Epidemiology

Footrot is a contagious infection and discharges or exudates from the affected feet contaminate the pasture or bedding. Infection occurs through contact with infected material and the organism gain entry into the body by penetration through broken skin. Prolonged wetting of the skin, scratches and bruises or surgical wounds facilitate the penetration of the bacteria and are therefore important predisposing factors. Penetration of nematode larvae such as *Bunostomum* spp and *Strongyloides* spp and, trombiculid mites through the skin can also facilitate the entry of the causative bacteria.

Wet and warm weather conditions favour the proliferation of the bacteria and soften the animal's skin thus making it easily breakable and penetrable. Dry and hot conditions are unfavourable for proliferation of *B. nodosus* and transmission of footrot and hence, the incidence of footrot tend to rise during the rainy season and drop during the dry season. In India, it has been noted that footrot is an important disease in areas of high rainfall and

relative humidity and in intensively managed herds. The intermingling and congregation of animals in communal grazing areas, poor floor types and poor disposal of urine and faeces favour the spread of the disease. Carrier animals may harbour the organism for 2-3 years.

Pathogenesis

B. nodosus produces a growth factor and extracellular proteolytic enzymes which facilitates its penetration, establishment and growth in the host tissues. The proliferation of the bacteria causes severe tissue destruction leading to interdigital dermatitis and suppuration.

Clinical features

Initially, there is a moist, swollen, hyperaemic and macerated interdigital skin and later on, a foul smelling discharge from the lesion is observed. Fever may or may not occur. Severe lameness occurs and the affected animals become recumbent. Affected animals may be seen to graze on their knees to relieve pain in affected fore feet. There is also reduced feed intake, weight gain and milk yield. Animals may die because of starvation.

Pathological features

There are no characteristic pathological features associated with footrot although grossly there is always interdigital necrosis. There is almost always some under running of the horn of the wall and usually the sole of the affected claws. A characteristic black, foul smelling material is present due to the bacterial necrosis of the horn. Spread of the infection to joints may result in pyo-arthritis and accumulation of pus in the joint cavity. At histopathology, neutrophils are abundant in pus.

Diagnosis

Clinical signs are highly suggestive of the disease. The disease can be confirmed by demonstration of *B. nodosus* in pus smears and scrapings taken from the edge of the lesions. The smears can be stained by Gram's method or by dilute carol fuchsin. The bacteria stain faintly by Gram's method but in carol fuchsin, they appear as large Gram-negative rods with terminal enlargement at one or both ends. The bacteria can be isolated from pus by culturing on a *B. nodosus* specific medium containing Eugon agar base with 0.2 % yeast extract, 10 % defribrinated horse blood agar and 1 µg lincomycin. Colonies of pathogenic strains of *B. nodosus* appear as beaded or papillate while the less pathogenic strains produce mucoid colonies Mouse or rabbit inoculation and fluorescent antibody tests are also used in the confirmation of the disease. Footrot should be differentiated from other causes of lameness such as traumatic injury, necrobacillosis, dermatophilosis (strawberry footrot), bluetongue, parasitic dermatitis, arthritis, foot and mouth disease and vesicular stomatitis. The clinical signs of footrot and necrobacillosis (foot abscess) are very similar but in necrobacillosis the principal bacterial isolate is *F. necrophorum.* The characteristic signs of necrobacillosis also include swelling of the tissues of the pastern, and the development of one or more sinceses at the coronet. The infection often spreads to involve the inter-digital space. Mixed infections with other bacteria is, however, not uncommon. Strawberry footrot is a proliferating dermatitis caused by *Dermatophilus congolensis* and it is characterised by itching and, lesions extending from the coronet to the hock or knee joints. Apart from coronitis which may be accompanied by separation of the hoof, the presence of fever, salivation, severe erosions on the muzzle and buccal cavity can be used to distinguish bluetongue from footrot. Lameness is not a feature of parasitic dermatitis but a foul smelling discharge and separation of the hoof may be confused with footrot. In addition, the

demonstration of larvae of *Strongyloides* spp, *Bunostomum* spp and trombiculid mites may be suggestive of parasitic dermatitis.

Treatment and Control

A single heavy dose of penicillin-streptomycin (containing 70,000 IU penicillin and 70 mg/kg streptomycin) given intramuscularly can be effective in the treatment of the disease. A follow-up treatment may be required if the response after the initial injection is not satisfactory. Chloramphenicol, tetracycline, erythromycin, tylosin, clindamycin, nitrofurazole parenteral and topical preparations can also be used in the treatment of the disease. Regular hoof trimming is recommended and has been found to facilitate recovery of the treated animals. Furthermore, hoof trimming can help to reduce the carrier state. Control is based on the prevention of the spread of the bacteria, maintaining good hygienic conditions in the herds and minimisation of predisposing factors. Foot-baths containing 5 % copper sulphate, 10 % zinc sulphate and 5 - 10 % formalin are used in intensive production systems.

Although vaccines containing *B. nodosus* in an oil adjuvant or pili of *B. nodosus* cells and *Pseudomonas aeruginosa* in incomplete Freund's adjuvants are used in intensive production units, vaccination of small ruminants against footrot in the traditional small ruminant systems in sub-Saharan countries is not common because of the low mortality and seasonal incidence of the disease.

4- DERMATOPHILOSIS (STREPTOTHRICOSIS)

This is an acute, subacute or chronic and sometimes fatal exudative dermatitis of animals and less frequently man which is characterised by exudation, matting of the hair/wool and formation of crusts and thick scabs. The disease is caused by a dimorphic Gram positive bacterium, *Dermatophilus congolensis.*

Epidemiology

Dermatophilosis causes losses in terms of skin damage, reduced meat and milk production, culling or death of the affected animals and, costs of control and treatment. The source of infection is the sick or carrier animal and the disease spreads by contact. Prolonged wetting and mechanical damage to the skin either by bruises, scratches or surgical wounds are the predisposing factors. Arthropod vectors such as ticks *(Amblyomma* spp), flies *(Stomoxys* spp, *Glossina* spp and *Musca* spp), lice *(Linognathus spp)* and sheep ked *(Mellophaga ovinus)* may be

involved in the transmission of dermatophilosis. *Amblyomma* spp ticks seem to play the most important role in the transmission of the disease in the field. The incidence of the disease increases with increase in rainfall, humidity and insect activity and hence the prevalence of the disease tends to higher during the rainy season compared to the dry season. Grazing of animals in spiky vegetation types predisposes them to damage of the skin and thus facilitating the penetration of the organisms.

Pathogenesis

After penetration through the skin D. congolensis causes an exudative epidermitis. Secondary bacterial infection cause extensive suppuration of the lesions or toxaemia. The lesions begin with the production of a greasy exudate and crusts on the skin which later on turn into yellowish scabs. Tension of the skin caused by adherent scabs at flexion points results in fissures. The yellowish scabs then become hard, horny and confluent resulting into alopecia. Localised lesions are common but a generalized condition has also been observed.

Clinical features

Goats are more susceptible to dermatophilosis than sheep. Clinical signs include popular and scab formation on the muzzle, face, nose, ears, scrotum and feet. The under surface of the scabs is covered with a yellow, creamy or haemorrhagic and hair-matting exudate. Concurrent infection with the contagious ecthyma virus and stress factors such as malnutrition, pregnancy and lactation exacerbate the disease. The case fatality in untreated goats is high although spontaneous recovery may occur. In sheep, the lesions start on the dorsal parts of the body and spread laterally and ventrally. Lesions may also occur on the ears, neck, face, muzzle and outer sides of legs. *D. congolensis* may cause strawberry footrot which is a proliferative dermatitis characterized by development of small, raised and dome-shaped crusts on legs especially on the anterior aspect of the pastern. Coalescence of the lesions results in the formation of wartlike masses which may extend from the coronet to the hock or knee regions.

Pathological features

At necropsy, the disease is characterised by ulceration of the skin, extensive dermatitis and secondary bacterial pneumonia. Histopathologically, there is oedema, congestion and infiltration of the epidermis with neutrophils, vacuolation of skin cells and mononuclear cell infiltration.

Occasionally, the bacteria may spread to the liver, kidneys and lymph nodes and cause hepatitis, nephritis and hyperplasia of lymph nodes.

Diagnosis

Epidemiological and clinical features are highly suggestive of the disease. The disease is confirmed by demonstration of Gram-positive mycelial organisms in impression smears made from the under surface of the scabs. The smears can be stained with 10 % Giemsa for 30 minutes or 1 % methylene blue for 30 seconds. The bacteria can be isolated by culturing suspensions of scab material which has been ground with sterile sand on blood agar containing 1,000 IU aerosporin per ml of medium. The cultures are incubated in a candle jar at 37 °C for 48-72 hours, after which whitish-yellow raised colonies with an irregular surface and clear zone of haemolysis are observed. The colonies are hard to lift from the medium. Serological methods of diagnosis include fluorescent antibody test, ELISA and counterimmunoelectrophoresis. The differential diagnosis of dermatophilosis includes mange, contagious ecthyma, fungal dermatitis, fleece rot and photosensitization. The hemorrhagic or yellowish under surface which is evident when scabs are removed and the absence of itching differentiates dermatophilosis from mange. In addition, the mange mites can be demonstrated in skin scrapings. Contagious ecthyma can be differentiated by the presence of large, thick, greyish-black and tenacious scabs which may also distort the lips and muzzle. The causal virus can be demonstrated by virological and serological tests. Fleece rot, which is caused by *Pseudomonas aeruginosa* is characterized by formation of a mat of exudate on the wool which may also be stained green, red, yellow, brown, or blue following proliferation of chromogenic bacteria on the lesions. The restriction of scabs on unpigmented and hairless parts of skin and, a history of grazing on photosensitizing plants will be highly suggestive of photosensitisation.

Treatment and Control

Heavy doses of penicillin-streptomycin (containing 70,000 IU/kg penicillin and 70 mg/kg streptomycin) are effective if administered in early stages of the disease. Heavy doses of long acting tetracyclines (20 mg/kg) may be used and a 2.5% chloramphenicol ointment may be applied topically. Cyclophosphamide (25 mg/kg) given orally has been found to be effective in the treatment of the disease in sheep. Control of ticks and biting insects by dipping or spraying with insecticides may limit transmission of the disease. Zinc sulphate (0.5 %), copper sulphate or

magnesium flurosilicate (0.2 %) solutions have been found to be effective in reducing the spread and incidence of the disease. Wherever possible injury of the animal's skin should be avoided.

5- CASEOUS LYMPHADENITIS

This is a chronic insidious disease affecting small ruminants and it is characterised by caseous abscesses in peripheral lymph nodes although the organism can spread and cause abscessation in other organs. The disease is caused by a Gram-positive facultative anaerobic and pleomorphic bacterium, *Corynebacterium pseudotuberculosis.* The economic importance of caseous lymphadenitis is related to the condemnation of the affected carcasses.

Epidemiology

Caseous lymphadenitis occurs among goat and sheep populations world-wide. Caseous lymphadenitis affects animals of all ages although it is commonly encountered in adult animals because of cumulative chances of getting infected rather than true age related susceptibility. Infection is mainly acquired by contact and, wounds or skin abrasions are the major portal of entry. Occasionally, the disease can be acquired by ingestion. Inhalation of infective material can lead to lung abscesses or pneumonia. Wet skin can be easily macerated and thus enhance penetration of bacteria. The bacteria can survive in soils which are rich in organic matter or in formites at low temperature for along time. Pastures, animals shed and dips contaminated with pus discharges from ruptured or incised abscesses may be a source of infection. Biting insects or ticks can damage the skin and facilitate transmission. In addition, un-hygienic surgical procedures such as vaccination, ear marking, wool shearing and castration can spread the disease. The use of contaminated hypodermic needles was reported to be responsible for an outbreak of the disease in a goat herd in Nigeria.

Pathogenesis

After penetration through the skin *C. pseudotuberculosis* is carried via the lymphatic and blood vessels either as free or within macrophages to the regional lymph nodes or other parts of the body. The pathogenicity of *C. pseudotuberculosis* is related to its ability to produce a haemolysin and a toxic wall factor. It has been found that the haemolysin has a phospholipase activity and it acts on the sphingomyelin of the erythrocytes and endothelial cell membranes causing haemolysis and increased vascular permeability. This facilitates further invasion of the bacteria in the tissues. The toxic wall factor protects the bacterium from phagocytosis by lysosomes thus

enabling it to survive within phagolysosomes. This is considered responsible for the chronicity of the lesions associated with *C. pseudotuberculosis*. The final outcome of the infection is determined by the initial number of bacteria entering the body of the host, the multiplication rate of the organisms and efficiency of the host defence mechanisms.

Clinical features

The incubation period can extend from 3 weeks to 4-5 months. Caseous lymphadenitis is a mild disease characterised mainly by abscessation of the prescapular, parotid, submandibular and precrural lymph nodes. Occasionally, abscessation may occur in the lungs, kidneys, spleen, heart, tongue, spinal cord, brain and joints. The general health of the animals is usually not affected although the presence of numerous active abscesses leads to progressive weight loss, weakness, collapse, coughing or respiratory distress. Other non-specific but rare signs may occur when the location of the abscesses interfere with the normal function of a particular organ or system. It has also been observed that toxaemia may occur in kids and lambs leading to arthritis and sometimes death.

Pathological features

The major gross pathological feature is the suppuration of the affected lymph nodes. The incised lymph nodes contain a thick greenish-white or yellowish-white insipissated or semifluid pus surrounded by a fibrous capsule. Insipissation may not occur in goats. On histopathology, there is a necrotic central area surrounded by neutrophils, giant cells, macrophages, plasma and epithelial cells. Gram-negative organisms can be demonstrated in smears made from the edge of the lesion. Infection of the lungs is associated with interstitial fibrosis.

Diagnosis

A provisional diagnosis of the disease can be based on clinical and pathological features. Confirmation of the disease is achieved by the demonstration of *C. pseudotuberculosis* in smears made from pus. In Gram-stained smears, the bacteria appear as pleomorphic Gram-positive rods. Pus cultured on sheep or ox blood agar for 24-48 hours at 37 °C produce small white and dry colonies surrounded by a narrow zone of haemolysis. The colonies become dry, crumbly and creamy in colour with time. Other bacteria such as *S. aureus*, *C. pyogenes* and *Actinomyces pyogenes* which cause similar abscesses in or close to lymph nodes can be differentiated by

isolation and characterization of the bacteria. Other causes of chronic wasting such as chronic parasitism and malnutrition should also be considered in the differential diagnosis.

Treatment and Control

Treatment of affected animals is considered to be not economically justifiable because of the non-fatal and non-progressive nature of the disease. However, treatment may be needed for valuable stock such as breeding animals. *C. pseudotuberculosis* responds to penicillin although the perfusion of the drug through the capsule of the abscess is poor. Parenteral antibiotics may be used in severe cases. Surgical drainage of the affected lymph nodes is recommended. The disease can be controlled by elimination of the source of the infection through culling of the affected animals. Surgical procedures such as castration, shearing or mass vaccination should be carried out under aseptic or hygienic conditions and, infected premises should be disinfected. Vaccination of 2-3 month old kids and lambs is practiced in some countries.

6- ANTHRAX

This is a peracute, acute or subacute and often fatal disease of animals and man and, in small ruminants it is characterised by septicaemia, splenomegaly and gelatinous infiltration of subcutaneous and subserosal tissues. The disease is caused by a large Gram-positive, spore-forming bacterium, *Bacillus anthracis.*

Epidemiology

Strict vaccination

programmes have reduced the incidence of the disease in most countries including india in recent years. Nevertheless, sporadic cases are still being reported. Spores are formed when the vegetative bacteria are exposed to atmospheric oxygen, suitable temperature (20-40 °C) and relative humidity (> 60 %). Spores may remain viable in the soil or water holes for many years. They may be dispersed by wind, predators, fertilizers or effluent from factories processing contaminated animal products. Animals are infected by ingestion of food, water or soil contaminated with spores. Infection may also occur by inhalation or through broken skin. Abrasion of the oral mucosa facilitates the penetration of bacteria. Mechanical transmission by biting insects has been reported. Movements of nomadic flocks of sheep and goats can introduce the disease to non-endemic areas. Outbreaks of the disease may occur following vaccination with inadequately attenuated vaccines. Wild animals can act as carriers of the disease and this makes

it difficult to eliminate the disease in areas bordering national parks or game reserves because it not possible to control the movement of wild animals or institute effective vaccination programmes.

Pathogenesis

The pathogenicity of *B. anthracis* is related to the presence of the antigenic capsule and the ability of the organism to produce a leucocidal protein toxin which is antiphagocytic, increase vascular permeability, delays blood clotting and produces capillary thrombosis. Increased capillary permeability causes leakage of body fluids into tissues and body cavities causing oedema and haemonchoncentration. Oedema of the lungs interferes with pulmonary perfusion leading to hypoxia, respiratory distress and inadequate supply of oxygen to the central nervous system. Leakage of body fluid into body tissues also results in decreased serum calcium and increased serum potassium leading to hyperirritability and convulsions which are observed in some animals. Presence of the toxin in the circulation causes severe anoxia, hypoglycaemia, alkalosis and shock which terminate into death.

Clinical features

The incubation period is 1-3 weeks. Peracute and acute forms of the disease occur in sheep and goats. The peracute disease is characterized by sudden death without premonitory signs, although there may be fever, dyspnea, muscle tremors, congestion of the mucosae and terminal convulsions in few animals. The course of the acute disease takes about 2 hours and it is initially characterised by severe depression and listlessness. Fever (42 °C), anorexia, laboured breathing, congested and haemorrhagic mucosae, increased heart rate, rumenal stasis and reduced milk production are common features. There may blood discharges from the mouth, nostrils, anus and vulva. Diarrhoea or dysentery and oedema of the tongue, sternum, flanks and perineum have been observed. Pregnant animals abort and blood-stained or reddish-yellow milk is produced. Animals then collapse and die after terminal convulsions.

Pathological features

Post mortem examination of carcasses suspected to have died from anthrax is not recommended because of the risk of exposure of the vegetative organisms to air which triggers the formation of endospores and, hence contamination of the environment. There is also an additional occupational risk. The common gross post mortem features of anthrax in goats or sheep include

complete absence of rigor mortis and rapid putrefaction and bloating of the cadaver. Non-clotting dark tarry blood oozes from the mouth, ears, nostrils, anus and vulva. The spleen is grossly enlarged with softening and sometimes liquefaction. Severe enteritis, ecchymotic haemorrhages throughout the body tissues and blood-stained fluid in body cavities are frequently observed. Histopathologically there is widespread necrosis and haemorrhage in tissues and, capillary thrombosis. Large numbers of vegetative *B. anthracis* can be demonstrated in peripheral blood during the terminal stages of the disease.

Diagnosis

Clinical signs are highly suggestive. The disease can be confirmed by demonstration of large square-ended rods in thin blood smears prepared from the ear and tail veins or from the oedema fluid. Smears stained with 1 % polychrome methylene blue (McFadyean reaction) for two minutes reveal square-ended blue rods in chains surrounded by a pink capsule while those stained with 10 % Giemsa for 30 minutes show a red-mauve capsule. Spores can also be demonstrated by the Schaeffer and Fulton malachite green technique. *B. anthracis* can be cultured from portions of the spleen and ear or blood by inoculating on sheep or ox blood agar. After aerobic incubation at 37 °C for 24-48 hours flat, dry greyish colonies with a granular 'ground glass' appearance are observed. At low magnification the edges of colonies show curved and curled projections giving rise to a 'medusa head' appearance. Intramuscularly inoculation of guinea pigs with 1 ml broth culture or oedema fluid leads to death in 24-48 hours with marked inflammatory reaction at the site of inoculation and extensive gelatinous oedema in subcutaneous tissues. Blood smears prepared from guinea pigs show typical capsulated organisms. Inoculation of mice also produces a fatal disease. The selective medium for *B. anthracis* is polymyxin-lysozyme-EDTA thallous (PLET) medium. The Ascoli test is also commonly used in the diagnosis of anthrax. The differential diagnosis of anthrax include lightening stroke, acute bloat, peracute lead poisoning, peracute blackquarter and other clostridial infections. Lightening stroke is associated with singeing of the hair and, in addition there will be a history of an electrical storm. Peracute blackquarter is mainly restricted to young animals and the crepitating swelling of the affected muscles is not observed in anthrax. Demonstration of *B. anthracis* in tissues of suspected affected animals will help to rule out acute bloat whereas, in acute lead poisoning nervous symptoms dominate.

Treatment and Control

Treatment of peracute cases is usually untimely because of sudden death. An anthrax antiserum may result in recovery if used in early stages of the disease. Oxytetracycline at a dose rate of 5 mg/kg body weight parenterally can be effective if used in early stages of the disease. Large doses of penicillin-streptomycin combinations at 12-hour interval given concurrently with the antiserum for 5 days have also been found to be effective. Control of anthrax in endemic areas is achieved by annual vaccination with live attenuated vaccines or avirulent spore vaccines. Inadequately attenuated organisms may revert to virulent forms and cause a clinical disease. If an outbreak occurs, affected animals should be isolated and strict quarantine measures should be imposed and followed by vaccination of the unaffected animals. The infected premises should be disinfected using strong disinfectants such as 5 % sodium hydroxide or formalin. Clothes can be disinfected by soaking in 10 % formaldehyde and, where facilities are available hides and skin should be disinfected with gamma irradiation to avoid human infection. Carcasses should be buried in 2-metre deep pits and covered with quicklime to prevent spore formation.

7- BLACKQUARTER (BLACKLEG)

Blackquarter is an acute infectious disease of ruminants which is characterized by inflammation of muscles, severe toxaemia and high mortality. The disease is caused by *Clostridium chauvoei* which is a Gram-positive, spore-forming and rod-shaped bacterium.

Epidemiology

C. chauvoei may be present in the liver, spleen and alimentary tract of apparently healthy animals and the clinical disease occurs when conditions in tissues become favourable for spore formation. Spores are resistant to heat and common disinfectants and can persist in soils which are rich in humus or in water holes for many years. The source of infection contaminates the soil, pasture and water reservoirs. Dead animals may be sources of spores to the environment. Animals are infected by ingestion of contaminated food or water. Spores may also enter the body through broken skin. Unhygienic mass vaccination or surgical procedures such as wool shearing or tail docking may spread the spores and result in outbreaks of the disease. Infection may occur through laceration wounds which occur in the genital tract during parturition. Sheep appear to be more susceptible than goats.

Pathogenesis

Ingested *C. chauvoei* spores pass through the intestinal wall and are carried through the lymphatic channels and blood circulation to muscles and other tissues where the lie dormant. When the muscles are bruised or necrotised the latent spores germinate and elaborate alpha, beta, gamma and delta toxins. The alpha toxin is a necrotising and lethal histotoxin which causes necrotising myositis and absorption of the toxin by muscles lead to toxaemia and death. The beta toxin destroys the nuclei of muscle cells. Exotoxins and other metabolites produced by the multiplying bacteria may cause lesions in the myocardium. Bacteraemia has also been found to develop terminally.

Clinical features

Affected animals exhibit stiff gait and hot painful swelling of the affected muscles. The muscles become oedematous and spongy. There may be crepitation but this not as marked as in cattle. Muscles of the shoulder, loin and buttocks are the most commonly involved. Serous or blood-stained fluid may ooze from the affected areas. Fever, lameness, severe depression are common features. The skin over the affected area becomes dark or black and, in later stages the swellings become cold and painless. Extensive local lesions can occur at the portal of entry.

Pathological features

The carcass rapidly putrefies and bloats. Sometimes, blood stained fluid may ooze from the nostrils and nose. There is excess fluid in body cavities which contain air bubbles, fibrin or blood. A blood-tinged or yellowish subcutaneous oedema fluid which may contain gas is a common feature. The incised affected muscles are dark-red or black with a characteristic rancid odour. Regional lymph nodes may be oedematous and haemorrhagic. Lesions tend to be deeper in sheep than in goats. The liver may decompose and produce gas.

Diagnosis

Clinical and pathological features can aid a tentative diagnosis of blackquarter. The disease is confirmed by the demonstration of large Gram-positive single rods or chains with oval, sub-terminal or central spores in smears made from the affected tissues or exudates. Smears should be made as soon after death as possible from aseptically removed pieces of the affected tissues such as muscles, subcutaneous tissue, liver, kidney and intestinal mucosa in order to avoid invasion with enteric facultative anaerobes such as C. perfringens and Cl. septicum. C. chauvoei

is a strict anaerobe and difficult to culture. However, the bacteria can be cultured from affected muscles, liver or kidneys using Cl. chauvoei sheep blood agar medium incubated anaerobically at 37 °C for 24-48 hours. Colonies are small (1-2 mm), grey and rough. They are surrounded with a clear zone of haemolysis. Colonies of most clostridia resemble and can be differentiated by Gram stain or fluorescent antibody test. The latter test uses a fluorochrome-labelled C. chauvoei antiserum. The differential diagnosis of blackquarter includes anthrax, lightning strike, snake bites, malignant oedema and other clostridial infections. Anthrax can be differentiated by its characteristic splenic lesion and the demonstration of the large square-ended bacilli in Giemsa-stained or polychrome methylene blue-stained smears (McFadyean reaction) from the ear or tail veins. It is recommended to rule out anthrax by the McFadyean reaction before carrying out a *post mortem* examination of the suspected cases. A history of an electrical storm and singeing of the hair will help to differentiate blackquarter from lightning strike. Malignant oedema and other clostridial infections may be differentiated by the fluorescent antibody test.

Treatment and Control

In early cases of the disease large doses of penicillin (10, 000 IU/kg body weight) given intravenously may result in recovery. Infiltration of the affected tissues with penicillin may also be effective in early stages of the disease. Long acting preparations of Penicillins are usually recommended. Annual vaccination using polyvalent clostridial vaccines is the main method of control of the disease in endemic areas. Vaccines derived from local strains of the bacterium are recommended. Combined blackquarter and anthrax or multi-component clostridial vaccines are commonly used in the field. Vaccination of pregnant ewes or does 2-4 weeks before parturition is useful in order to stimulate the production of antibodies that can passively protect the neonates. Quarantine measures can prevent spread of the disease in the event of an outbreak. Carcasses should be burned and buried in deep pits as for anthrax.

8-MALIGNANT OEDEMA (GAS GANGRENE)

This is an acute, febrile and fatal soil-borne wound infection of animals characterized by acute gangrenous inflammation at the site of infection, oedema and toxaemia. The disease is caused by clostridial organisms and *Clostridium septicum, C. chauvoei, C. perfringens, C. sordellii* and *C. norvyi* have all been isolated from the malignant oedema lesions. However, *C. septicum* is the most frequent isolate.

Epidemiology

Malignant disease is a sporadic disease which occurs world-wide. C. septicum occurs as normal flora in the intestinal tract of animals and faeces from such animals are a source of environmental contamination. The spores of C. septicum can persist in the soil and water reservoirs for a long time. All breeds and age groups of domestic animals are affected and infection occurs by contamination of wounds with spores of the bacteria. Deep puncture wound and severe trauma to tissues create anaerobic conditions which are favourable for the proliferation of the organisms. Contamination of wounds which may occur during castration, docking, wool shearing, vaccinations, intramuscular injections and dipping can result in outbreaks. The organism may also gain entry through the umbilical vessels of the new-born animals or lacerations in the genital tract which may occur during parturition.

Pathogenesis

Injury to the skin and mucous membranes facilitates penetration of the organisms into the body. Trauma of tissues is associated haemorrhage and effusions which create anaerobic conditions that are favourable for the proliferation of the bacteria. The bacteria multiply and produce an alpha toxin which is haemolytic, necrotising and lethal. The toxin causes necrosis, gangrenous inflammation and oedema at the site of infection. Absorption of the toxin into blood circulation is associated with toxaemia and shock. Other toxins which help to amplify the pathogenic effects of the alpha toxin such as beta, gamma and delta are also produced.

Clinical features

Clinical signs may be observed as early as 12-48 hours or 4-5 days after infection. Initially there is a soft swelling, marked erythema and pain of the affected area. The swelling expands rapidly, becomes tense and the skin over it becomes dark. Emphysema and marked frothy exudation from the wound may occur, but it is not observed in *C. norvyi* infections. Fever (41-42 °C), weakness, depression, muscle stiffness and tremors and lameness occur. Death occurs within 24-48 hours after the onset of the clinical disease. In infection acquired through the genital tract clinical signs appear within 12-24 hours and they include swelling of the vulva, perineal region and pelvic tissues. A reddish-brown discharge from the vulva is also observed.

Pathological features

At necropsy, there is gangrene of the skin and oedema of the subcutaneous and intermuscular connective tissue around the site of infection. A serous or blood-stained gelatinous oedema fluid which contain gas accumulates at the lesion but in *C. norvyi* infection, the oedema fluid is clear or gelatinous but contains no gas. When muscles are involved they become congested, pale red or brownish. Haemorrhages are observed in the subserosal tissues and the body cavities contains a serosanguinous fluid. A foul putrid odour is common in *C. perfringens* and *C. sordellii* infection. The uterus becomes atonic, reddish in colour and emphysematous.

Diagnosis

The clinical and necropsy features are quite characteristic but the disease has to be confirmed by isolation of the causative bacteria in smears made from the affected tissues. Blocks of affected tissues for laboratory diagnosis should be collected and chilled as soon as possible after death because *post mortem* invasion of tissues with enteric clostridia may complicate the diagnosis. Malignant oedema should be differentiated from blackquarter, anthrax, snake bite and other histotoxic clostridial infections. The characteristic muscle involvement which is evident in blackquarter is not a frequent feature in malignant oedema. Exudation of dark tarry blood from natural orifice is highly suggestive of anthrax and, the latter can be confirmed by demonstration of capsulated organisms by the McFadyean reaction. Other clostridial organisms can be differentiated by immunofluorescence.

Treatment and Control

Injection of penicillin or cephalosporidine on the periphery of the lesion is commonly practised in suppress replication and production of toxins by the bacteria. Other broad spectrum antibiotics can also be used. Antibiotic therapy should be accompanied with surgical drainage and irrigation of the infected wound with hydrogen peroxide. The infection can be controlled by maintaining asepsis when performing surgical procedures on animals. Prevention of animals from other causes of wounds may reduce transmission and incidence of the disease. Infected premises should be properly disinfected. In endemic areas annual vaccination of animals with specific or polyvalent formalized bacterins is recommended. In high risk areas, animals may be protected from accidental contamination by vaccination prior to anticipated surgical operations.

9-TETANUS

This is a highly fatal infectious disease of all domestic animals and man caused by a neurotoxin produced by *Clostridium tetani* and it is characterised clinically by hyperaesthesia, tetany and convulsions. *C. tetani* is a rod-shaped, spore forming Gram-positive bacterium in young cultures but becomes Gram-negative in old cultures.

Epidemiology

Tetanus is a sporadic disease which occurs world-wide. C. *tetani* is normal intestinal flora of mammals which are sources of environmental contamination. The bacterium form resistant spores which can persist in the faeces of herbivores or soil for many years. Spores enter the body through deep puncture wound and they normally lie dormant in tissues until condition become favourable for the proliferation and production of the toxin. Outbreaks of the disease may occur following mass contamination of animals during vaccination, castration, docking, shearing or other surgical procedures. Grazing on rough and spiky pastures may traumatise the buccal mucosa and facilitate entry of the bacteria. The wound may heal and close leaving the dormant spores in tissues, and they may proliferate later on when conditions become favourable. Although the disease is primarily caused by toxins produced by organisms already in tissues, pre-formed toxins in feeds or toxins produced in the gut by ingested organisms may also cause a clinical disease.

Pathogenesis

Trauma and necrosis of tissues create anaerobic conditions which favours the proliferation of dormant *C. tetani* spores and production of a potent neurotoxin (tetanospasmin). The toxin travels from site of production to the central nervous system through the blood system or through the peripheral nerves. The presence of the tetanospasmin at the inhibitory synapses or motor neurons blocks the release the gamma aminobutyric acid thus blocking the inhibitory neural impulses. As a result, there is constant potentiation of the sensory stimuli which leads to constant spasticity of muscles and hyperaesthesia. Tetanic spasms of the respiratory muscles cause asphyxia, cardiac arrest and death.

Clinical features

The incubation period is 1-3 weeks but may be longer depending on the pathogenicity of the strain, amount of toxin produced and amount of toxin entering the neural pathways or blood

stream. The earliest signs include muscle stiffness, tremors and prolapse of the third eyelid. This is followed by trismus, unsteady gait and inability to move which is caused by stiffness of the limbs and abnormal flexion of joints. Tetany of the masseter muscles causes drooling of saliva from the mouth and regurgitation of food through the nostrils. There is also anxiety, dilatation of the nostrils, retraction of the eyelids and hyperaesthesia. Increased muscular activity may result in increased body temperature (up to 42 °C). Spasms of the alimentary and urinary tract muscles cause constipation and retention of urine. Abnormal muscular contractions may cause opisthotonus, curvature of the spine and bending of the tail. Startled animals fall down with their fore and hind limbs stretched. The disease is highly fatal and death occurs 3-4 days after the onset of the clinical signs. However, spontaneous recovery may occur in animals which show a mild disease. A transient period of temporary improvement may occur before severe terminal spasms of the respiratory muscles.

Pathological features

No specific pathological lesions are associated with the disease except for the wound or traumatized tissue at the site of entry and toxin production. *C. tetani* may be cultured from such lesions.

Diagnosis

The muscular spasms and prolapse of the third eyelid are characteristic features of tetanus and a history of recent surgical procedures or trauma of tissues can be very supportive in the diagnosis of the disease. The disease can be confirmed by demonstration of the organisms in Gram-stained smears from the wounds in which they appear as Gram positive single rods or chains with bulging round or spherical spores at the end giving a typical 'drumstick' appearance. On blood agar, small, slightly raised, feathery, semitranslucent or grey colonies which are surrounded with zone of haemolysis appear after 48 hours of incubation. Smears from young cultures reveal Gram-positive rods whereas, those from old cultures show Gram-negative organisms. The differential diagnosis of tetanus include strychnine poisoning, plant poisoning, heart water, enterotoxaemia of lambs and cerebral meningitis. The muscular spasms in strychnine poisoning are not as marked as in tetanus and, a history of exposure to strychnine or demonstration of *C. tetani* or the toxin tissues of the suspected animals will help to differentiate the two conditions. In heartwater, the nervous signs are less severe and fever is a frequent feature. Enterotoxaemia

can be differentiated by isolation of the causative bacteria while cerebral meningitis is accompanied with depression.

Treatment and Control

A tetanus antitoxin is used to treat affected animals and is effective if given in early stages of the disease. Large doses of penicillin given parenterally or injected locally at the site of infection has been found to reduce further proliferation of the bacteria and toxin production. Local injection of antitoxin near the wound before debridement and irrigation with hydrogen peroxide is recommended to prevent spread of the toxin from the wound. Muscle relaxants such as acepromazine (0.05 mg/kg) should be given intramuscularly twice per day until the signs subside. Affected animals should be kept in a quiet environment and provided with enough space and soft bedding to avoid injury which may occur following muscle spasms. Intravenous or stomach tube feeding may be necessary. Prevention of wound contamination with the *C. tetani* is the major principle of control of the disease. Surgical or other procedures which may be associated with trauma to the tissues should be carried out under strict hygienic conditions. A tetanus antitoxin should be given before mass surgical operations are carried out to prevent outbreaks should contamination of the wounds occur. In endemic areas, animals should vaccinated to prevent outbreaks. A toxoid produced from an alum precipitated, formalin-treated toxin is available commercially and it provides protection for one year beginning from 2 weeks post vaccination. A booster vaccination given after 12 months provides lifelong immunity. Vaccination of ewes 8 weeks and then 2-3 weeks before parturition stimulates antibody production for passive protection of neonatal animals.

10- INFECTIOUS NECROTIC HEPATITIS

This is an acute septicaemic disease of animals especially sheep which is characterized by sudden death, hyperaesthesia, severe depression and sternal recumbency. It is caused pathogenic strains of *Clostridium norvyi* type B but the occurrence of a clinical disease is associated with necrosis of the liver tissue which makes the environment favourable for the proliferation of the bacterium and production of a lethal alpha toxin.

Epidemiology

C. norvi B is present in the intestinal tract of clinical normal animals which act as carriers. Faeces from carrier animals and cadavers of dead sheep are the source of infection. Faecal

contamination by carrion animals is also a source of infection. Water and soils may be contaminated by spores carried away from other areas by floods. Wild animals and birds have also been reported to be involved in the spread of spores. Infection occurs mainly through ingestion of spores and all ages of sheep are affected although the incidence of the disease has been found to be higher in healthy mature sheep of 2-4 years old. Neonatal animals may be infected through the umbilicus and infection through the genital tract can also occur. The occurrence of the disease is related to the distribution of liver flukes {*Fasciola* spp). A seasonal incidence of occurrence of the disease which is related to the seasonal incidence of *Fasciola* spp and their snail hosts has been demonstrated. In communal grazing system, overstocking and the congregation of animals in watering points during the dry season can result in outbreaks of fasciolosis and infectious necrotic hepatitis. Irrigation creates favorable habitats for snail hosts of liver flukes and may be associated with high incidences of both fasciolosis and infectious necrotic hepatitis. Damage to the liver tissue caused by *Dicrocoelium dendriticum* and hepatoxic chemicals can precipitate the occurrence of the disease.

Pathogenesis

After infection, the spores cross the intestinal barrier and are transported through the lymphatics and blood circulation to the liver and the spleen where they remain dormant. Damage of the liver tissue caused by migrating liver flukes create anaerobic conditions which activate latent spores. The bacteria multiply and elaborate alpha and beta toxins which are necrotizing, lethal and hemolytic. The toxins cause necrosis of the hepatic tissue and the presence of toxins in blood circulation result in diffuse toxemia.

Clinical features

Sudden death without evidence of premonitory signs may occur. Animals which survive sudden death become depressed, show disinclination to move and lag behind or separate from the rest of the flock. The neck and head may be extended and the back may be arched. There is fever (40-42 °C) which falls to subnormal temperature prior to death. Rapid and shallow respiration, ruminal stasis and hyperesthesia which is manifested by spasmodic twitching of the ears are common features The animals then falls on sternal recumbency and dies without struggling.

Pathological features

Usually the animal is in good condition but rapid putrefaction occurs. Blood-stained froth at the mouth and nostrils may be observed. There is an extensive haemorrhagic subcutaneous oedema in the sternum, ventral abdomen and inguinal regions. Congestion and cyanosis of the subcutaneous tissue results in blackening of the skin and hence, the name black disease. Thickening and oedema of the abomasal wall and congestion of the duodenal mucosa may be evident. The liver becomes engorged and dark-brown with characteristic 1-4 cm yellowish necrotic areas which are surrounded by a bright red zone of congestion are seen especially under the capsule of the diaphragmatic lobes. These areas may be deeply seated and only evident after careful incision of the liver. Haemorrhagic tracts caused by migrating immature liver flukes are evident but adult flukes may be absent. The serous cavities contain a blood-stained or serous fluid which may lead to ascites, hydrothorax and hydropericardium. Subendocardial and subepicardial hemorrhages are evident and congestion of the parietal surface of the rumen, reticulum and omasum may occur. Large numbers of C. norvi B may be demonstrated in impression smears made from the liver sections. The presence of a central zone of necrosis surrounded by a leucocytic zone containing mainly polymorphonuclear cells and occasionally lymphocytes in histological sections taken from the suspected liver is considered to be pathognomonic. A large number of vegetative or sporulating *C. norvyi* are present within the leucocytic zone.

Diagnosis

Epidemiological, clinical and pathological features may be suggestive. The disease is confirmed by demonstration of C *norvi* type B in impression smears made from the edges of the necrotic lesion. The bacteria may be cultured from pieces of the necrotic liver which have been aseptically removed from the carcass. Pieces of the liver tissue can be preserved in formalin for histological examination. The demonstration of organisms in typical lesions and demonstration of toxins in peritoneal fluid or in the liver is considered to be a positive diagnosis. The fluorescent antibody test is a rapid and simple method of diagnosis of infectious necrotic hepatitis. The clinical pathology of black disease is characterised by elevation of the liver enzymes especially gamma glutamyl dehydrogenase and, eosinophilia.

Infectious necrotic hepatitis has to be differentiated from fasciolosis. In the latter, the course of the disease is longer and the affected animals exhibit depression and anorexia. In fasciolosis, the liver is enlarged, friable and mottled and, immature flukes may be seen through the capsule together with subcapsular haemorrhages which they cause by perforation, but the necrotic foci characteristic of infectious necrotic hepatitis are absent. Other disease characterised by sudden death such as anthrax, blackquarter, malignant oedema, pulpy kidney and other clostridial enterotoxaemias can be differentiated from infectious necrotic hepatitis by identification of the causative bacteria in smears from the affected tissues using the fluorescent antibody test.

Treatment and Control

Sudden death often precludes timely and effective treatment although antibiotic therapy may be helpful in early stages of the disease. In endemic areas, vaccination of animals with an alum precipitated toxoid is commonly practised and may confer life long immunity. The use of multi-component vaccines with other clostridial species is recommended. Vaccination may reduce mortality during outbreaks. Control of fasciolosis and snail hosts can greatly reduce the incidence of the disease. Infected carcasses should be properly destroyed to avoid contamination of the environment with *C. norvyi* type B spores and infected premises should be disinfected.

11- ENTEROTOXAEMIA CAUSED BY CLOSTRIDIUM PERFRINGES TYPES B AND C.

Clostridium perfringens type B causes lamb dysentery and enterotoxaemia in goats. *C. perfringens* type C also causes acute enteritis in lambs.

Epidemiology

C. perfringens is found in the intestinal tracts of clinically normal or sick animals and pastures or soils are contaminated with faeces from such animals. Resistant spores are formed and can persist in the soil for months. Overcrowding and prolonged confinement have been found to be favourable for the spread and increased severity of the disease. Infection is acquired by ingestion of contaminated food or water. Lambs may also acquire the infection from contaminated udders or teats during suckling.

Pathogenesis

Following ingestion, the organism colonise and proliferate on the intestinal mucosa. C. *perfringens* type B producing alpha, beta and epsilon toxins whereas, *C. perfringens* type C produce alpha and beta toxins only. The beta toxin causes a severe haemorrhagic and ulceration of the intestinal mucosa. In adult animals the toxins produced are inactivated by trypsin but the neonate animals do not produce enough quantities of trypsin to destroy the beta toxin. Hence the disease is restricted to lambs under 1-2 weeks old. Necrosis and desquamation of the mucosa occurs resulting into ulcers. The irritation of the intestinal mucosa caused by presence of the organisms and toxins increases peristaltic movements and disturb the absorptive mechanisms on the mucosa resulting in loss of water and electrolytes from tissues into the gut. This is followed by dehydration, and acidosis. In addition, toxaemia which is caused by presence of toxins in the circulation cause shock which progress into death.

Clinical signs

Peracute, acute, subacute and chronic syndromes may occur. The peracute disease is characterized by sudden death without any premonitory signs. The acute syndrome is characterized by depression, failure to suckle, severe abdominal pain, bleating and lagging behind the flock or recumbency. A brownish or bloody diarrhoea is also present. The lambs then become comatose and die within 24 hours from the onset of the disease. The subacute syndrome is manifested by dullness, sluggish movements and abdominal pains. Tenesmus and a mucoid yellowish or blood-stained diarrhoea are observed. Death follows after prostration and coma. The chronic disease is mainly characterized by unthriftiness and a mucoid or blood-stained diarrhoea may be observed.

Pathological features

The acute and subacute cases are characterised by haemorrhagic enteritis, congestion and ulceration of the mucosa which becomes dark red. The intestinal contents are bloodstained and the peritoneal cavity contains excess serous or serosanguinous fluid. Adhesions of intestinal loops and presence of frank blood in the intestinal lumen have been reported. Perforation of the ulcerated intestine may occur resulting in peritoneal effusion, fibrinous peritonitis and adhesions. Subepicardial and subendocardial haemorrhages and, hepatic and renal degeneration may be evident. In chronic cases, there may be splenomegaly and clotted milk may be found in the

abomasum. Large numbers of *C. perfringens* can be demonstrated in smears made from the affected portions of the intestine.

In adult sheep, *C. perfringens* type C causes a condition known as struck which is often characterised by sudden death although the affected animals may exhibit abdominal pain and convulsions. Ulcerative and haemorrhagic enteritis, fibrinous peritonitis, petechiae in serosal tissues and transudation in the peritoneal, pleural and pericardial are observed at *post mortem.* If the examination is delayed, rapid putrefaction of the carcass occurs and the disease may resemble malignant oedema.

Diagnosis

A provisional diagnosis can be made on the basis of clinical and pathological features but the syndromes caused by *C. perfringens* can be confirmed by demonstration of the bacteria in Gram-stained smears from affected portions of the small intestine. The presence of many vegetative Gram-positive bacilli in the smears can support the diagnosis. Isolation and typing of the bacteria and demonstration of the toxins in filtrates of the intestinal contents may be a positive diagnosis. ELISA is used to detect specific antitoxins in serum or beta toxins in the intestinal contents. Enterotoxaemia should be differentiated from salmonellosis and colibacillosis which also cause haemorrhagic enteritis in neonatal lambs or kids by demonstration of the causative organisms in intestinal contents or faeces. In addition, in colibacillosis ulceration of the mucosa is not a common features.

A hyperimmune serum is effective in the treatment of the disease if given in early. Antibiotic therapy can be effective in treating mild cases of the disease. Penicillins, oxytetracyclines and chloramphenicol can be used. Vaccination of pregnant ewes 2 months and then 2 weeks before parturition using *C. perfringens* type B or C toxoid to stimulate antibody production for passive protection of neonatal lambs is recommended.

A booster dose should be given annually. Cross-protection between *C. perfringens* type B and C bacterins has been reported to occur. When outbreaks occur, sick animals should be isolated and

treated while animals at risk should be protected using a specific immunoglobulins against *C. perfringens* type B. Maintenance of good hygiene in the herd can greatly reduce transmission of the disease.

12- PULPY KIDNEY DISEASE

This is a toxaemic of sheep caused by toxin produced by *Clostridium perfringens* type D in the intestines and it is characterised by diarrhoea, paralysis, convulsions or sudden death. Goats are less commonly affected.

Epidemiology

The disease occurs world-wide. *C. perfringens* type D is an obligate parasite of the intestinal tract but under certain conditions it proliferates and produce large quantities of toxins which can be lethal. Heavy grain diet or lush pastures have been found to be favourable for the proliferation of the bacteria and occurrence of the disease. Thus, the disease commonly affects well-fed animals especially in intensive feedlot units. Factors which result in intestinal stasis or slow the of passage of the ingesta through the intestines such as heavy tapeworm infestation favour the accumulation of the toxin and occurrence of the disease. Inclement weather, coccidiosis and deworming can predispose animals to the disease. Lambs and kids of 3-12 weeks and 6-12 months old have been found to be the most susceptible groups.

Pathogenesis

C. perfringens type D organisms are abundant in the ileum and less so in other parts of the small intestine. Sudden change from low to high energy and especially starchy diets favours rapid multiplication of the saccharolytic *C. perfringens* type D which produces an epsilon toxin. The toxin is endotheliotropic and binds to the endothelial cells causing damage. Damage to the capillary endothelium results in increased permeability of the intestinal mucosa and this facilitate further absorption of the epsilon and other toxins. The toxin also causes capillary damage in other tissues such as kidneys, lungs and the brain resulting in oedema. Extracellular oedema in the brain is associated with nervous signs.

Clinical signs

Sudden death is the principal manifestation of the peracute disease in young animals although some of the animals may be dull, depressed and anorexic. In acute cases, there is frothy salivation, green or pasty diarrhoea, staggering, recumbency, opisthotonus, colonic convulsions, coma and death. Colic and bloat may occur. Affected adult sheep often lag behind the rest of the flock and show nervous signs as in young animals which include hypersensitivity, staggering gait, ataxia and knuckling of the fetlock. Champing of the jaws, blindness, salivation, rapid and

shallow respiration, atonic rumen and pasty faeces may also be evident. In goats, the acute disease is characterised by diarrhoea or dysentery, abdominal discomfort and convulsions. Death may occur within 24-36 hours of onset of the disease. In both sheep and goats, the subacute syndrome is characterised by anorexia, intermittent diarrhoea/dysentery or presence of epithelial shreds in faeces. The chronic disease is characterised by progressive weight loss, emaciation and anaemia but goats may also be diarrhoeic. The chronic nervous form of the disease is characterised by aimless wandering, incoordination, paralysis of the masseter muscles, inappetence and ruminal atony.

Pathological features

At necropsy, the carcass is in good condition and no gross changes are observed in the peracute disease. The acute syndrome is characterised by presence of a clear straw coloured fluid in the pericardial sac which rapidly clots on exposure to air, patchy congestion of the abomasal and intestinal mucosa and, presence of custard ingesta in the intestines. Diffuse petechial haemorrhages occur on the peritoneal surface of the abomasum and intestines. Petechial or ecchymotic haemorrhages also occur in the muscles of the flank, muscular portion of the diaphragm, epicardium and in the thymus. There is rapid decomposition of the carcass and purple discoloration of hairless areas of the body. The small intestine is distended with gas. A dark congested liver with haemorrhagic spots on its surface and gelatinous or blood-tinged pericardial fluid are observed a few hours after death. The kidney has a mottled appearance, soft consistency and the cortex is jelly-like or semi-fluid (pulpy kidney). Nephrosis, congestion of the renal cortex and rupture of capillaries occur. In young animals terminal rupture of the abomasum has been reported. In goats, the acute disease is characterised by pulmonary oedema, necrosis of the small and large intestinal walls. The intestinal contents may be green, blood-stained or mucoid and, fibrinous casts or strands may present the lumen of the large intestine. The mesenteric lymph nodes are oedematous.

In histological sections of the brain, the presence of perivascular oedema, haemorrhages and bilateral symmetrical areas of leucoencephalomalacia in the basal ganglia, thalamus, substantial nigra and cerebellar peduncles is characteristic of the nervous form of the disease (also known as focal symmetrical encephalomalacia).

Diagnosis

The diagnosis of the disease is based on the epidemiological features especially the type of diet, clinical and pathological features. Gram-positive *C. perfringens* D rods can be demonstrated from smears of the ingesta or intestinal lesions. Isolation of the bacteria by culturing a sample of faecal material and demonstration of epsilon toxin in intestinal contents can be highly suggestive of the disease. Protection of mice injected with toxin filtrates from the ingesta using a specific antiserum is diagnostic. An agglutination test using specific antiserum for the epsilon toxin is also used to confirm the disease. Other diagnostic tests include ELISA, counterimmunofluorescence, passive haemagglutination and radial immunodiffusion. The differential diagnosis of pulpy kidney disease in young animals include acute ruminal impaction, polioencephalomalacia, other clostridial enterotoxaemias and acute pasteurellosis. No convulsions are observed in acute ruminal impaction and the course of the disease is longer (1-3 days) and polioencephalomalacia takes a longer course. Acute pasteurellosis can be differentiated by isolation and identification of *Pasteurella* spp from the affected tissues. In adult animals rabies, acute lead poisoning and pregnancy toxaemia should be considered in the differential diagnosis of focal symmetrical encephalomalacia. In rabies, there will be a history of encounter with the rabid animal or bite wounds. The presence of materials containing lead such as paints can be suggestive of lead poisoning. Pregnancy toxaemia occurs during late pregnancy in under inadequate nutrition and ketonuria is common feature at clinical pathology.

Treatment and Control

A hyperimmune serum is used in the treatment of the disease. Combining the hyperimmune serum with sulphadimidine has been found to be effective in goats. Oxytetracyline is effective in treating subacute cases. Chelating agents may be used to neutralise the toxins. Outbreaks of the disease may be prevented by vaccination of animals prior to anticipated changes in diet. Vaccination accompanied with reduction of feed intake has proved to be effective in the control of the disease. An alum precipitated, formalin-killed whole culture toxoid is commercially available. Vaccination of animals using toxins prepared in Freund's adjuvant have been found to provide immunity for up to 2 years. Oral vitamin E preparations stimulate immune response in vaccinated animals. Lambs should be vaccinated at 3 days and 4 weeks old followed by re-vaccination at 6 months. Kids are first vaccinated twice at 4 weeks interval and then re-vaccinated at 6 months. Severe anaphylactic reactions have been reported in Saanen kids

following revaccination with the toxoid. Vaccination using a multi-component clostridial toxoid may be beneficial.

13- BOTULISM

This is a highly fatal motor *paralysis* caused by ingestion of a neurotoxin produced by a Gram-positive, spore forming anaerobic bacterium, *Clostridium botulinum.* Four antigenically distinct types of *C. botulinum,* A, B, C and D may cause the disease.

Epidemiology

The vegetative form of *C. botulinum* is commonly found in the intestinal tract of herbivores and faeces from these animals contaminate the environment. The spores which are formed are highly resistant to environmental conditions. *C. botulinum* has been found to proliferate only in decomposing animal carcasses or sometimes plant materials. Carrion animals may spread the organisms from one area to another. Pica caused by deficiency of protein in the diet or starvation may force animals to crave on infected carrion or decomposing plant materials and subsequent ingestion of lethal doses of the toxin. Deficiency of phosphorus in the diet lead to osteophagia and if the bones are contaminated with *C. botulinum* toxin animals may ingest lethal doses of the toxin. Botulinum toxin from dead rodents, birds, chicken litter or inadequately sterilised fertilisers may contaminate water sources resulting in outbreak of the disease in animals using such water sources. Warm and wet conditions are favorable for the proliferation of C *botulinum* and toxin production.

Pathogenesis

Proteolytic enzymes present in the alimentary tract digest the toxin and hence, ingestion of large doses of the toxin is required for a clinical disease to occur. Following ingestion, the toxin crosses the intestinal wall into systemic circulation. Presence of the toxin at the neuromuscular junctions inhibits the secretion of acetylcholine, the neuromuscular transmitter. This inhibition prevents transmission of impulses to the motor endplates resulting in flaccid paralysis. Death is caused by asphyxiation following paralysis of the respiratory muscles. A toxoinfectious form of botulism caused the neurotoxin produced by organisms already present in body tissues has been reported.

Clinical features

In initial stages, the acute disease is characterised by stiffness of muscles, incoordination and excitability. The affected animal becomes listless and, the head is raised or lowered during walking or may be held on one side. Weakness of the neck muscles may result in torticollis. Lateral bending of the tail, arching of the back, salivation, serous nasal discharges and frequent urination also occur. Abdominal respiration and flaccid paralysis are observed in the terminal stages of the acute disease. The chronic disease is characterised by ruminal and intestinal stasis.

Pathological features

No specific pathological features are associated with the disease although congestion of the intestinal mucosa and serosa, subepicardial and subendocardial haemorrhagesmay be observed. Presence of foreign bodies such as bones, sand and pieces of wood in the stomach or intestinal contents; catarrhal enteritis; pulmonary oedema and excess pericardial fluid may be observed. Perivascular haemorrhage in the brain and destruction of the Purkinje cells may be evident in histological sections. At clinical pathology the toxin can be demonstrated in the liver.

Diagnosis

A provisional diagnosis can be based on epidemiological features such as starvation, pica or osteophagia and clinical signs. Demonstration of large quantities of the toxin in suspected feed or intestinal tracts of dead animals is diagnostic. Occurrence of the clinical disease in unvaccinated susceptible animals fed on suspected feed and absence of the disease in vaccinated animals is confirmatory. Botulism resembles the paralytic form of rabies, but a history of a bite wound caused by a rabid animal should be highly suggestive of rabies. Plant poisoning, lead poisoning, polioencephalomalacia hypocalcaemia, hypomagnesaemia and louping ill should also be differentiated on the basis of epidemiological features and demonstration of the aetiological agents.

Treatment and Control

A hyperimmune serum given together with the antitoxin for 5 days may result in recovery. Treatment is not effective in late stages of the disease. Good nursing and supportive intravenous or stomach tube feeding is recommended for animals which cannot feed on themselves. Animals should be put on sternal recumbency to prevent bloat. Control of the disease is achieved by removing the infected feed and correcting the dietary deficiencies which predispose animals to

the disease. Proper disposal of carcasses to avoid contamination of the pastures and watering points is recommended and in high risk areas, annual vaccination of animals is useful. A polyvalent toxoid containing type A, B, C and D strains is commercially available.

14- COLIBACILLOSIS

This is a disease of new-born lambs and kids caused by pathogenic strains of *Escherichia coli* and characterised by septicaemia or enteritis depending on the strains of bacteria involved.

Epidemiology

The disease is common under intensive production systems. Faeces of infected animals are the main sources of infection. Sub-clinically infected animals act as reservoirs which contaminate bedding, pens and feed or water troughs making them sources of infection. People working with animals can transmit the infection between herds or pens. Stress factors such as cold, wet or windy weather; poor hygiene in animal houses and overcrowding predispose animals to the disease. Inadequate intake of immunoglobulins through colostrum immediately after birth has also been found to increase the susceptibility of animals to the septicaemic form of the disease (colisepticaemia). Outbreaks may occur when there is mass lambing or kidding.

Pathogenesis

The occurrence of clinical colibacillosis depends on the type and pathogenicity of the infecting strain of *E. coli*, host susceptibility and presence or absence of predisposing factors. Thus, two syndromes of the disease, that is, septicaemic (colisepticaemia) and enteric colibacillosis can occur. Colisepticaemia is caused by invasive strains of *E. coli*. Invasion of tissues may occur through the intestinal lumen, the umbilical vessels, nasopharyngeal mucosa and tonsillar crypts. Posses adhesive pili, resistance to antibacterial activity of serum and production of endotoxin are the factors which enhance the pathogenicity of the invasive strains of *E. coli*. Presence of receptors for the pili in the epithelium of intestinal mucosa also facilitates establishment of the

bacteria. After successful establishment on the mucosa the bacteria produce endotoxins which pass into systemic circulation and initiate bronchoconstriction, pulmonary hypertension and pulmonary oedema. Invasive bacteria also cause tissue damage.

Enteric colibacillosis is caused by enterotoxigenic strains of *E. coli* which are capable to colonise, proliferate and producing an enterotoxin in the upper small intestine. The bacterial

fimbriae attach on the receptor sites on the villous epithelial cells and the bacteria multiply and colonise the villous surface. The colonisation of the villi and production of enterotoxins disrupt the absorptive mechanisms on the intestinal surface resulting in the secretion of fluids and electrolytes from the systemic circulation into the intestinal lumen. This leads to electrolyte imbalance, dehydration, acidosis, hyperkalemia, circulatory failure and death.

Clinical and pathological features

Septicaemic colibacillosis is common in lambs and kids. Lambs and kids of 1-2 days and 3-8 weeks old have been found to be the most susceptible groups. The syndrome may be peracute in which case sudden death occurs without any premonitory signs. The acute disease is characterized by stiff gait or recumbency, depression, fever, hyperaesthesia and tetanic convulsions. Animals may collapse because of acute meningitis. The chronic form of the disease is characterised by polyarthritis. The bacteria may also cause local reactions in other tissues. No gross pathological lesions are observed in peracute septicaemic colibacillosis because of sudden death. In the acute form there are widespread subserosal and submucosal petechial haemorrhages. Enteritis and gastritis are common features. Fibrinous exudates are found in joints and in serous cavities. Fibrinopurulent meningitis and peritonitis may also be encountered. Infection through the umbilicus is associated with omphalophlebitis.

Enteric colibacillosis is manifested mainly by a haemorrhagic or mucoid diarrhoea various degrees of diarrhoea and slight fever. Other enteropathogens such as rotaviruses, salmonellae and *Campylobacter* spp may also be involved and complicate the clinical picture. Pathologically there are widespread haemorrhages in the intestinal mucosa and large numbers of the bacteria can be demonstrated in smears from the intestinal mucosa.

Diagnosis

The epidemiology, clinical signs, pathological features and, response to treatment may support a presumptive diagnosis of colibacillosis. Confirmation is achieved by the isolation and characterisation of *E. coli* from suspected animals. Bacterial culture alone is of limited use because of the presence of non-pathogenic strains of *E.coli* and, demonstration of specific toxins may be of great value to support the diagnosis. In the peracute form of the disease the organisms may be isolated from abdominal viscera and heart blood.

The differential diagnosis of colisepticaemia include clostridial enterotoxaemia and salmonellosis. These conditions can be confirmed by isolation and identification of the causative bacteria. The differential diagnosis of enteric colibacillosis include dietetic diarrhoea, coccidiosis and campylobacteriosis. Dietetic diarrhoea is manifested by passage of voluminous and pasty or gelatinous faeces and the animals are usually bright or alert although they may be inappetent. Other enteritides can be differentiated by isolation and identification of their aetiologic agents

Treatment and Control

In view of the diversity of strains of *E. coli* which are involved in the syndrome it is important to carry out drug sensitivity testing before any treatment is instituted. Trimethoprim-sulphonamide combination (15-25 mg/kg) and kanamycin (20 mg/kg) given parenterally and colistin administered at a rate of 1-2 g/kg in drinking water have been found to be effective in the treatment of the disease. Other antibiotics such as oxytetracycline, neomycin, chloramphenicol and sulphadimidine are also used. Vaccination of dams 2-4 weeks before parturition to stimulate production of specific antibodies is recommended in order to provide passive protection bf neonatal lambs and kids through colostral immunoglobulins. Formalin-killed whole-cell vaccines are commercially available. Specific *E. coli* strain vaccines produced using K99+ pili antigens have been found to confer immunity to lambs and kids. Ewes have to be vaccinated twice in their first year of lambing, first at 8-10 weeks and then at 2-4 weeks before lambing. In subsequent years, one vaccination 2-4 weeks before parturition has been found to be satisfactory. Maintenance of good hygiene in the animal environment can reduce transmission and incidence of the disease. Provision of adequate colostrum to newly born kids and lambs will help to protect them from colisepticaemia.

15- SALMONELLOSIS

This is a disease of animals and man caused by different species of salmonellae and is characterized clinically by three major syndromes: peracute septicaemia, acute enteritis or chronic enteritis. *Salmonella dublin, S. typhimurium* and *S. anatum* are the common species associated with the disease in sheep and goats. *S. abortusovis* has been found to cause abortion in sheep.

Epidemiology

Salmonellae are widespread and the disease occurs world-wide. *Salmonella* spp are enteric bacteria and carrier animals shed the organisms in faeces thus contaminating the environment. It has been found that infection with *S. dublin* may result in a clinical disease or an active or passive carrier state. Active carriers constantly shed the organisms in faeces whereas, passive carrier will shed the organisms when stressed and, they may also manifest an overt disease. Recovered animals become subclinical carriers and shed the organisms in faeces. *S. typhimurium* may also originate from man or wild animals. Infection is acquired by ingestion of contaminated material. Animals may acquire the infection through food of animal origin and pastures contaminated with infective slurry or improperly treated fertilisers. Watering points may be contaminated with slurry from infected herds or fertilisers. Intensification of animal management favours spread of the disease from carriers animals. The organisms may be introduced in the herd via contaminated feed stuffs, formites, birds or nematodes. Stresses such as transport, starvation, parturition, overcrowding in communal grazing land, holding yards and dips activate latent infections and favour rapid spread of the disease. Disruption of the intestinal flora by factors such as antibiotic therapy, change of diet and water deprivation increases the susceptibility of the host to infection. Infection in animals occurs mainly by ingestion but in sheep it has been shown that infection may also be acquired by inhalation of infective material. Animal salmonellosis is the principal reservoir for human salmonellosis.

Pathogenesis

The ability of *Salmonella* spp to produce disease is facilitated by the presence of virulence factors. It has been found that pathogenic salmonellae posses adhesive pili, protective plasmids and, produce an enterotoxin, cytotoxin and lipopolysaccharide. These act together and enable the bacteria to adhere and colonize the intestinal epithelium, survive the phagocytic activity of macrophages and increase the permeability of the intestinal epithelium. The presence of bacteria on the intestinal wall also initiates an inflammatory response. After successful establishment, colonization and disruption of the integrity of the intestinal wall, the organisms the pass through lymphatic system to mesenteric lymph nodes after which a clinical disease may occur depending on the virulence of the organisms, immune status and age of the host and, presence of intercurrent infections or other stress factors. From the mesenteric lymph nodes, the organisms

invade the reticuloendothelial cells and then enter the blood stream causing septicaemia, enteritis and localization in various tissues. Invasion of bacteria in the uterus and placenta causes abortion.

Clinical features

Enteric salmonellosis is the commonest form of the syndrome encountered in sheep and goats. The incubation period is 1-4 weeks. The syndrome is characterised by fever (40-41°C), anorexia, listlessness, severe diarrhoea and sometimes dysentery or tenesmus. Faeces have a putrid smell, mucoid and may contain blood clots or fibrin casts. Fibrin sheets may be found in the intestinal mucosa. Shallow and fast respiration, rapid pulse and congestion of the mucosae are observed. Abortion is a common feature. There may also be dehydration, toxaemia, loss of weight, prostration, recumbency and death. New-born animals that survive the septicaemic disease develop severe enteritis characterised by diarrhoea. Polyarthritis and pneumonia are a common sequel. Does and ewes often die after abortion and lambs born alive may die subsequently. *S. dublin* is most common cause of the disease in goats. *S. typhimurium* also causes peracute septicaemia or acute enteritis.

Pathological features

Acute enteritis is characterised by muco-haemorrhagic enteritis and submucosal petechiation. In *S. typhimurium* infection, there is necrotic enteritis in the ileum and large intestines. The intestinal contents are putrid, mucoid, blood-tinged or may contain frank blood. The intestinal mucosa may be covered by an extensive diphtheritic membrane. The mesenteric lymph nodes are enlarged, oedematous and haemorrhagic. There is also enlargement and fatty degeneration of the liver; thickening of the gall bladder wall and presence of blood-stained fluid in the serous cavities. The histopathological picture is characterised by necrosis, oedema, congestion and infiltration of the lamina propria and submucosa of the caecum, colon and small intestine with neutrophils, lymphocytes, plasma cells and macrophages. Focal necrosis in the mesenteric lymph nodes and thrombosis of the submucosa vessels occur. Hepatocellular necrosis and neutrophilic and mononuclear cell infiltration in the portal tracts may be evident. Necrosis and neutrophilic infiltration in the mesenteric lymph nodes and lymphoid and reticuloendothelial hyperplasia occur in protracted cases.

Diagnosis

A provisional diagnosis can be based on the epidemiological, clinical and pathological features and the disease can be confirmed by bacterial isolation and serotyping. In the acute disease the bacteria are present in heart blood, spleen, liver, bile, mesenteric lymph nodes and intestinal contents while in chronic cases, the bacteria can be isolated from the intestinal lesions or other viscera. Lymph nodes which drain the caecum and lower intestine have been found to be rich in the bacteria. The organisms can be easily demonstrated in a thick smear made from the wall of the gall bladder. Selective media such as MacConkey agar, brilliant green agar, triple sugar iron agar and xylose-lysine deoxycholate medium are used in the isolation of *Salmonella* spp. Species-specific antibodies may be used to diagnose the disease but cross-reaction do occur.

Coccidiosis, campylobacteriosis and parasitic gastroenteritis should be considered in the differential diagnosis of salmonellosis. Unlike the above conditions, salmonellosis is often manifested by a more acute and often fatal enteritis. High faecal oocyst and demonstration of developmental stages of Eimeria on the intestinal wall may be highly suggestive of coccidiosis whereas, high faecal egg and worm burdens may be highly suggestive of parasitic gastroenteritis. These features are not observed in salmonellosis except when they occur as intercurrent infections. Campylobacteriosis can be differentiated by demonstration of Campylobacter spp in faeces. Salmonellosis can be treated using chloramphenicol (20 mg/kg) infused intravenously at 6 hours interval for 3 days. Other drugs include trimethoprim-sulphadoxine combination, sulphadimidine, framomycin, ampicillin and amoxycillin. Oral nitrofurazone daily for 5 days mixed in the feed or as a drench is commonly used in mass medication during outbreaks. The recommended treatment regime is to combine oral and parenteral therapy.

It is important to remember that oral antimicrobial therapy may disrupt the normal intestinal flora and increase host susceptibility to the disease. Supportive fluid therapy to alleviate the effects of dehydration and electrolyte loss is beneficial. In some countries, treatment of animals against salmonellosis has led to selection for drug resistant strains thus complicating the effectiveness of treatment of human cases of the disease. Salmonellosis can be controlled by avoiding faecal contamination of feed or water and maintaining good hygiene in the animal houses. Animals should be purchased from herds which are known to be free from the disease. Regular testing should be carried out to identify carriers which should be culled. Infected premises should be properly disinfected and the infective materials should be destroyed. Personnel from infected

herds should not be allowed to come into contact with disease- free animals. Vaccination of small ruminants against salmonellosis is not widely practiced.

16- MASTITIS

Mastitis refers to the inflammation of the mammary gland and is characterized enlargement of the udder and abnormal milk secretion with or without fever. The disease has a multiple aetiology but *Staphylococcus aureus* and *Streptococcus agalactiae* are the commonest bacteria isolated from cases of mastitis in small ruminants. Other bacteria encountered in include *Corynebacterium pyogenes*, *Klebsiella* spp, *Mycobacterium* spp and *Brucella* spp.

Epidemiology

Lack of information on this aspect is probably be related to the fact that the indigenous small ruminants are kept primarily for meat and, hence little attention has been paid to the economic significance of mastitis. However, with recent introduction of dairy goats and intensification of management systems, mastitis may become an important disease entity worth attention. Un-hygienic conditions in animal houses and poor milking hygiene are important predisposing factors. Mechanical or surgical wounds in the teats or udder facilitate penetration of the bacteria. Most often, *Mycobacterium* spp and *Brucella* spp spread systemically and lodge in the mammary tissue causing mastitis.

Pathogenesis

After entry through the teat canal the bacteria colonise and multiply in the mammary tissue. Some bacteria produce enzymes and toxins which cause inflammation and damage to the mammary tissue, Pyogenic bacteria cause abscessation and suppuration. These inflammatory changes are associated with abnormalities in milk. The severity of infection is determined by the virulence of the organism, extent of mammary tissue damage, stage of lactation and efficiency of host defence mechanisms in the mammary tissue.

Clinical features

The clinical signs of acute staphylococcal mastitis in goats include restlessness, elevated pulse (up to 144 per minute) and respiratory rate (up to 80 per minute) rates, hot, painful and enlarged mammary glands. Gangrenous necrosis of the mammary tissue may occur. On palpation there is

marked diffuse induration of the mammary glands and enlargement of the supramammary lymph nodes. The milk shows a thick yellowish discoloration or may be blood-stained.

Pathological features

The affected mammary glands are enlarged and hard on palpation. The teat orifices may be blocked. Abscesses may be present in different sections of the mammary tissue.

Diagnosis

A tentative diagnosis is based on the clinical signs especially presence of abnormalities in milk and pathological lesions. Confirmation is achieved by isolation or demonstration of the causative agents in smears prepared from pus or milk secretions. Cell counts and California mastitis test are also used in the diagnosis. Mastitis in goats' may also be caused by *Mycoplasma agalactiae* and *Candida albicans* and these should be considered in the differential diagnosis of the disease. Other mammary abnormalities such as oedema, passive congestion and haematomata are usually not associated with abnormalities in milk.

Treatment and Control

Bacterial mastitis can be treated by penicillin, streptomycin, oxytretracycline and gentamycin either as intramammary infusions or parenterally in systemic cases. Combination of systemic and intramammary antibiotic therapy is beneficial where there is systemic involvement. Some strains of *S. aureus* are resistant to Penicillins, hence drug sensitivity testing is recommended before the use of these drugs in the treatment of mastitis. Proper herd and milking hygiene is the most effective means of controlling mastitis.

Other bacteria such as *Mycobacterium* spp, *Listeria* spp, *Actinobacillus* spp and *Actinomyces* spp cause disease syndromes in small ruminants, the clinical and pathological features are similar to those observed in cattle.

Nutritional strategies to be adopted for better production and reproduction performance of sheep and goat

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Introduction

Small ruminants are in a sizable population in India and contribute significantly towards livelihoods security and are a source of regular income to rural landless, small and marginal farmers particularly woman. Currently, India ranks 3rd in sheep population, next to China and Australia and is placed at the 7th position among the top 10 countries of the world in terms of mutton and wool production with annual growth rate of 3.05% for goat and about 1.0% for sheep (GOI, 2012). Because of low input requirement, easy to manage and feed as compared to cattle, ability to thrive on different climatic conditions, high disease resistance, and high market demand sheep and goats are preferred animal. India is having 20% of the goat (124.6 million) and 5% of sheep (61.0 million) of the world. About 70% of India's goats are found in West Bengal, Rajasthan, Uttar Pradesh, Maharashtra, Bihar, Tamil Nadu and Madhya Pradesh and 72% of the sheep population is concentrated in Andhra Pradesh, Rajasthan, Karnataka and Tamil Nadu (Department of Animal Husbandry and Dairying, 2012). Indian breeds like Beetal, Jamunapari, Sirohi and Jakhrana have capacity to produce 4-5 kg milk/day totaling 400-600 litre in single lactation of 150-200 days and body weight 30-40 kg at 12 month of age indicated tremendous potential of Indian breeds.

Jammunapari, Beetal and Barbari have been used for improvement as milch breed. Black Bengal is small in size, prolific breeder with twinning and triplets are common. Chegu is known for its good quality Pashmina wool in Kashmir valley. Goats may consume grass, leaves, twigs, short, bark and aromatic herbs rich in crude fiber which even sheep do not eat. In other words they consume a considerably wider spectrum of plant parts and species. Though feeding behavior and digestive physiology of sheep and goat is comparatively similar but certain feature which differentiate them have been presented in Table 1.

Table 1. Comparative Feeding Behavior and Digestive Physiology in Goats and Sheep

(Devendra, 2001)

Characteristics	Goats	Sheep
1. Activity	Bipedal stance and walk long distances	Walk shorter distances
2. Feeding pattern	Browser, more selective	Grazer, less selective
3. Browse and tree leaves	Relished	Less relished
4. Variety in feeds	Greater preference	Smaller preference
5. Taste sensation	More discerning	Less discerning
6. Salivary secretion rate	Greater preference	Smaller preference
7. Recycling of urea in saliva	Greater	Less
8. Dry matter intake:		
-for meat	3% body weight (BW)	3% BW
-for milk	4-6% BW	3% BW
9. Digestive efficiency of course roughages	Higher	Lower
10. Retention time	Longer	Shorter
11. Water intake/unit dry matter intake	Lower	Higher
12. Rumen NH_3 concentration	Higher	Lower
13. Water economy	More efficient	Less efficient
14. Fat mobilization increased during period of feed shortages	More evident	Less evident
15. Dehydration		
-faeces	Less water loss	Relatively high water
-urine	More concentrated	Less concentrated
16. Tannins	More tolerance	Less tolerance

Goats are capable of consuming plants that are richer in tannins than can be tolerated by sheep and digest it much more efficiently (Wilson 1977; Kumar and Vaithiyenathan 1990; Silanikove 1994, 1996). The advantage of the goat over other ruminants while consuming tannin-rich plants relates to their superior capacity to neutralize the negative effect of tannins on palatability and digestibility (Silanikove et al., 1996). The more number of cellulytic bacteria in their rumen and longer retention time of digesta in their digestive tract of goat than sheep allow more efficient digestion of ration low in protein and rich in crude fiber. Goat consumes less water in water scares condition than sheep and utilized blood urea more efficiently. Goat is browser in nature and select twig and leaves by climbing on tree, tolerate heat stress and conserve water by reducing losses in urine and faeces.

Nutrient requirements and feeding of goat

Recently, a lot of research work have been carried out on requirement of goats in different research institutes of India and summarized (Mandal et al., 2005). Goat is reared for milk and meat by poor farmers, laborers and is called poor man cow in India. Some of them are dual purpose breeds like Jamunapari, Beetal, Barbari, Jhakrana, Surti etc. Black Bengal is reared for meat purpose. Changthangi, Gaddi and Chegu (pashmina) goats are hair type breeds. Milk production is primary objective of rearing milch breeds of goat. The average milk yield of the native doe per lactation is 60 liters which 100 and 250 liters in Barbari and Jamunapari goats in a lactation period of 120 days. Indian goats breeds like Beetal, Sirohi, Jamunapari and Jakhrana have capacity to produce 4-5 kg milk daily with 400-600 kg milk in a lactation ranges from 150-200 days (Rai et al., 2005). Average milk production of Black Bengal varied from 0.250 to 1.75 kg despite having prolificacy, fertility, early sexual maturity and adaptability to hot humid conditions. Beside 3% of milk, goats contribute about 37% toward meat produced in India (Dhara et al., 2012).

Nutrient requirement of goats

Table-2: Daily nutrient requirements for maintenance of adult goat (Ranjhan, 1998)

BW kg	DMI g	DM % BW	DCP g	TDN g	Ca g	P g
15	500	3.3	23	240	1.1	0.7
20	615	3.1	29	295	1.3	0.9
25	730	2.9	34	350	1.6	1.1
30	830	2.8	39	400	1.8	1.2
35	940	2.7	44	450	2.1	1.4
40	1040	2.6	48	500	2.3	1.5
45	1125	2.5	53	540	2.5	1.7
50	1230	2.4	57	590	2.7	1.8
55	1315	2.4	62	630	2.9	1.9
60	1410	2.3	66	675	3.1	2.1

Table-3: Daily nutrient requirement of pregnant does (Ranjhan, 1998)

BW kg	DMI g	DM % BW	DCP g	TDN g	Ca g	P g
15	700	4.7	42	385	2.1	1.4
20	865	4.3	52	475	2.6	1.7
25	1025	4.1	62	564	3.1	2.1

30	1170	3.9	71	645	3.5	2.3
35	1320	3.8	80	725	4.0	2.7
40	1460	3.6	88	802	4.4	2.9
45	1590	3.5	96	875	4.8	3.2
50	1725	3.4	104	984	5.2	3.5
55	1850	3.4	112	1018	5.5	3.7
60	1975	3.6	120	1086	5.9	3.9

Table-4: Daily nutrient requirement of lactating does (Ranjhan, 1998)

BW kg	Milk yield, kg	DMI g	DM % BW	DCP g	TDN g	Ca g	P g
20	0.5	865	4.3	51	468	4.3	2.9
	1.0	1185	5.9	74	640	5.9	3.9
25	0.5	968	3.9	56	523	4.8	3.2
	1.0	1290	5.2	79	695	6.4	4.3
30	0.5	1060	3.5	61	573	5.3	3.5
	1.0	1380	4.6	84	745	6.9	4.6
35	0.5	1155	3.3	66	623	5.8	3.9
	1.0	1470	4.2	89	795	7.3	4.9
40	0.5	1245	3.1	70	673	6.2	4.1
	1.0	1565	3.9	93	845	7.8	5.2
45	0.5	1320	2.9	75	713	6.6	4.4
	1.0	1640	3.6	98	885	8.2	5.3
50	0.5	1410	2.8	79	763	7.0	4.7
	1.0	1730	3.5	102	935	8.6	5.7
55	0.5	1490	2.7	84	803	7.4	4.9
	1.0	1805	3.3	107	975	9.0	6.0
60	0.5	1570	2.6	88	848	7.8	5.2
	1.0	1890	3.1	111	1020	9.4	6.3

Table-5: Daily nutrient requirements of growing kids (Ranjhan, 1998)

BW kg	ADG g	DMI g	DM % BW	DCP g	TDN g	Ca g	P g
10	50	380	3.8	27	265	2.0	1.4
	100	510	5.1	37	355	2.7	1.8
	150	635	6.3	47	445	3.4	2.3
15	50	510	3.4	33	330	2.7	1.8
	100	645	4.3	43	420	3.5	2.3
	150	785	5.2	53	510	4.2	2.8
20	50	640	3.2	39	385	3.3	2.2
	100	790	3.9	49	475	4.1	2.7
	150	985	4.9	59	590	5.1	3.4

25	50	760	3.0	44	440	3.8	2.5
	100	915	3.7	54	530	4.6	3.0
	150	1070	4.3	64	620	5.3	3.6

Nutrient intake

A number of feeding trials conducted at different research institute in India with different breeds of Indian goats have shown that dry matter intake varies from 35 to 80 g per kg metabolic body size with a mean of 70 g/kg $W^{0.75}$ (3.2% of BW). DMI for small breed (Black Bengal, Barbari) is higher than the larger breeds (Jamunapari, Beetal). The goats reared for Meat have a dry matter intake (kg/100 body weight) of 3-4 kg, whereas dairy goats have a dry mater intake of 4-6 percent of their live weight (Singhal et al., 2005). As per ICAR standard, the dry matter requirements of kids with 10, 15, 20, 25 and 30 kg body weight and growing at the rate of 50g/day are 425, 600, 700, 800 and 950 g, respectively (ICAR, 1985). Kutchi male goats consumed 64·0, 54·0 and 55·9 g DM/kg $W^{0·75}$/day in monsoon, winter and summer with mean of 58·0 g DM/kg $W^{0·75}$ /day (Bhatta et al., 2002). The DMI in alpine breed during lactation in temperate conditions is 3.6 kg/day or 6.8% of BW or 181 g per kg metabolic body size. DMI intake reaches maximum in 6 and 10 weeks of lactation and decreases thereafter. As pregnancy advances decreases in dry matter intake have been reported because of decrease in space in abdominal cavity. The dry matter is influenced by body weight, % dry matter in the feeds (12-35% in forages, 86-92% in hays and concentrates), palatability and physiological stage like growth, pregnancy and lactation. Maintenance: Data from 25 feeding trials conducted in Indian institute on growing goats was analyzed by multiple regression analysis to derive nutritional requirements of TDN, CP and DCP for maintenance and BW gain. Maintenance requirements for TDN, CP and DCP were 30.1, 5.83 and 3.22 g/kg $BW^{0.75}$, respectively. The corresponding requirements for one g gain in BW were 1.61, 0.45 and 0.34 g, respectively (Mandal et al. 2005). The dry matter, DCP and TDN requirement for maintenance are 76, 3.0 and 30 g per kg metabolic size as per ICAR (1985).

Pregnancy and lactation

The requirement for lactation including the maintenance requirement at different body weights is 345 g TDN and 45 g DCP per kg of 4% FCM over and above the maintenance requirement. Pregnant don't have additional nutrient requirement until the kids attain 70% of their growth or

last two months of gestation. Feeding 250 to 350 g concentrate in last two month will take care of advance pregnancy.

Growth

The requirement for growth has been given for body weights ranging from 10 to 25 kg and at each body weight for 3 different rates of growth (Table 5). Requirement of DCP, TDN, Ca and P are in ranges of 25-60, 270-620, 2-5 and 1.5-4 g, respectively.

Feeding habits of goats

Basically goats are browse by standing on their hind limbs and eat leafy twigs of herbs, shrubs, small trees. Goat's special feeding habits are on account of their prehensile tongue and movable upper lips, which allow it to eat nutrient rich leafy portions of plant. Goats have special preference toward shrubs and tree leaves from a wider array of plants, particularly woody plants. Goat consumes and sheep of similar size consume almost same amount of dry matter. Goats under browse condition perform better because it utilizes lignin better than sheep and its feed intake decreased as the forage matured (Devendra, 1975). The chopping and pelleting the forage helps in increase feed intake. Nutrient rich leaves and twigs of trees and shrubs may contain certain anti-nutritional inhibitors like lignin, silica and tannin, which affect the utilization of nutrients. Goats are less sensitive to the toxic effects of tannin than other ruminants.

Common feeds and fodders

Tree leaves: Babul, neem, papal, mango, prosopis, gliricidia, mulberry, Subabul, banyan, etc. These tree leaves are called as top feeds.

Grasses: Cenchrus ciliaris, C. setigerus, Para, guinea, Napier, etc.

Legume pastures: Stylosanthus hamata, S.scabra, siratro, butterfly pea, etc.

Legume fodders: Berseem, lucerne, cowpea, etc.

Dry feeds: Dry pods of babul, Prosopis juliflora, rain tree, Subabul; cereal straws, legume straws (groundnut haulms, gram straw), gram husk and gram waste.

Feeding of kids

The kids should be fed colostrum from the doe within one hour after birth and for the first 3 to 4 days to meet the nutrient requirement as colostrum is rich in all essential nutrients. It provides

antibodies for protection of man diseases and it has got laxative properties, cleans from its intestine the accumulated feacal matter known as meconium. Colostrum is fed to kids at the rate of 100 ml/kg body weight. Immunoglobulin are thermosenstive and kids may loos the ability to absorb immunoglobulins from colostrums 20-28 hours after birth. Colotrum can be stored in deep freezer for up to two years without loosing immunogenicity. While thawing temperature of colostrums should not be raised above 50°C. Colostrum can also be preserved with 1 to 1.5% (vol/wt) propionic acid or 0.1% formaldehyde. Then 250-350 ml mlik per kid depending on breed maybe fed from 4th day onward. Kids start nibbling the grasses from 15 days of age. Creep feed is also introduced at the same time. This help rapid growth of kid and help in development of rumen.

Table-6: Feeding of kids according to body weight

Body Weight (kg)	Milk (ml/day)		Green Fodder g/day	Concentrate Kg/day
	Morning	Evening		
2.5	200	200	-	-
3.0	250	250	-	-
3.5	300	300	-	-
4.0	300	300	-	-
5.0	300	300	Ad-libitum	50
6.0	350	350	-do-	100
7.0	350	350	-do-	150
8.0	300	300	-do-	200
9.0	250	250	-do-	250
10.0	100	150	-do-	350
15.0	100	100	-do-	350
20.0	-	-	1.5	350
20.0	-	-	1.5	350
25.0	-	-	2.0	350
30.0	-	-	2.5	350

Feeding of pregnant does

Reproduction increases the animal's nutrient requirement for reproduction considerably from one phase of reproductive cycle to another. Caprine foetal growth indicated that the rate of weight gain was maximal at 120 days (d) of gestation (Osuagwuh and Aire 1990). it has been observed that nutrient diversion to foetus and other associated tissues is extremely small before sixty days of gestation. In mid pregnancy, the nutrient requirements of foetus are still low, but placenta must grow at this time and if growth of placental tissue is restricted by low plane of nutrition, it will be unable to adequately nourish the foetus in final stage of pregnancy and consequently birth weight will be reduced (Osuagwuh et al 1980). Rapid rate of foetal growth during the final six weeks of pregnancy imposes a metabolic challenge to the doe, which is met by the mobilization of maternal body tissue (Osuagwuh and Aire 1990) and this may result in weight loss of doe, if the dietary supply of nutrients is inadequate (Sibanda et al 1997). However, it has been suggested that retardation of foetal growth late in gestation should have a less severe effect on subsequent neonatal development than retardation at an early stage as bovine foetal growth is attributed more to hypertrophy than to hyperplasia with an increase in foetal age (Prior and Laster 1979). An unscientific approach to animal feeding during pregnancy may lead to reproductive wastage resulting from either abortion or neonatal death due to low birth weight resulting from malnutrition of pregnant does (Osuagwuh and Akpokdje 1981; 1986) or dystocia due to absolute foetal oversize as a result of high level of feeding throughout gestation (Osuagwuh et al 1980). The last one –third of gestation period is considered to be an active period of foetal development and about 70-80 percent foetal mass development occurs during this period. Inadequate feeding of nutrient during this period may lead to decline in the body reserve as a result several deficiency disease of pregnancy become apparent causing considerable monitoring loss to farmers. A balanced ration containing 5-6 % DCP and 50-60% TDN will be satisfactory to meet the requirement. A free choice lick of mineral mixture will take care of calcium and phosphorus requirement. The feeding of quality leguminous fodder and concentrate having 25% protein should be offered between 400 to 500 g depending upon the condition of doe. Allow good grazing if available and make sure that does get plenty of exercise. Several days before the does freshen reduce the quantum of concentrate ration to one half and add bran to provide more bulk. After kidding, feed a bran mash for a few days, gradually bringing the doe to the full feed for milk production (Rastogi et al., 2006).

Feeding of lactating goats

Nutrient requirements are higher during lactation. The ration for lactating does should contain high quality roughages like Lucerne, berseem and other cereal grasses through which it will receive not only fresh nutrients particularly of minerals, vitamins and proteins but also the bulk needed for volatile fatty acids, viz., acetic, propionic and butyric acid needed for high milk production. To supplement more nutrients particularly of energy, cereal grains at the rate of 350 g for each liter of milk must be provided. The protein percent may vary from 14 to 16 %, the feed may be fed in two lots, at the time of morning and evening milking. Add 1% trace mineralized salt and 1% calcium phosphorus mineral mixture to concentrate mixture. Molasses (5-7% of concentrate mixture) may be used to increase palatability and to reduce dustiness of feed. Keep a clean, fresh supply of water available at all times. After two weeks gradually increase the concentrate level to that suggested by milk yield. As soon as the doe leaves some concentrate, reduce the amount until she again cleans it up. The concentrate should be fed on individual requirement basis of each doe. This can be done most easily by feeding the concentrate at milking times.

Feeding breeding bucks

Breeding bucks requires dry matter at the rate of 3 to 4 percent of body weight. During the non-breeding season, the buck does not require additional grain if he is on good pasture. During the breeding season, the concentrate mixture fed to the does may be fed at the rate of 250, 350 and 400 g (depending on the body weight) daily. Ration having 5-6% DCP and 55-60% TDN with sufficient minerals and vitamins will be enough to maintain normal health and fertility. Provide roughage free choice along with clean fresh water and minerals. Care must be taken not to allow the buck to get too fat. Reduce the intake of energy feeds as needed to prevent this. Make sure the buck gets plenty of exercise.

Nutrient requirement and feeding of sheep

Feed accounts for 55-60% cost of rearing the sheep. Adult body weight of Indian sheep is ranges 30-40 kg as against 70 kg or more in the exotic breeds. The rate of growth is faster in the exotic breeds than native Asian breeds.

Dry matter intake

Beside the genetic make-up, inadequate nutrition is the major factor responsible for such a low growth rate and body weight. Large scale crossbreeding work has been done from 4th five year plan period to 7th five year plan involving exotic meat and fine wool type breed and local indigenous sheep through All India Coordinated Research Project (AICRP) on sheep for mutton and AICRP on sheep for wool located in different parts of the country with coordinating unit at Central Sheep Wool Research Institute, Avikanagar. Dry matter intake depends on the diet offered to sheep and the physiological age of the animals. Based on studies conducted in India and asian countries the dry matter intake variation of 44 g DM/W$^{0.75}$ in barley to 75 d DM/W$^{0.75}$ in Alfa-Alfa hay (Joshi and Ludri, 1970) in the growing and mature sheep, the dry matter intake is considerably increased in the lactating animals and varies between 120-140 g/ W$^{0.75}$ with average of 130 g/ W$^{0.75}$ DMI. Feeding trails with Muzzafarnagari sheep (Ali et al., 1979; Singh et al., 2013), it was observed that for growing lambs (15-35 kg) the dry matter intake was 73.1 g/W$^{0.75}$.

Protein requirement for maintenance

The protein requirement has been determined both by factorial methods and nitrogen balance trials. Studies conducted at IVRI in adult rams showed endogenous urinary nitrogen (EUN) excretion as 28 mg per kg live weight. The requirement calculated with this figure was 8 g digestible crude protein for 45 kg body weight sheep. The EUN was found to be 38 mg per kg body weight per day or 1.282 g per m^2 body surface. Metabolic fecal nitrogen (MFN) determined by extrapolation of curve based on the experiment of three levels of protein intake was found to be 214 mg per 100 g dry matter intake. The daily DCP requirement for maintenance was calculated to be 0.875 g per kg metabolic body weight or 123 g per 35 kg ram per day. Some of the experiments conducted on the Indian sheep fed on an ingestion of 31 to 35 g of DCP the sheep 30 kg body weight were in positive nitrogen balance. Therefore 35 g DCP can be taken as the requirement for 30 kg sheep which comes to 2.73 g DCP per kg metabolic size. NRC (1968) standards give 54 g DCP for 45 kg body weight body weight adult sheep for maintenance which comes to about 36 g of DCP for 30 kg. The protein requirement for maintenance is not much different from the requirement suggested by NRC.

Energy requirements

The dry matter requirement for India breeds of sheep weighing 30 kg would be around 750 g for maintenance (2.27 kg/100 kg body weight) which is not very much different than the NRC (1985) and Paul et al. (2003). NRC requirement is 390 g TDN per 30 kg of sheep which is not very much higher than Indian data. In calculating the energy requirement for maintenance 350 g TDN for 30 kg body weight sheep has been taken as adequate which comes to 27.3 g per kg metabolic size. This comes to 98 kcal ME/kg $W^{0.75}$ as compared to 101 (NRC, 1985)

Growth

The requirements for growth have been divided into 3 categories namely: (i) Pre-ruminant growth (birth to 90 days age) (ii) Actively growing period and (iii) Finishing period. The pre-ruminant growth is mainly on the milk feeding along with supplementation through creep. Birth weights of the lambs from ewes receiving the lower protein rations are generally low than those from ewes receiving the higher protein rations. However, the birth weights are not influenced by increasing the total protein content of the ration from 10-13 percent.

There is significant correlation between the milk yield of the dam and the growth of the lambs. At IVRI, Izzatnagar, 160 days old Muzzafarnagari lambs were reared on milk and creep feeding. The energy requirement of early weaned lambs comes to about 76 Kcal ME/$W^{0.75}$ gaining at the rate of 115 g per day. As growth rate per day increase energy requirement also increases proportionately. The growth rate of Indian sheep and their crosses with sufolk and Dorset is lower than the growth observed in the western breeds. Some of the Indian breeds can also grow faster, at the rate of 120-150 g per from weaning to slaughter weight of 35 kg, when their rations contain about 80 percent concentrate and 20 percent roughage giving thereby a ME concentration of 2.3 Mcal/ Kg diet.

Feeding of Sheep

Sheep are fed on natural pastures for maintenance and production. Pasture and range are their natural habitat ranging from great heights of Himalayas to plains of Rajasthan desert. They survive under extremely wide variety of climatic conditions and utilize most adverse type of vegetation ranging from grasses, legumes, weeds, herbs and shrubs. They are also regarded as excellent weed destroyer. The natural pastures available in India do not support the growth specially during dry season due to poor quality vegetation. During such lean period animals

walks for long distance in search for feed and lose weight. Therefore for better growth and production, additional supplementation of concentrate mixture to grazing is required. A number of studies have been conducted at different research stations especially at Livestock Farm Hisar, IVRI, Izzatnagar, Mathura, Central sheep and Wool Research Institute, Avikanagar. Supplementation of about 550g concentrate mixture in addition to grazing Malpura lambs increased yield by 55%, whereas, supplementation of 400 g mixture resulted in an increase of carcass yield by 30 percent as compared to lambs on grazing alone. (Bhatia et al., 1973; Karim and Santra, 2000). Supplementation of 250 g concentrate mixture increased weight gains and wool production at Mathura and result were comparable to those supplemented with legume fodder. Supplementation of green berseem could replace 100 percent of concentrate protein supplement for maintenance of sheep without affecting much of their body weights and causing no apparent deleterious effect on health of the animals (Singh, 1982)

Feed requirement of ewes is highly variable and is closely linked with its breeding cycle i.e. weaning, mating, pregnancy or early lactation. The requirement of such variable situation is described here.

Flushing

A special feeding is practiced for improving ewe body condition prior to mating by increasing the level of nutrition. Flushing is usually done three weeks prior to breeding either at the beginning or at the end of the breeding season. The ewes are either allowed to graze excellent pasture during the whole day or fed about 250 g of grain per ewe daily. This stimulates ovum production, increase the number of twins and results in 10 -20% increase in lambing flushing is generally not profitable when supplemental feed is fed to ewes in normal condition. Excessively fat ewes or those in very poor health condition will perform at a reduced rate. The shepherd is in a better position to judge the body condition of ewe to decide for flushing.

Feeding during pregnancy

Pregnant ewes are fed separately from dry ewes to get a body weight gain of 100 g per day. The level of nutrition is gradually increased after the third month of pregnancy so that at six weeks before lambing the ewes are offered full diet until lambing, It is advisable that changes in diet during this critical period are avoided. Grazing for 1 -2 hours daily is necessary even if feed is not available in adequate quantity. Dry roughage should be offered first in the barn, before

turning the ewes out for grazing. Roughage should always be offered first followed by the concentrate mixture. Usually diets of higher energy concentrates (40 -50%) protein and good quality and palatable roughage (70 - 80% TDN) are fed. The level of different nutrients in the late pregnancy depends on the live weight of the ewe, the number of lambs and the type of feed stuff used in the formation of the diets. Usually it comes to 80 to 100% more than dry ewe of the same body weight. Appetite declines at the latter stage of pregnancy but the ingredients of the feed should not be changed even after lambing. The gestation period of ewes ranges from 144 to 152 days.

Feeding during lactation

The intake of the ewes immediately after lambing is low and, increases gradually. However, maximum feed intake does not occur until after peak milk yield and ewes with high milk yields are in negative energy balance. For this reason, diets high in energy concentrates are fed. The diet of ewes should gradually increase from lambing to the days or a mixture of cereal grains and wheat bran in the ratio of 2: 1 along with legume hays from 1 -2 kg. The ewe at this stage can consume dry matter up to 4% of their body weight. The supplemental feeding should have 16-18% crude protein and enough minerals particularly copper, cobalt, common salt, calcium, phosphorus and sulphur.

Feeding dry ewes

The ewes between weaning and mating develop their body condition. Milking is generally stopped to hasten the oestrus. During this period the ewes require some rest period before they change their body condition for mating. Therefore, during rest period, the requirement of the flock is less, and is kept in a low level of feeding. The flock can be used as scavengers to clean up the poor and over grown pastures, banks, stubbles, etc. The practical way to find out whether the non-producing ewes are receiving sufficient nutrients from grazing is to weigh them periodically. If the animals are maintaining their body weight or putting on a little weight, to the extent of about 20 to 30 g per day, they can be stated to be on maintenance ration.

Feeding for lamb fattening

Lamb fattening is the prime objective of the sheep rearing. The higher the feed intake by lamb, the higher is the rate of gain and the efficiency of feed conversion. Maximum feed intake can be achieved with a balanced diet in terms of all nutrients (i.e. energy, protein, vitamin and trace

elements) being present in the ration. Supplementation of the diets with a vitamin -trace element mixture will improve performance considerably. Vitamin -A (5000 I.U. /kg feed) is essential. Because of high level of phosphorus in grains and cakes, supplementation with limestone is also essential for a correct balance between calcium and phosphorus.

Lambs are weaned at 4 weeks age, and during the last 10 days before they are allowed a restricted milk suckling and solid feed intake is increased. This results in slight reduction in their growth. Good quality hay like alfalfa or other leguminous hay and concentrate mixture, containing 16% crude protein with barley grain, soybean meals, vitamin-trace element mixture and limestone, as basic ingredient is offered from two week age. The same concentrate mixture is offered after weaning. Feed should always be available in the feeders as lambs eat about l00g hay per day. Adequate nitrogen intake in relation to energy intake is crucial on the optimum growth of lambs. It is, therefore, under intensive conditions of fattening where lambs are expected to reach marketable size quickly to feed lamb diets high in energy concentrates and a minimum amount of roughage to maintain the normal functioning of the digestive tract.

The protein concentrate of diets varies from 6 to 12% according to the increasing live weight from 15 kg to 40 kg. However, in order to avoid frequent changes of diet which may affect intake, two levels are used i.e. 16% protein until 90 days of age and 14% protein from 90 days until slaughter.Under intensive feeding management practices, sexes are separated after weaning. Female lambs are fed good quality forages with a concentrate mixture containing 16% crude protein until two months of age, changing to 14% thereafter until they reach 3 -3.5 month age. The selected ewes for breeding weigh about 25 kg and desired weight at mating is 40 kg at the age of 12 months, then the expected total gain of 15 kg live weight should be obtained in 260 days or about 60 g daily.

Feeding rams

Generally, rams are maintained on the same feeding as ewes. In case of over fat ewes, they should be thinned by gradual reduction in feed and plenty of exercise. For normal size ram, during breeding time, supplementary feeding for a month before as well as during the whole breeding season should be given. At this time each ram may be offered 250 to 500 g of the grain mixture consisting of crushed grain 2 parts, wheat bran 1 part and salt, daily according to grazing condition

Table-7: Nutrient requirement of sheep (Based on NRC 1985)

Body weight (kg)	Weight change/Day	Dry mater /Animal	Energy % Body weight	TDN (kg)	DE (Mcal)	ME (Mcal)	Crude Protein (g)	Ca (g)	P (g)	Vitamin A Activity (IU)	Vitamin E (IU)
Ewes Maintenance											
50	10	1.0	2.0	0.55	2.4	2.0	95	2.0	2.8	2350	15
60	10	1.1	1.8	0.61	2.7	2.2	240	2.3	2.1	2820	16
70	10	1.2	1.7	0.66	2.9	2.4	113	2.5	2.4	3290	18
80	10	1.3	1.6	0.72	3.2	2.6	122	2.7	2.8	3760	20
90	10	1.4	1.5	0.78	3.4	2.8	131	2.9	3.1	4230	21
Flushing 2 week prebreeding and first 3 weeks of breeding											
50	100	1.6	3.2	0.94	4.1	3.4	150	5.3	2.6	2350	24
60	100	1.7	2.8	1.00	4.4	3.6	157	5.5	2.9	2820	26
70	100	1.8	2.6	1.06	4.7	3.8	164	5.7	3.2	3290	27
80	100	1.9	2.4	1.12	4.9	4.0	171	5.9	3.6	3760	28
90	100	2.0	2.2	1.18	5.1	4.2	177	6.1	3.9	4230	30
Nonlactating – First 15 weeks gestation											
50	30	1.2	2.4	0.67	3.0	2.4	112	2.9	2.1	2350	18
60	30	1.3	2.2	0.72	3.2	2.6	121	3.2	2.5	2820	20
70	30	1.4	2.0	0.77	3.4	2.8	130	3.5	2.9	3290	21
80	30	1.5	1.9	0.82	3.6	3.0	139	3.8	3.3	3760	22
90	30	1.6	1.8	0.87	3.8	3.2	148	4.1	3.6	4230	24
Last 4 weeks gestation (130-150% lambing rate expected) or last 4-6 lactation suckling singles											
50	180(45)	1.6	3.2	0.94	4.1	3.4	175	5.9	4.8	4250	24
60	180(45)	1.7	2.8	1.00	4.4	3.6	184	6.0	5.2	5100	26
70	180(45)	1.8	2.6	1.06	4.7	3.8	193	6.2	5.6	5950	27
80	180(45)	1.9	2.4	1.12	4.9	4.1	202	6.3	6.1	6800	28
90	180(45)	2.0	2.2	1.18	5.1	4.2	212	6.4	6.5	7650	30

Last 4 week gestation (180-225% lambing rate expected)											
50	225	1.7	3.4	1.10	4.8	4.0	196	6.2	3.4	4250	26
60	225	1.8	3.0	1.17	5.1	4.2	205	6.9	4.0	5100	27
70	225	1.9	2.7	1.24	5.4	4.4	214	7.6	4.5	5950	28
80	225	2.0	2.5	1.30	5.7	4.7	223	8.3	5.1	6800	30
90	225	2.1	2.3	1.37	6.0	5.0	232	8.9	5.7	7650	32
First 6-8 weeks lactation suckling singles or last 4-6 week lactation suckling twins											
50	-25(90)	2.1	4.2	1.36	6.0	4.9	304	8.9	6.1	4250	32
60	-25(90)	2.3	3.8	1.50	6.6	5.4	319	9.1	6.6	5100	34
70	-25(90)	2.5	3.6	1.63	7.2	5.9	334	9.3	7.0	5950	38
80	-25(90)	2.6	3.2	1.69	7.4	6.1	344	9.5	7.4	6800	39
90	-25(90)	2.7	3.0	1.75	7.6	6.3	353	9.6	7.8	7650	40
First 6-8 weeks lactation suckling twins											
50	-60	2.4	4.8	1.56	6.9	5.6	389	10.5	7.3	5000	36
60	-60	2.6	4.3	1.69	7.4	6.1	405	10.7	7.7	6000	39
70	-60	2.8	4.0	1.82	8.0	6.6	420	11.0	8.1	7000	42
80	-60	3.0	3.8	1.95	8.6	7.0	435	11.2	8.6	8000	45
90	-60	3.2	3.6	2.08	9.2	7.5	450	11.4	9.0	9000	48
Ewe lamb Non lactating – First 15 weeks gestation											
40	160	1.4	3.5	0.83	3.6	3.0	156	5.5	3.0	1880	21
50	135	1.5	3.0	0.88	3.9	3.2	159	5.2	3.1	2350	22
60	135	1.6	2.7	0.94	4.1	3.4	161	5.5	3.4	2820	24
70	125	1.7	2.4	1.00	4.4	3.6	164	5.5	3.7	3290	26
Last 4 weeks gestation (100-120% lambing rate expected)											
40	180	1.5	3.8	0.94	4.1	3.4	187	6.4	3.1	3400	22
50	160	1.6	3.2	1.00	4.4	3.6	189	6.3	3.4	4250	24
60	160	1.7	2.8	1.07	4.7	3.9	192	6.6	3.8	5100	26

70	150	1.8	2.6	1.14	5.0	4.1	194	6.8	4.2	5950	27
Last 4 weeks gestation (100-120% lambing rate expected)											
40	225	1.5	3.8	0.99	4.4	3.6	202	7.4	3.5	3400	22
50	225	1.6	3.2	1.06	4.7	3.8	204	7.8	3.9	4250	24
60	225	1.7	2.8	1.12	4.9	4.1	207	8.1	4.3	5100	26
70	225	1.8	2.6	1.14	5.0	4.1	210	8.2	4.7	5920	27
First 6-8 weeks lactation suckling singles (Wean by 8 weeks)											
40	-50	1.7	4.2	1.12	4.9	4.0	257	6.0	4.3	3400	26
50	-50	2.1	4.2	1.39	6.1	5.0	282	6.5	4.7	4250	32
60	-50	2.3	3.8	1.52	6.7	5.5	295	6.8	5.1	5100	34
70	-50	2.5	3.6	1.65	7.3	6.0	301	7.1	5.6	5450	38
First 6-8 weeks lactation suckling twins (wean by weeks)											
40	-100	2.1	5.2	1.45	6.4	5.2	306	8.4	5.6	4000	32
50	-100	2.3	4.6	1.59	7.0	5.7	321	8.7	6.0	5000	34
60	-100	2.5	4.2	1.72	7.6	6.2	336	9.0	6.4	6000	38
70	-100	2.7	3.9	1.85	8.1	6.6	351	9.8	6.9	7000	40
Replacement ewe lambs											
30	227	1.2	4.0	0.78	3.4	2.8	185	6.4	2.3	2410	18
40	182	1.4	3.5	0.91	4.0	3.3	176	5.9	2.6	1880	21
50	120	1.5	3.0	0.88	3.9	3.2	136	4.8	2.4	2350	22
60	100	1.5	2.5	0.88	3.9	3.2	134	4.5	2.5	2850	22
70	100	1.5	2.1	0.88	3.9	3.2	132	4.6	2.8	3250	22
Replacement ram lambs											
40	330	1.8	4.5	1.1	5.0	4.1	243	7.8	3.7	1880	24
60	320	2.4	4.0	1.5	6.7	5.5	263	8.4	4.2	2820	26
80	290	2.8	3.5	1.8	7.8	6.4	268	8.5	4.6	3760	28
100	250	3.8	3.0	1.9	8.4	6.9	264	8.2	4.8	4700	30

Lamb finishing -4 to 7 month old											
30	295	1.3	4.3	0.94	4.1	3.4	191	606	3.2	1410	20
40	275	1.6	4.0	1.22	5.4	4.4	185	606	3.3	1880	24
50	205	1.6	3.2	1.23	5.4	4.4	160	506	3.0	2350	24
Early weaned lamb –Moderate growth potential											
10	250	0.5	5.0	0.40	1.8	1.4	127	4.0	1.9	470	10
20	250	1.0	5.0	0.80	3.5	2.9	167	5.4	2.5	940	20
30	300	1.3	4.3	1.00	4.4	3.6	191	6.7	3.2	1410	20
40	345	1.5	3.8	1.16	5.1	4.2	202	7.7	3.9	1880	22
50	300	1.5	3.0	1.16	5.1	4.2	181	7.0	3.8	2350	22
Early weaned lambs –Rapid growth potential											
10	250	0.6	6.0	0.48	2.1	1.7	157	4.9	2.2	470	12
20	300	1.2	6.0	0.92	4.0	3.3	205	6.5	2.9	940	24
30	325	1.4	4.7	1.10	4.8	4.0	216	7.2	3.4	1410	21
40	400	1.5	3.8	1.14	5.0	4.1	234	8.6	4.3	1880	22
50	425	1.7	3.4	1.29	5.7	4.7	240	9.4	4.8	2350	25
60	350	1.7	2.8	1.29	5.7	4.7	240	8.2	4.5	2820	25

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Supplementation of various minerals, vitamins and probiotic for enhancing the performance of sheep and goat

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Nutrition exerts a huge influence on flock reproduction, milk production, and lamb and kid growth; 1) late-gestation and lactation are the most critical periods for ewe and doe nutrition, with lactation placing the highest nutritional demands on ewes/does; 2) nutrition level largely determines growth rate in lambs and kids (Ben Salem & Smith, 2008). Lambs and kids with higher growth potential have higher nutritional needs, especially with regard to protein and 3) animals receiving inadequate diets are more prone to disease and will fail to reach their genetic potential. The ideal nutrition program supports optimum production, is efficient and economical, and minimizes related problems. Although cattle, sheep and goats are all ruminants, they have some significant differences in their nutrient and feeding considerations;

1. Goats and sheep will graze grass and browse forbs (weeds and wild flowers) and brush closer than other herbivores and thus require more intense grazing management.
2. Goats tend to browse vegetation of higher quality than do cattle.
3. Sheep are fairly selective feeders, preferring grasses/pastures and forbs; goats, on the other hand, are mainly browsers, preferring shrubs and forbs.
4. Goats and sheep “sort” grain mixes, selectively choosing preferred ingredients, and therefore should be fed pelletized or textured feeds.
5. Goats like to eat with their heads up and will select portions with higher nutrient content.
6. Sheep are very sensitive to copper (Cu) toxicity, whereas goats can consume two to three times the Cu level that sheep can, with no ill effects.
7. Goats, on the other hand, are very sensitive to phosphorus (P) levels (do not exceed 0.40 % on the feed tag; 0.35 % is ideal). Sheep have a similar P requirement to goats but are less sensitive to higher levels.

Sheep and goats require nutrients for body maintenance, growth, reproduction, pregnancy, and production of products such as meat, milk and hair. The groups of nutrients that are essential for these small ruminants are water, energy, protein, minerals and vitamins. Many factors affect the

nutritional requirements of sheep and goats, including maintenance, growth, pregnancy, lactation, fibre production, activity, and environment. As the productivity of sheep and goats is increased through selection and crossbreeding with animals having a higher production potential, nutritional requirements will also increase. Therefore, the more productive sheep and goats should be fed high quality feed, especially weaned animals being prepared for market, young replacement females and females in late gestation and early lactation. Ewes and does feeding twins or triplets have greater nutritional requirements than ewes or does feeding a single offspring.

Minerals and Vitamins for Sheep and Goats

In order to understand the fundamentals of small ruminant nutrition, we must know the role of minerals and vitamins in addition to energy and protein, essential for growth, production, and reproduction. There are many minerals that are required in the diet of sheep and goats. These are usually divided into macro-minerals (calcium, phosphorus, sodium, potassium, magnesium, sulphur and chlorine) and micro or trace minerals (iron, iodine, copper, zinc, molybdenum, manganese, cobalt, selenium). Macro-minerals are required in larger amounts than trace minerals, with that requirement expressed as a percent of the diet, or as grams per head per day (Fontenot et al., 1989). Some of these are already in sufficient quantity in forages, so supplementation is not needed. Others may not be present in adequate amounts, so must be supplemented. Plant content of mineral elements is dependent upon the interaction of a number of factors, including soil, plant species, stage of maturity, yield, pasture management and climate (Khan et al., 2006). Young and alkaline soils tend to be more abundant in most trace elements than the older, more acid, coarse, sandy soils. Practical determination of animal's mineral status is often very difficult. Blood analysis is a poor indication of mineral status for many of the minerals. The body has a significant storage capability for many of the minerals (for example, the calcium in bone, and iron in the blood). Therefore, until body reserves are depleted, symptoms of deficiency may not be apparent. More involved processes like liver biopsy may be required to determine the mineral status of an animal. Sheep and goats, as small ruminants, can manufacture the B-complex vitamins in their rumens. However, animals who are under a health stress, producing milk at extremely high levels or whose rumen is not functioning may not be able to accommodate their body's need for the B-complex vitamins and supplementation may be required.

Calcium (Ca), Phosphorous (P) and vitamin D

Ca and P are usually considered and always found together, yet they may be considered to be opposite in effect (excess Ca is 'equivalent' to deficiency in P). They are also both interactive with vitamin D as well as iron and copper. 99% is stored in the skeleton and 1% or less is used vitally in blood clotting, membrane permeability, muscle contraction, nerve function, cardiac regulation and enzyme activation. The skeleton is the store for both Ca and P and somewhat surprisingly, the goat can add and draw from this reserve in times of deficiency (Herm et al., 2015). There is normally a positive Ca balance during pregnancy when the skeleton is added to and a negative balance after kidding where up to 30% of the skeleton may be utilised. Sheep and goat requires 1.3g of Ca and 1.0 g P for each 1kg of milk produced. If we consider both these figures it is obvious that a Ca: P ratio of 1.4: 1 is ideal, suiting both the above. Ca deficiency manifests itself by rickets, milk fever (especially after kidding). Lack of Vitamin D will also help promote this, since it is required for retention of Ca in the bones. Vitamin D is required for the deposition and remobilisation of the above into the skeleton. It is the antirachitic (prevents rickets) vitamin and its main source is from sunlight and is formed on the skin. Absorption is through the skin or by simply licking off.

80% of the P in the body is found in the bones and teeth. In addition it functions with calcium in bone formation, is essential for cell growth, energy utilization, maintaining acid-base balance, is a component of DNA and is required by rumen microbes for optimal growth and activity. P deficiency is more likely, less severe and harder to diagnose. Basically it causes 'poor thrift,' lower milk yields and general lethargy. Ca and P work on the thyroid gland together with Iodine to govern the metabolic rate. Very crudely, Ca acts as a brake and P an accelerator. Unlike cows, goats excrete a large proportion of Ca and P and therefore have a relatively large requirement. Deficiency symptoms are uncommon but sheep and goats that are kept indoors in winter etc. are most likely to suffer and therefore need supplementary feeding.

Sodium (Na) and Potassium (K)

1.5 g per day is required, which is equivalent to about 3.5 g of salt (NaCl). Large excesses are detrimental to vitamin A uptake and excess in the diet is excreted in the goat and sheep urine. There are large differences between goats as to preference to salt and a pure salt lick is the best

(and cheapest) option. Salt blocks combined with vitamins are not ideal because the vitamin content will degrade fast in this aggressive environment.

It is now recognised that for goats relatively large quantities of K are needed. It is normally available in feedstuffs containing a high proportion of roughage and should not usually pose a problem. Deficiencies include emaciation, retarded growth, and low feed intake with poor milk yields. It is not a toxic element and it is always a wise precaution to incorporate it in feed supplements.

Magnesium (Mg) and sulphur (S)

70% is found in the bones and teeth, the rest in the blood. It functions in carbohydrate and fat metabolism and is a catalyst in over 300 enzyme systems. Again up to a third can be mobilised at times of need. A daily requirement of 1.2g per day is necessary. The first symptom is the lowering of the milk yield, possibly followed by magnesium tetany and hypomagnesaemia (Altura, 1991). This is most common when animals are put out on to lush grass in spring when the Mg content in the grass is at its lowest and requirement greatest. It is relatively rare in goats.

Two amino acids (methionine, cysteine) and two B-vitamins (biotin, thiamine) contain S. S also functions in maintaining bone, cartilage, tendon and blood vessel integrity (contained in chondroitin) (Noronha, 2002). Rumen microbes are capable of synthesizing the entire S containing compounds from inorganic sulphur. High S levels in the diet partially inhibit the use of Cu and Mo.

Copper (Cu) and zinc (Zn)

Cu is involved in haemoglobin formation, enzyme systems, nervous and immune system function (Chia et al., 1992). Cu interacts with Fe, Zn, S and Mo in antagonistic relationships. Cadmium also has the same 'blocking' effect as molybdenum and this has occurred when goat keepers have put contaminated waste sludge on to their pastures to act as a fertiliser. Sheep are very susceptible to Cu poisoning as dietary Cu levels approach or exceed 20 ppm. Very small quantities of Cu are required and these must be consistently fed to aid digestion and utilise the Fe by forming ceruloplasmin etc. Again deficiencies are very noticeable in the coat with 'spectacles' forming around the eyes, especially noticeable with dark wool type sheep and haired goats (Clauss et al., 2007). More serious Cu deficiencies can be seen with the appearance of 'Swayback' where the back actually does sway and the goat has difficulty walking. Cu deficiency

caused by the presence of excess Mo in the soil which prevents the Cu being absorbed. Mineral mixes or trace mineral salt formulated for cattle or horses should not be fed to sheep because they are too high in Cu and sheep accumulate Cu in the liver more easily than other livestock species. If sheep mineral contains Cu don't feed a trace-mineralized salt containing Cu. Cu poisoning also may result from low intakes of Mo, S, Zn and Ca. Stressful situations such as handling, strenuous exercise, transporting, a declining nutritional state and weather can cause a sudden release of the stored Cu into the blood, and cause toxicity.

Zn is important in stress management, immune response, enzyme systems and protein synthesis. Exact requirements are not known but between 10-60 ppm (mg/kg DM) is considered satisfactory. Level below 6-7 ppm does cause deficiency with stunted kids and lambs that do not thrive (Kirchgessner et al., 1981). Little Zn is available and must be supplied from the diet since it is not stored in the body as a reservoir. Zn has a profound effect on males much more than females since it is involved in sperm production and the development of the sex organs. Deficiency symptoms include high bacteria in the mouth with excess saliva, stiffness of the joints and a low male sex drive. In vegetable diets Zn combines with phytic acid to form insoluble salts and becomes unavailable. Dry diets are more likely to cause parakeratosis and wetting of the feed hydrolyses the phytate salts and liberates the Zn. So wetting of the feed for males is recommended. Zn deficiency is best spotted by the condition of the coat - there is reduced hair growth, a staring coat and also lameness. Zn is not very toxic; one would need around 1000 ppm to cause problems.

Manganese (Mn)

Occurs mainly in the liver (cofactor in several enzyme systems) and is another essential mineral, when fed at 5 ppm in the feed, deficiency symptoms were noted. These included lethargy whereby goats would lay down a lot, walk poorly and deformities in the forelegs were also noticed (Chia et al., 1992). A change in the sex ratio in favour of male twins was reported and a lowering of the reproductive efficiency in the males and a lower conception rate in the females with delayed oestrus observed. A daily requirement of 60-90 ppm in the feed is generally suggested as being ideal (Kirchgessner et al., 1981).

Iodine (I) and Cobalt (Co)

I is primarily involved in the thyroid hormones that regulate rate of metabolism. Deficiency usually is not a problem except with goitrogenic forages or feedstuffs like turnips, kale, rape, white clovers (Merck, 1986). Low levels are needed daily and are vitally important since goats and sheep can excrete 94% of their daily uptake via the milk, whereas cows lose only 2%. More I in the diet give directly more in the milk. It is also temperature dependent with six times more I appearing in the milk at 30ºC than at 5ºC. I concentrate in the thyroid gland in the throat and is used in the production of thyroxine hormone. Only 0.15 mg per day is required but this is essential. The percentage of I available is proportional to its concentration in the soil and not what is growing on it (the same I percentage occurs in grass as in deep rooted weeds). A harsh coat is also common and perhaps the birth of live males, but dead female kids. The female has a larger thyroid gland and a bigger need for thyroxine and therefore a greater need for I.

Sheep have a greater need of Co than cows and goats have 4 times the need of sheep. Co is directly involved in the formation of vitamin B_{12} (Arinola et al., 2008c). Deficiency gives off-flavours in the milk, loss of appetite, weakness, emaciation, anaemia, low productivity etc., and the latter symptoms are often categorised under the generic term 'pine'. 0.5 mg is required daily and it is most important that it is given on a daily basis

Iron (Fe)

Fe involved in cellular respiration and oxygen transport via haemoglobin. Additionally, some is found in the enzyme systems and Fe is fundamental to all living tissue. Deficiencies can occur, especially in kids and lamb due to low body reserves and exacerbated by the low Fe content of goats milk during suckling (a big difference here with cows and sheep milk). For adults a daily intake of 75 mg is considered acceptable for lactating goats. Deficiency is relatively rare in farm animals with anaemia being the standard symptom. Fe toxicity is very rare because of huge doses needed to cause problems (Youdim et al., 1989). The Fe in grass and oil meals (100-300mg per kg), in Dicalcium phosphates or limestone (500mg per kg) and cereal grains (30-60mg per kg) should provide enough. Any extra poses no problems and the Fe content of the milk is not dependent upon the diet (very different from I).

Selenium (Se) and vitamin E

Se is very toxic in anything other than really minute quantities, but is nonetheless essential. 0.2 mg per day is officially recommended. Basic feedstuffs are often deficient in Se and many have Se rich compounds added to compensate. Strangely, weeds and deep-rooted plants have a greater concentration of minerals than grass, yet for Se it is the same for all growth (Combs Jr, 1981). Therefore the best guarantee for adequate Se is to 'Selenise' the soil via a special Se rich top-dressing.

Vitamin E is tied up with Se as a co-partner, but there are still some doubts as to its exact function. It is known to be concerned with the cell nucleus, the development of the foetus and the performance of the males. It is an antioxidant, facilitating absorption, storage and protection of vitamin A. vitamin E is found in oil meals and bran, however, if goats can be persuaded to eat cod liver oil, recent evidence shows that deficiency symptoms are created by forming gut conditions favourable to the destruction of both vitamin E and Se. The method of storage of feedstuffs is very important as the concentration of vitamin E is dependent upon it: basic feedstuffs can easily be made to be very deficient simply by bad storage conditions. Apart from white muscle disease and muscular dystrophy, lack of vitamin E also causes sterility in males. Note that kids have no reserves of fat soluble vitamins (A, D and E) and sudden death of kids less than 2 weeks old is often due to lack of vitamin E in particular. This is normally overcome by feeding colostrum but the vitamin E content is also affected by the nutrition of the dam during pregnancy. With kids there is degeneration of muscle including the heart, whereas in older animals it will manifest itself as stiffness of the limbs (Combs Jr, 1981).

Vitamin A

Vitamin A is recognised as very important to all livestock including sheep and goats and its primary function is fortifying the outer defences of the skin and mucous membranes against disease. Vitamin A aids disease resistance and is required for good vision, lactation and reproduction. It is not yellow in colour but the carotenoid pigments found in carrots, maize etc. are bright yellow and contain the precursor to vitamin A known as Carotene. Carotene is converted in the intestinal wall and this depends upon the thyroid gland. Since the thyroid is very large in the goat, this animal is a very efficient converter of vitamin A; in fact all carotene is

converted: this is why goat's milk is pure white whereas the milk from cows (relatively inefficient converters) is still yellow with unconverted carotene present.

Vitamin A can be stored in the liver for two or three months after sheep and goats have been eating green forage for several months. Consequently, when animals are eating fresh pasture, or fresh or well-made hay, no supplemental vitamins are needed. Deficiency symptoms are rare and include night blindness, poor reproductive performance and metritis. Vitamin A is destroyed by sunlight and therefore old hay is very low in this vitamin. For the new-born kid and lamb the colostrum is very important since they have very small reserves of vitamin A. It is worth noting that the vitamin A content of goat milk is directly proportional to the amount of beta-carotene occurring in the feed.

Vitamin B-complex

Sheep and goat along with other ruminants are blessed with bacteria that live in the rumen and synthesise the B vitamins. Therefore it has been suggested that supplementation is not necessary, but there are several reasons for vitamin B inclusion:

1. Inhibition of synthesis of certain B vitamins by substances in feedstuffs occurs, especially those with high starch levels.
2. Parasites in the gut totally remove certain B vitamins.
3. Some B vitamins cannot be synthesised in sufficient quantities to meet demand - especially with heavy milkers and the shortfall must be provided via the feed.

Conventional feedstuffs contain fairly constant amounts of vitamin B_1 and the higher the amount fed the lower the amount synthesised. However diets with high carbohydrate content increase the requirement of vitamin B_1 which is one reason why straight grain diets should not be fed since they act as vitamin B_1 antagonists. There is a relationship between vitamin B1 deficiency and disease resistance and deficiency causes damage to the central nervous system (polioencephalomacia and cerebrocorticalnecrosis). This is exhibited by collapse, twitching etc. and the only cure is vitamin B_1 injection. 50-60 mg per day is the recommended daily intake. Vitamin B_1 is also used as a preventative for acetonaemia.

Nicotinamide, also a member of the B group vitamins. Recent evidence again shows limited synthesis and the majority of the vitamin is derived from the goat's feed intake. Supplementation

improves milk production and butterfat levels. There is good evidence that nicotinamide present in cereals is 'bound' i.e. not available and therefore must be added by supplementation in the diet.

In high cellulose diets (where hay comprises a large percentage), the biosynthesis of pantothenic acid is impaired. It is found in fresh vegetables and, in milk, bound to the proteins. It serves an important function in the formation of enzymes and certain antibodies, and since recent evidence has shown that deficiency can occur, it is always best to incorporate it in the feed via supplementation on a daily basis.

Vitamin B_{12} is directly associated with Co. Large excesses of Co in the gut will result in analogues of vitamin B_{12} being formed these are identical to the natural vitamin except for a slight molecular variation. These analogues surprisingly have zero vitamin activity, despite being 99+% identical to the original and will cause vitamin B_{12} deficiency symptoms. Obviously, administering even more Co is not the answer as this creates further problems and the best solution is to ensure a low daily dose of Co is provided and in the case of vitamin B_{12} deficiency, an injection of this vitamin, whilst the gut flora returns to a normal healthy state.

Table-1: Requirements of minerals and vitamins for various classes of sheep
(based upon the NRC, 1985)

Nutrient	Young Lamb	Mature Ewe	
		Early Pregnancy	Nursing Twins
Calcium, %	0.55	0.25	0.40
Phosphorous, %	0.25	0.20	0.30
Potassium, %	0.60	0.50	0.80
Magnesium, %	0.12	0.12	0.18
Sulfur, %	0.15	0.15	0.25
Sodium, %	0.10	0.10	0.15
Iron, mg/kg DM	40	40	40
Copper, mg/kg DM	10	10	10
Manganese, mg/kg DM	40	40	40
Zinc, mg/kg DM	30	30	30
Selenium, mg/kg DM	0.30	0.30	0.30
Vit A, IU/lb DM	500	1000	1200
Vit D, IU/lb DM	100	100	100
Vit E, IU/lb DM	7	7	7

Choosing a mineral and vitamin supplement

There are a variety of salt and mineral mixes commercially available that are specifically formulated for sheep. These mixes range from trace mineralized salt to salt-free minerals to mineral mixes that contain vitamins. When you feed a complete trace mineral mix containing salt, no other source of salt should be available to your sheep. Some commercial mineral mixes also contain vitamins A, D and E. If you buy a mineral mix with added vitamins, choose the one containing the highest level of vitamin A (up to 500,000 IU). Adding specific minerals like Ca is also a way of incorporating minerals into the diet in some circumstances (adding limestone or calcium carbonate is an inexpensive way to supply the Ca required by lambs fed high grain diets or ewes fed green feed or grass hay as roughage). Minerals can also be supplied in a custom mineral mix that is specifically designed to meet the mineral requirements of your sheep based on an analysis of your home grown feeds. When the nutrient content of your home grown feeds changes, so must the minerals supplied in your custom mineral mix.

Table-2: List of feed additives used for feeding in sheep and goats

S. No.	Feed additive	Benefits of feeding
1.	Aspergillus Oryzae (Yeast)	Stimulate fibre-digesting bacteria, stabilize rumen pH, and reduce heat stress
2.	Calcium Propionate	Increase blood glucose and calcium levels
3.	Protected Choline	A methyl donor used to minimize fatty liver formation and to improve fat mobilization
4.	Enzymes	Increase fibre digestibility by reducing fibre (cellulase and xylanase enzymes) and DM intake
5.	Magnesium Oxide	Alkalinizer (raising rumen pH) and increases uptake of blood metabolites by the mammary gland, raising fat test
6.	Methionine Hydroxy Analog	Minimize fatty liver formation, control ketosis, and improve milk fat test
7.	Probiotics	Produce metabolic compounds that destroy undesirable organisms. Probiotics provide enzymes improving nutrient availability, or detoxify harmful metabolites

8.	Propylene Glycol	Used as a source of blood glucose, to stimulate an insulin response, and to reduce fat mobilization
9.	Sodium Bentonite	Clay mineral used as a binder, which shifts VFA patterns, slows rate of passage, and exchanges mineral ions. Field claims to tie up mycotoxins have been reported
10.	Sodium Bicarbonate / Sodium Sesquicarbonate (Buffer)	Increase dry matter intake and stabilize rumen pH
11.	Yucca Extract	Decrease urea nitrogen in plasma and milk by binding ammonia to the glycofraction extract of Yucca shidigera plant, improving nitrogen efficiency in ruminant animals
12.	Zinc Methionine	To improve immune response, harden hooves, and lower somatic cell counts

Feed additives for sheep and goats

Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as rumen pH shift, growth, or metabolic modifier. Several feed additives contain nutrients such as sodium in sodium bicarbonate, or protein in yeast culture. Feed additives are not a requirement or guarantee for high productivity or profitability. Most sheep and goat producers will use very few, if any, feed additives. However, feed additives are heavily marketed and producers should be aware of what they are, what claims are made for individual feed additives and which work and which do not.In conclusion, supplementation of micronutrients and feed additives in diets of sheep and goats enhanced body weight gain, and productive and reproductive performance of sheep and goats.

Table-3: List of commercially available feed additives used for feeding in sheep and goats

Sr. No.	Feed additive (trade name)	Contain	Benefits of feeding
1.	Goat SHAG	Combination of probiotics, electrolytes, vitamin and mineral pack.	Improve growth rate and milk production.

2.	Secret Shake	Combination of Proteins, Spray Dried Egg Product, Amino Acids, Carbohydrates, and Electrolytes in a highly digestible palatable form.	To pull weight without losing shape and bloom.
3.	Sheep and Goat Nutri-Drench	High energy source containing high vitamins, minerals, amino acids and glucose.	These nutrients support life and are needed quickly to restore a non-functioning mmune system. Support for multiple birth and disease, increase milk production, stimulate appetite, energy burst for weak newborn kids.
4.	Full Stream for Goats and Lambs	Calcium	A topdress feed supplement for goat and lamb wethers, designed to increase absorption of calcium in animals prone to urinary calculi.
5.	Duramax" with Oxy-gen for Goats	High potent vitamin and mineral mobility package	Better nutrient absorption through the digestive system.

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Common Nutritional and Metabolic Diseases of Small Ruminants

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Goats can adapt to different areas where the environment, and consequently the quality and the quantity of pastures vary widely. The adoption of intensive methods of husbandry in goats for higher milk yields is likely to increase the incidence of metabolic diseases. Therefore, under more intensive production systems, it is imperative to pay more attention animal health and welfare. Estimation of blood biochemical parameters such as hormones, metabolites and proteins are helpful complementary diagnostic tools and form the basis of metabolic profile tests which help to predict and prevent the occurrence of several metabolic diseases. Pregnancy and lactation are physiological stages thought to induce metabolic stress. Underfeeding pregnant sheep can induce deleterious effects on foetal and newborn lambs by adversely affecting placental size, foetal growth, deposition of foetal fat reserves for use after birth, maternal udder development and colostrum and milk production. This may be even more important in grazing goats because they cannot meet their energy requirements for late pregnancy especially when parturition is scheduled out-of-season, or in the instance of marginal and hill land goat production. Therefore goats fed pasture or roughage should benefit from being supplemented with a diet of high nutritional level in late pregnancy. Production diseases of ruminants are a manifestation of their inability to cope with the metabolic demands of high production, and thus continue not only to be a cause of economic losses to and but also from animal welfare concern. More recent definitions of production disease have been informed by the influence of high production and management on 'factors such as animal behaviour, immunity and gene expression', thus the definition has been expanded to include not only 'metabolic and nutritional diseases' but diseases of 'infectious and genetic nature'.

A pivotal time in the life of a livestock occurs during a period 2-3 weeks prior to through 2-3 weeks after calving, denoted as the transition period, when the animals face tremendous metabolic and physiologic changes that challenge the homeostatic mechanisms of body. The change from gestational non-lactating to nongestational lactating state dents both the metabolic and immune status of transition cows. During transition period, animals undergo physiological

stress in order to prepare for and recover from parturition, dramatically alter their metabolism to supply the mammary gland with nutrients necessary for milk synthesis, and also deal with reduced dry matter intake (DMI), negative energy balance (NEB) and oxidative stress. Recent developments in the evaluation of oxidative stress in farm animals have contributed significantly to our understanding of the fundamental processes involved in metabolic disorders. Oxidative stress is believed to play an important role in regulating the metabolic activity of some organs and productivity in farm animals. Oxidative stress results when pro-oxidants (free radicals) exceed the capacity of antioxidants. A free radical is defined as any species capable of independent existence that contains one or more unpaired electrons. Reactive oxygen metabolites (ROMs) are capable of attacking all of the major classes of biomolecules, although lipids are particularly susceptible. Oxidative stress can be particularly dangerous because no clinical symptoms are shown and the condition is diagnosed by means of dedicated analytical methods. ROMs have several normal physiological functions, but 'oxidative stress' will occur when excess production cannot be counteracted by antioxidant mechanisms, potentially leading to pathological changes. Several defence mechanisms are available to prevent oxidative damage, including scavenging systems, such as the enzymes glutathione peroxidase (GSH-Px) and superoxide dismutase (SOD). In addition, thiol (SH) groups, commonly found in the cysteine side chain, are the most chemically reactive sites on proteins, such as albumin, and have strong reducing properties. The most common production and metabolic diseases encountered in goats are as follows:

Pregnancy Toxemia (Ketosis)

Pregnancy toxemia is a metabolic disorder that occurs in does during the late stage of gestation. Does that have low energy levels are more susceptible to toxemia. This low energy level is caused by a sudden increase in nutritional demands as a result of rapid fetus development. Under these conditions, the doe's body is depleted of carbohydrates that are used to produce glucose or sugar. When this condition occurs, rumen capacity decreases as the uterus expands to handle the growth of one or more fetuses. Pregnancy toxemia can occur in young and old does with good or poor body condition. Studies have shown, however, susceptibility to pregnancy toxemia to be higher in older, fatty animals carrying multiple fetuses. During pregnancy, the doe's body resorts to another source of energy when carbohydrates are in low supply. This alternative source involves the production of glucose from other noncarbohydrate substances to facilitate glucose

availability to the fetuses. These events often coincide with the beginning of milk production. During late gestation, an average of 30 to 40 grams of glucose a day per fetus is required to meet metabolic demand. If the doe's body does not meet this demand, its body will store use fat as an energy source. This mechanism of breaking down stored fats will consequently overwhelm the liver's capacity, result in hepatic lipidosis or fatty liver, and ultimately, impair liver function. As the doe's body progresses in mobilizing more body fatty tissue, it will produce highly toxic byproducts or ketone bodies that are released into the blood circulation, causing an increase in hepatic fat accumulation.

Signs Pregnancy toxemia occurs frequently within 1 to 3 weeks from kidding, and it is associated with prepartum mortality in a doe herd. The first signs of pregnancy toxemia are:

- Little or no appetite
- Depression
- Lethargy or sluggishness
- Muscular imbalance or poor coordination, known as ataxia
- Grinding of teeth
- Blindness

Does become so weak they are forced to lie down and, in most cases, will not be able to rise again; legs are usually tucked underneath the body. They also have sweet or foulsmelling breath when there is a high level of ketones or toxins in the blood. These symptoms may occur within a few hours to 2 days from the onset of signs. If symptoms persist, does could progress to coma or even death. A doe's death is attributed to reduced liver and kidney function. When the doe dies, the fetus or fetuses also die. However, if a fetus dies and is not removed quickly, septicemia will occur, carrying the pathogen throughout the doe's bloodstream. Diagnosis For an accurate diagnosis of pregnancy toxemia, a differential diagnosis is important to determine this metabolic disorder from other disorders with similar signs such as hypocalcemia or hypomagnesemia, resulting from low calcium or magnesium levels in the blood. Other disorders with similar symptoms include diseases that affect the nervous system such as polioencephalomalacia, enterotoxemia, rabies, listeriosis, and lead poisoning. When possible, a quick laboratory analysis is important to diagnose and treat pregnancy toxemia.

As with many diseases, a prompt diagnosis and proper care leads to successful treatment. A clinical diagnosis is fundamental and consists of the histories of the animal and herd, the identification of the clinical signs, and detection of high levels of ketone bodies in the urine. Ketone bodies can be determined by using commercial, quantitative tests (e.g., Ketostick). Prognosis is given by the levels of acidosis, dehydration, and hepatic and renal failure that occur. At necropsy, does present fatty infiltration of the liver, enlargement of adrenal glands, and atrophy of the kidneys. When available, laboratory analyses can be useful tools for diagnosis; however, producers must be mindful of associated costs. In most cases of pregnancy toxemia, the levels of glucose in the blood are normal, and some affected does have shown hyperglycemia (higher levels of glucose in the blood). Thus, the levels of glucose in the blood are not a good indicator for the diagnosis of pregnancy toxemia.

Treatment

The success of the treatment depends upon the diagnosis of pregnancy toxemia in its early stages. Does can be successfully treated with 60 to 90 ml of propylene glycol administered orally 2 to 3 times per day, along with the administration of insulin. Administer 20 to 40 IU protamine zinc insulin intramuscularly every other day to help restore glucose uptake.

• Administering electrolyte solutions containing 5 percent dextrose orally, intravenously, or subcutaneously is also recommended. If the doe is in a comatose state, the treatment is frequently costly and prognosis is poor. Treatment methods include:

• Administer orally propylene glycol, 4 ounces/4 times a day. Administration of sodium bicarbonate solution intravenously or orally is also used to treat ketoacidosis. If possible, consider an ultrasound to determine the number of viable fetus (es) the doe is carrying.

• Consider the induction of labor in a doe that is near term or parturition using 15 to 20 mg dexamethasone intravenously or intramuscularly.

• In the case of fetal death, a fetotomy, which is the removal of fetal tissues and placenta, is recommended, followed by the administration of an antibiotic such as procaine penicillin G at 20,000 IU/kg, to prevent infection.

• Consider the administration of vitamin B complex intramuscularly and probiotics orally. Treatment should be discontinued when the doe presents signs of improvement.

Prevention

A good feeding management practice is needed at the late stage of pregnancy. During the last 6 weeks of gestation, provide grain as it is an essential source of carbohydrates. Does carrying multiple fetuses should be fed adequate energyTDN levels (Tables 1 and 2). Producers should be mindful that the levels of energy in the diet might vary depending on forage quality and availability, doe body weight and condition score, and the number of fetuses the doe is carrying. It is important to balance the levels of protein in the concentrate because protein must be available for ruminal microbial function. The primary sources of energy found in forages are the large and complex carbohydrate molecules, cellulose, hemicelluloses, and pectin. The doe's body cannot digest these components of the forages, but the rumen microbial population can. The bacteria and protozoa of the rumen will degrade cellulose and hemi-cellulose and, consequently, supply energy to the doe. Consider supplying concentrated rations with ionophores. Ionophores increase the ruminal utilization of volatile fatty acid propionic acid, which, in turn, will be used in the production of energy. Also, avoid stress and sudden dietary changes at late pregnancy.

Lactational Ketosis / Fatty Liver Disease

Similar to the disease process described for pregnancy toxemia, dietary glucose deficiency occurring during peak milk production can result in a ketotic state in heavily lactating dairy goats. This is generally not a disease problem in sheep or non-dairy breed goats.

Clinical Signs

Lactating does will initially reduce milk production. Refusal of grain and further reductions in milk production will ensue. Does will rapidly lose body condition during early lactation. Body temperature, pulse rate and respiratory pattern will be within normal limits. Rumen activity may diminish. In severe cases, neurologic signs (nervous ketosis) similar to those described for pregnancy toxemia will be observed. Causes. Glucose demand to support lactose (milk sugar) production by the mammary gland tremendously increases the does requirement for dietary glucose precursors. Sugars and starches primarily in cereal grains are the predominate sources of glucose precursors. As lactation is initiated, dry matter intake starts at it’s lowest level on the day of kidding and then slowly increases. However, milk production by the mammary gland increases glucose demand more rapidly than accounted for by dietary intake. This results in a period of negative energy balance, resulting in body weight loss to support lactation. If grains are

increased in the diet too rapidly, a condition of acidosis might result (see lactic acidosis). To compensate for the reduced glucose availability, the doe will mobilize body protein and reserve fat to meet increased energy and glucose needs. Excessive body fat mobilization results in large amounts of fatty acids being delivered to the liver for processing. The liver can only metabolize a fraction of the fat delivered and in the face of low blood glucose concentrations, will generate excessive amounts of ketone bodies. Fatty acids not metabolized to ketone bodies will be synthesized back into fat and stored in liver cells. Excessive liver fat storage will result in associated fatty liver disease.

Treatment

Similar to pregnancy toxemia, glucose supplementation in the form of intravenous dosing followed by 3 days of oral propylene glycol is needed. Repeat treatments may be necessary for full recovery. Corticosteroid therapy is also used to stimulate the doe's ability to generate glucose from amino acids. In refractory cases, insulin therapy in conjunction with glucose infusions may be necessary. Supportive therapy to stimulate intake and dietary modification to increase glucose availability are also warranted. Prevention. Good supportive care following kidding and appropriate dietary management of the early lactation doe are important. Recently kidded does should be managed carefully to ensure adequate opportunity to eat a well-balanced diet without any obstacles. Recently kidded does may be more timid and reluctant to compete for food. Observe does carefully for any indications of other postparturient disease problems that may negatively impact appetite. Ensure the early lactation diet has higher protein and energy content, but is not excessive in grain. Gradually increase grain over the first 2 weeks of lactation. Body condition score of the late pregnant doe is again critical. Does should enter lactation with some body reserve, but not excessive. Heavy body condition does will not only have more fat reserves to mobilize and be more susceptible to fatty liver disease, but their intake will be reduced. Excessively thin does will not have the nutrient reserves to support good lactational production.

Periparturient Hypocalcaemia (Milk Fever)

Hypocalcemia (low blood calcium concentration) is a disease commonly seen in dairy cattle on or immediately following calving. Sheep can experience hypocalcemia during late pregnancy associated with rapid calcium loss to the developing fetus for bone mineralization. Other species

can experience hypocalcemia at or near the time of peak lactation (lactational eclampsia). Based on limited information available regarding goats, it seems dairy breed goats are potentially prone to all three manifestations of hypocalcemia.

Clinical Signs

Hypocalcaemia is usually seen in high producing dairy goats one to three weeks post-kidding and is much rarer than pregnancy toxaemia. Initially the doe is ataxic, nervous and hyperactive but quickly becomes sternally recumbent. The doe stops eating and the ears are cold. The pupils are dilated and respond very slowly or not at all to a flashlight being shown directly at them. The head may be turned back to the flank. Sometimes the hind legs are splayed out behind the doe. The heart is very hard to hear or feel) and beats quickly and weakly. Death follows bloat, regurgitation of rumen contents and aspiration. The course of disease can be as little as a few hours and occasionally may occur as "sudden death", i.e. the doe is found dead in the morning. Serum calcium levels are decreased, usually less than 1.7 mmol/L (normal 2.1 - 2.8 mmol/L). To help in diagnosing hypocalcaemia at a postmortem examination, serosanguinous blood obtained from heart clots can be centrifuged and the serum analysed for Ca++ levels. The values obtained will accurately reflect pre-mortem values as long as haemolysis and putrefaction have not yet occurred. Again, this disease may look like other diseases and the doe must be examined by a veterinarian in order to differentiate from polioencephalomalacia, advanced grain overload, toxic mastitis, lead poisoning, listeriosis, etc.

Treatment

Clinical cases of hypocalcaemia are usually treated with calcium borogluconate solution (20 mg Ca++/ml) iv and sc. Response should be dramatic. The doe usually starts to shiver and brightens up by the time treatment is finished. If she does not, it may be that the diagnosis is incorrect or is complicated by another disease. It is important that iv treatment only be given in the face of strong clinical evidence of disease. Calcium can easily cause death if given i.v. to an animal with normal calcium levels.

Prevention

Long term under nutrition is required for primary hypocalcaemia to develop. Goats require calcium rich diets after kidding. Alfalfa hay can provide this. Cereal crop forages such as wheat or oat hay are very low in calcium (0.15% and 0.24% dry matter (DM) basis respectively) as

opposed to alfalfa hay (1.4% DM) and should be avoided unless the ration is balanced with other calcium sources. Over-feeding of calcium in late gestation by feeding alfalfa without balancing with anionic salts has been associated with hypocalcaemia in cattle. Feeding an anionic ration in late gestation will also improve calcium absorption from the gut and from the bones. The ration in late gestation and early lactation should also have calcium: phosphorus ratio of greater than 1.5 to 1. Prevention of pregnancy toxaemia will also help to prevent hypocalcaemia as well.

Hypomagnesemia (Grass Tetany, Lactation Tetany, Milk Tetany)

Hypomagnesemia is a common problem in beef cattle on spring pasture, but sporadically seen is dairy cattle and small ruminants. Many clinical syndromes have been identified relative to disease circumstances, but all have hypomagnesemia in common. Lactating does on spring pasture are susceptible (Grass tetany or Lactation tetany) as well as growing kids on milk replacer (Milk tetany).

Clinical Signs

Hypomagnesemia (low blood magnesium concentration) usually occurs in early lactation and results in a life threatening disease process characterized by severe tetanic muscle spasms. Affected animals initially show ataxia, stiffness and hyperexcitability. This rapidly progresses into recumbency and paddling. All muscles are overstimulated resulting in extreme leg stiffness and observed muscle spasms. This is very different from the paralytic muscle weakness of hypocalcemia. Convulsions may be triggered by some stimuli including predator attacks, severe weather changes, transportation and other stressors.

Causes

Magnesium is inefficiently absorbed from the rumen. Dietary levels of potassium and excessive calcium can interfere with magnesium absorption. Potassium is especially of concern relative to magnesium absorption. Magnesium also plays a role in maintenance of blood calcium concentrations and hypomagnesemia can induce hypocalcemia. Besides mineral interactions, differences exist between grasses and legumes as to magnesium content. Grasses contain less magnesium than legumes and when growing rapidly in cooler conditions (lush spring pasture), magnesium availability is greatly reduced. Goats like other ruminants, have little ability to manage blood magnesium concentrations if dietary levels or absorption are depressed. The

combination of low intake coupled with greater losses during early lactation result in the clinical syndrome.

Treatment

Like hypocalcemia, hypomagnesemia must be treated as an emergency situation. Intravenous administration of combined magnesium and calcium solutions is necessary. This may be followed by subcutaneous injections of magnesium sulfate solutions as well as oral magnesium supplementation. Response to intravenous therapy is rapid, but may be short-lived. Repeat treatments may be necessary. Subcutaneous and oral supplements are useful in preventing relapses.

Prevention

Appropriate dietary supplementation of magnesium from late pregnancy through early lactation is needed. Dietary magnesium should be increased to account for high dietary potassium, up to a point. Dietary magnesium should not exceed 0.4% of dry matter. A suggested ratio of dietary potassium to magnesium of 4:1 is suggested. Magnesium can be supplemented in mineral mixes, but it is unpalatable. Mixing 1 part magnesium oxide, 1 part trace mineral salt and 1 part soybean meal or other palatable feed has been shown to be effective in maintaining good magnesium intakes and preventing disease problems.

Lactic Acidosis (Grain Overload)

The rumen microflora can only handle gradual changes in forage:grain ratio. If the proportion, absolute amount or type of grain changes too quickly, then lactic acidosis will develop. Feeding order (i.e. grain before forage) also can cause lactic acidosis. The type of rumen bacteria change to gram positive from gram negative and lactic acid is produced. This lowers the pH of the rumen. Once below 5.5, protozoa and bacteria start to die. The acid gets absorbed into the body creating general acidosis. If the pH is low enough, the rumen gets "burned" and, if the goat survives, it often gets secondary rumen and liver infections from bacteria or fungi. Fibre (e.g. hay or silage) is important in the diet as well as it stimulates the goat to chew, thus producing alkaline saliva which serves to buffer the rumen. Diets with little fibre or chopped too finely are more at risk of lactic acidosis.

Clinical Picture

Simple indigestion may be the first indication of a feeding problem. The goat backs off her feed, usually only for one feeding. If longer than 24 hrs then something else is wrong. Chronic feeding problems will manifest as variable appetite, depressed milk fat and chronic laminitis. Acute laminitis shows up as painful feet. What is more common is the chronic form in which the toes grow abnormally fast with "rings". The quality of the horn is poor and flaky. Goats may be lame and prone to foot abscesses. Milk fat is depressed because fibre is necessary for the rumen flora to produce the correct volatile fatty acid to make milk fat (acetate). With more severe lactic acidosis, the protozoa die, the rumen becomes static and the goat becomes depressed and dehydrated. The rumen is fluid filled and "sloshy". Diarrhea smells acidic and is yellow in colour. In very severe cases, there is no diarrhea because of total gut stasis. The goat may appear "drunk" and ataxic. She will go down and will look very similar to milk fever, i.e. cold with dilated pupils. Rumen examination (pH and examination of flora) need to be done to confirm a diagnosis.

Treatment

In severe cases, treatment is heroic and may involve a rumenotomy in which the rumen is surgically emptied out. Supportive therapy includes iv fluids, rumen transfaunation (rumen juice from a healthy animal), alkalinizing solutions for the rumen (only done with caution), antibiotics and nursing care.

Prevention

Rations should be formulated and balanced correctly for the correct production group. Forage should be fed before grain and the daily amount divided into at least 3 separate feedings. A total mixed ration (TMR) helps keep the rumen flora happy by not overwhelming them with carbohydrate at any one time. Feed changes all need to be made gradually over several days so the flora have time to adapt. For small holders with a few goats, grain security is an important issue.

Low Milk Fat Syndrome

Clinical Signs

Milk composition is an important aspect of dairy goat production as it influences income and quality of product produced. Low milk fat syndrome is a commonly encountered problem in the dairy cattle industry and one frequently observed in dairy goat production. Low milk fat is defined as a milk fat content well below standards for a breed with possible inversions of milk protein and fat content. For breeds where milk fat is typically between 4 and 5%, low milk fat may result in fat percentage at 3% or lower.

Causes

The phenomenon of low milk fat syndrome has be well studied with a number of hypotheses proposed as to the cause. Recent research with dairy cattle has unified two observations as to dietary causes. Diets low in fiber and high in grain can produce milk with low fat content. Similarly, diets with higher polyunsaturated fats can cause the same problem. Currently research suggests an intermediate compound resultant from rumen biohydrogenation of dietary polyunsaturated fatty acids produces a family of compounds identified as conjugated linoleic acids (CLA). Many isomers of CLA have been identified, but one, trans-10, cis-12 CLA has been shown to suppress fat synthesis in the mammary gland. The suppression in milk fat production is dose-dependent to the amount of trans-10 CLA.

Prevention

There is no treatment other than to prevent the formation of trans-10 CLA in the rumen. Low fiber diets with high grain intake seem to initiate the right rumen conditions to generate more trans-10 CLA. Feeding diets higher vegetable fats will also increase trans-10 CLA production. Preventive practices should focus on appropriate fiber to concentrate levels in the diet and minimizing additional vegetable fat supplemention (whole soybeans, whole cottonseed).

Urolithiasis

Introduction

Bucks and wethers are prone to urinary tract blockage due to urinary calculi (stones). The most common type in Ontario are calcium phosphate and struvite (magnesium phosphate) from high grain diets rich in phosphorus but deficient in calcium. The calculi often have the appearance of sand. The male urethra is narrow and long. At the end of the penis is the urethra process (vermiform appendage). Sand may become blocked anywhere but most frequently is at the urethral process, sigmoid flexure (about the level of the testicles) and ischial arch as the urethra travels out of the pelvis.

Clinical Signs

The blocked goat will be uncomfortable and will strain and act depressed. Often the presenting complaint is constipation. If observed carefully, the producer may notice frequent dribbling of small amounts of urine which may be blood tinged. If not sure if the goat is urinating, place in an unbedded, cement pen by himself for several hours. Prepucial hairs may have dried crystals on the end. If not noticed and blockage is total, the bladder ruptures in 24 to 36 hrs. After rupture, the abdomen swells with urine and the goat appears more depressed. He may live another few days before succumbing to the toxins in his system. Occasionally the urethra ruptures and the urine pools under the skin. This condition is called "water belly". In bucks, the penis can be exposed and the urethral process examined. Sand or stones, discolouration and swelling may be evident. A normal appearing process may mean the blockage is higher. In wethers, often the prepuce is adherent to the penis and it is difficult to expose the end. Veterinarians may "tap" the abdomen to detect urine in cases of suspected bladder rupture. Catheterization of the urethra is difficult and should only be attempted by a vet. It isn't possible to catheterize into the bladder as there is a diverticulum at the pelvis that the catheter cannot get past.

Treatment

If the blockage is at the urethral process, then it can be snipped off. If urine is voided after this "surgery" then the prognosis, while not good, has some hope. Oral therapy with ammonium chloride which dissolves the remaining stones is highly recommended. If the blockage is higher, then there are two options, both with major problems. A perineal

urethrostomy, in which the penis is exposed and cut in its location below the rectum and the urethra exposed, often results in failure if the blockage is higher. In addition, even if immediately successful, it is a salvage procedure as the hole heals up in a few weeks and the goat re-blocks. Therefore it is not a suitable option for breeding bucks or pets. The second option is very expensive and few practitioners will undertake the surgery. The abdomen is opened and the bladder opened. A catheter is introduced from the bladder into the urethra and the stones flushed down the penis. If successful, all stones are removed and the buck is still capable of breeding. Often the stones are firmly lodged, there is tissue damage from the stones and recovery is very prolonged. Only valuable bucks or valued pets are recommended for this option.

Prevention

As usual, this is a condition better prevented than treated. The diet should have a calcium:phosphorus ratio of 1.5 to 2:1. Salt should be included at 1% of total dry matter intake. Plenty of fresh, palatable water should always be available. Diets high in potassium should be avoided. Vitamin A requirements should be met (good quality green hay and pasture will do this). For herds with previous problems, it is sometimes recommended to include ammonium chloride in the ration at ½ % of dry matter intake. This is particularly true with kids on creep grain. Other diseases such as coccidiosis, pneumonia, etc. which might cause decreased water consumption or increased needs may spark an "outbreak" of urolithiasis so these diseases should be managed as well.

White Muscle Disease

Southern Ontario soil is very deficient in selenium. Feeds often have less than 0.1 mg Se/kg. dry matter. Vitamin E may also be deficient in the ration but is usually not assayed for on feed analyses. Selenium and vitamin E are anti-oxidants. Deficiency causes acute muscle necrosis known as white muscle disease. Usually young fast growing kids are affected anywhere from birth to full grown. Kids are acutely painful, reluctant to move but may still eat. Sometimes it manifests itself as sudden death as the heart muscle is affected. Selenium deficiency has also been identified as a cause of illthrift in growing lambs. Cattle supplemented with selenium (when deficient) have fewer problems with toxic mastitis and retained placentas. It has also been shown that selenium supplementation helps with cell

mediated immunity. Oxidized milk (cardboard off-flavour) has been associated with Vitamin E deficiency in cattle. Injection of kids at birth with 1/4 cc of a commercial Vitamin E Selenium preparation is common practise [read the label to confirm dosage as there are different formulations out there!]. It is advisable to inject with a sterile 22 g (blue) needle under the skin (instead of into the muscle). Does can be injected two to four weeks prior to kidding as well. Kids should be re-injected at one month of age if no feed supplementation. Feed supplementation should be done with caution. Selenium can be added to feed supplements and premixes to a maximum of 0.3 ppm. Read the feed label to discover what is in the premix currently. Veterinarians can script in higher levels but this should be done after forages and grains have been analyzed. Too high levels can result in death.

Iodine Deficiency Abortion

If goats are not supplemented with iodized salt, iodine deficiency will result. Because the needs of pregnant does are highest (0.8 ppm DM of feed), the most common manifestation of iodine deficiency is abortion or birth of stillborn, and weak kids with enlarged, goitered thyroid glands. The kids may have a reduced hair coat but the most obvious sign are the large bilateral swellings on the neck. The thyroid gland may be several times normal size. Fetuses should be sent to the Animal Health Lab for diagnosis and immediate supplementation of the pregnant does should be done. If iodized salt is already fed, the needs may have increased if the does are grazed on brassica plants (turnips, cabbage, forage rape) while pregnant.

Polioencephalomalacia

This is a neurological disease caused by real or relative thiamine deficiency. Thiamine (vitamin B1) is made by the normal bacteria in the rumen. Kids or does on high carbohydrate diets may have an upset in normal rumen flora. A change in bacterial types may cause either a deficiency of thiamine or production of an enzyme which inhibits thiamine activity. The end result is the disease polioencephalomalacia (softening and necrosis of the grey matter of the brain). Overdosing with amprolium (in the treatment of coccidosis), exposure to high levels of sulphur in the diet, or grazing on mare's tail (equisetum) can also result in "polio" but are unusual in comparison to high CHO diets.

Early on in the course of the disease, the goat may show a stiff legged gait. The head may be held high and the animal is anxious. As the disease progresses (often within 6 hours), the goat is blind and the head may be pulled straight back towards its shoulders. The front legs are stiff and the animal may fall down. Once down the abnormal head and neck stance is more evident (opisthotonus). The pupils will constrict to light but the goat will not react to a hand menace. Other rule outs are tetanus (the animal is not blind), pulpy kidney, lead poisoning, listerosis, and other toxins e.g. organophosphates and organochlorines.

Sometimes the only way to make a diagnosis is through a response to treatment. Early polio cases often respond, at least partially if not completely to thiamine administration (by a veterinarian). Often some response occurs within a few hours of initial treatment. Most other neurological diseases respond slowly or not at all to indicated treatments (unless specific poisonings). Because thiamine deficiency does cause brain necrosis however, time is important. The longer treatment is delayed, the more likely irreversible brain damage may occur. One case may not necessarily mean a herd problem but the feeding management should be reviewed. Some problem herds do require routine thiamine supplementation but first feeding management should be investigated. There are many more nutritional diseases e.g. copper deficiency/toxicity, zinc deficiency etc.

Prospects of parasite control in animals in present ecological environment changes

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Parasites infection in animals is a serious problem. They may be internal or external in nature. All these parasites lead to disease in the animals which can cause production losses. The losses may be due to reduction in milk, meat and fiber production along with mortality among them. Poor hide and fiber quality in parasites infested animals further culminate in to economic losses due to poor market value. These losses when added with money incurred on parasitic control measures make a huge loss if calculated on national level in a country like India which carries one of the largest animal populations of the world.

Chemotherapy is only measure available at present to fight against the parasitic menace in livestock. However, their use in food animals is of serious concern these days as people are very much conscious about their presence in food products like milk and meat.This has been a burningissue of last decade due to contamination of human food products with chemical substance which had adverse effect on embryonic development and in making super resistant human microbial pathogens(Waller, 2002) Further, frequent and indiscriminate use of the available drugs results anthelmintic resistance among various parasites and use of the anthelmintic further becomes ineffective without desired result. The anthelmintic resistance among parasites is so rampant these days that it has become a worldwide problem and reports are wide spread and from various part of the world. Further there is substantial evidence that when a parasite develops genetic resistance against a chemical or drug from one certain group it will also be resistant to other drugs of same chemical group.The Food and Agriculture Organization is continuously looking in to the matter and monitoring the parasite resistance. A survey by OIE and FAO in more than 150 countries of the world revealed that 54.5 percent countries were affected with ecto and endoparasites resistance (Nari, 2005).

In the backdrop of worldwide reports of parasite resistance to market available drugs it has been realized that some alternative way to control the parasites is needed which would simultaneously help to slow down the pace of parasites resistance development.The alternative parasite control

measures do not look to totally avoid the use of chemotherapeutics but to make it more judicious and keep it as low as possible. Simultaneously it also encourages the use of other potential ways to parasites control.

In presentchanged scenario, the strategic parasites controlprogramme is well knit activity which integrate various approaches like minimizing the chances of infections, boosting of immune system by enhancing it by better nutrition and improved genetics of host and encouraging only judicious and need based use of chemotherapy. Strategically managed parasites control programme is an amalgamation of following approaches.

1. Genetic Resistance

Resistance may be defined as the ability of a host to reduce the number of parasites that establish, reproduce or survive, whereas, resilience may be defined as the ability of host to thrive and perform well even in the presence of parasites. They are genetic characterstics and heritable from one generation to another generation. Resistance is an important and practical approach to select animals that are more resistant to worm infections. It has been well documented that genetic resistance exists within and between species. If the animals which are less resistant to parasite infection are culled, the entire herd will perform better as the number and severity of parasite infections should decrease in the herd. Resistance and resilience to parasite infection has been shown to be in part genetically inherited. Animals that always have high fecal egg counts, high FAMACHA scores or always require treatment should be removed from the herd. It should also be noted that different breeds tend to be more resistant and resilient to parasite infestations (Waller and Thramsborg, 2004).

The benefits of selection for resistance (FEC) alone will ensue from the phenotypic effects like fewer worms, low impact on production, fewer drenches being needed for their control and reduced contamination of pasture. Other genetic effects will depend on the sign and magnitude of the genetic correlation between FEC and other traits in the breeding objective.The benefits of selecting for resilience are that production is being measured directly and improvement is not dependent on favourable genetic relationship with FEC. There may not be phenotypic benefits from having fewer worms (Waller, 2006).

2. Epidemiological approach

This approach includes the seasonal variation in the pattern of infective stages and their availability in the surrounding environment of host. The epidemiology of parasitic infections is governed by weather conditions along with common managemental practices traditionally adopted in a locality. It may vary from place to place and environment to environment. However, it makes the basis of parasites control using the available resources (Singh et al.2005). In a diversified ecological environment like Indian conditions, one set of parasitic management practices effective northern plains may not be useful in southern humid region or practices used successfully in Semi-arid Western region may not be workable in Temperate and Sub temperate Himalayan region. It is because the epidemiology of parasites infections is variable.Knowledge of epidemiology givesus ideas about type and quantum of parasitic threats, their relationship with environmental factors like temperature, relative humidity and rainfall etc. It also tells us about the locally available conditions which parasites uses for its best propagation and perpetuity. Such knowledge of epidemiology of infections is of immense help to formulate the strategy against these problems by enhancing the better management and use of available resources like pasture, drugs and livestock species non host or resistant to infections. For example monsoon season is most affected by parasitic gastroenteritis (PGE) caused by strongyle worms, a pre monsoon drenching with anthelmintic would be quite effective to control the disease. Likewise, coccidiosis affects young animals, specially sheep and goats, when they cross 2 month age. It can be controlled by anticoccidial treatment in lambs and kids as they approach 2M age. Pregnant animals can be drenched with anthelmintic to avoid peri-parturient egg rise and thus contamination of pasture can be avoided which culminate in lowering of parasitic disease. Epidemiological knowledge in biting insects can be helpful to manage animal grazing strategically to avoid strike and thus control the transmission of diseases.

Epidemiological approach of parasitic control specially aim to check the accumulation of parasitic infection, its perpetuation in animal surrounding and further its availability to susceptible animals by minimizing the exposure chances. Information on host-parasite-environment interaction can be used to modify the livestock management practices time to time to keep the animal healthy and free from parasite in changing ecological scenario. Further, such approach helps us to check the blanket use of chemotherapy and encourage their judicious application.

3. Pasture Management

Both for ecto and endoparasites infections the infective stages come from the pasture. The grazing ground provide shelter to infective agents, the L3, in case of gastrointestinal nematode leading to PGE and breeding ground in case of biting insect like flies, ticks etc. Further it facilitates the infection in host through necessary support to infective stages in the form of medium to create infection. A clean and safe pasture ensures the minimum parasitic load in grazing animals. The provision of clean pasture for new born lambs as CSWRI, Avikanagar found effective in containing the occurrence of parasitic gastroenteritis in young sheep (Singh and Swarnkar, 2005). On the basis of availability of infective stages the pasture can be defined as clean, safe and Dangerous pasture. A fellow grazing land maintained animal free for long time can be treated as clean pasture. Generally pastures developed after an agriculture crop, renovated with tillage, improved by burning, not allowed grazing for more than 6-12 months can be treated as clean pastures. This is because the infective stages of ecto and endoparasites both get killed due non availability on the host on one hand and due to onslaught of variable climatic factors time to time on the other hand. However, in present scenario of Indian agriculture where land is increasingly being used for intensive agriculture and residential colonization, pasture lands have dwindled to limited areas and they are intensively grazed. In such situation the concept of clean and safe pasture has lost and pressure of grazing on pasture would be increasing in future to come.

Pasture being the continuous and pivotal source of infection in parasitic diseases, its management and proper use becomes of paramount importance for controlling of parasitic infections. If practices like rotational grazing, alternate grazing, low grazing animal density are very important to check the building up of infective stages in pasture, the ploughing, resting and burning practices help to kill the piled up infective stages. Alternate grazing system in which each grazing is alternated with different host species, specially those which do not share the common parasite also helps in thinning down the infective parasite site population on the pasture. Alternating the young animals grazing with older lot also help to reduce the infection as the level of resistance of the two groups is different. Depending upon day to day temperature and humidity conditions, the infective larvae migration/climbing on the grass is different. Availability of infective larvae to host in peak sun light hours is much lowered than in low light intensity. Thus restricting grazing to strong sun light can avoid infection in animals.

4. Nutritional approach

Though information on nutrition-parasite interaction is meager yet it is now clear and known fact that good nutrition to animals improves their health as well as their immune status. The improvement of the host diet during parasitism has been associated with two distinct benefits (1) It provides the nutrients for strengthening the immune system to fight against infection 2) It contribute to compensate the damage caused by presence of the parasites and to maintain the host production(Hoste et al. 2005). Several field trials in sheep have shown that resistance to gastrointestinal nematodes can be improved by using dietary protein or non-protein nitrogen supplementation (Steel, 2003: Knox et al., 2006).Growing kids showed aclear improvement in resilience with the higher plane ofnutrition and so also there were indication of an improved resistance status in those animals getting higher plane of nutrition (Aguilar et al 2002; Torres-Acosta et al. 2004). There are several reports showing higher values of peripheral eosinophil counts in supplemented kids compared to non supplemented(Torres-Acosta et al. 2004). Studies conducted on supplementation in animals suggest that nutritional approach works two ways. It improves the immune status of animals by immunomodulation through regulation of lymphocyte and macrophage activation, lymphocyte proliferation, antibody production and hormone secretion etc. on one hand (Athanasiadou and Houdijk, 2010) and working directly on parasite and suppressing their size, reproductive growth and fecundity and thus reducing the pasture contamination. Etter et al. (1999) reported that increase in the protein supply to lactating goats by 144%, eliminated peri-parturient relaxation in immunity and reduced the faecal egg counts around parturition in goats. Further, various studies suggested that higher plane of nutrition reduced the establishment of larvae in the host and also helped in expelling the adult worms from them. On the other side field trials confirmed that energy supplements improved resilienceagainst parasites in goats and sheep (Retama-Flores et al. 2012) and the effect was explained as a balancing both N and energy supply in the rumen. More exploration on the subject on nutrition and parasites interaction with respect to immunity to parasites can be of immense help to develop a methodology alone or in combination with other treatments to check the parasitism.

5. Biological approach

Under this, some pre existing natural enemies of different infective stages of parasites are looked as potential resource material to control the parasitic disease. Concept behind the approach is to use parasites of common livestock affecting parasites to overcome the problem of parasitism.

The efficacy of *Duddingtonia flagrans* against natural infections of *Haemonchus contortus* is noteworthy. A good amount of work on this fungus has been done in India also (Sanyal 2001; Khan et al. 2008). The spores of this fungus, naturally occurring in gastrointestinal tract of ruminants, are passed out in faeces. The hyphae developed from these spores in dung/faecal pallets trap the developing infective larvae and thus limit the infective stages before it being picked up by host. This approach works indirectly by Reducing the Risk of Infectivity in the Field. *D. flagrans* and some other fungi are being looked now as affordable andreliable means to control the gastrointestinal nematode infections. Drawback with this approach is that a large proportion of spores dosed per os are destroyed in the digestive tract(Ojeda-Robertos et al 2009) and need to be overcome to improve the efficacy of this approach. Another drawback is that the growth of fungus in faecal pad is climate dependent and need favourable conditions for growth and so may not work in all weather condition. Use of Gambusia, the mosquito fish and insect eating birds against mosquitoes and other insects to check theirgrowth and growing population is also a potential and probable future approach in this direction. However, they are still in infancy and need a lot of work to be used as an effective approach as they may very change the biodiversity profile in the region.

6. Non conventional approach

Higher nutritional plane of animal though improve the immune status of animal yet its economic viability as single approach is not beyond doubt (Martinez-Ortiz-de-Montellano et al., 2007). The use of COWP (Copper oxide wire particles) has been tested as one of non conventional approaches in sheep and goats in association of supplementary feeding. COWP has showed to have a long and persistent effect against *Haemonchus contortus* infection (Galindo-Barbosa et al. 2012). Even the uses of some tropical plants which contain some secondary metabolites (particularly condensed tannins and hydrolysable CT) have been used along with food as well as extracts (Katki et al. 2013; Pathak 2013). The compound can be found in leguminous plants like leucena and mimosa in addition to other plants like oak trees. They work as neutraceuticals as they have not been used for their food value but for their anthelmintic effects. Condensed tannins (CT) works to ways, 1) They directly affect the worm population in affected animals by reducing worm fertility, eliminating adult worms, and retarding the establishment of incoming larvae. 2) Their action in worm control is indirect by increasing the availability of digestible proteins in intestine through rumen by pass and thus boosting their immune status. The CT extracts were also high in antioxidant capacity, with good ORAC values.Use of CT containing extracts under

in-vitro and in-vivo conditions resulted lesions in cuticle, the muscles of intestine of exposed worms. However, use of tanniferrrous plants with feed suffers due to its bitter taste in higher concentration (> 6%) affecting feed palatability. Further, the concentration of CT in plants over a period does not remains constant and differs season to season, cultivar to cultivar, age to age and in different geographical regions. So to derive an effective dose with good anthelmintic effect is difficult. Currently, feeding behavior of animals with respect to heterogeneous plants environment and total consumed in relation to CT is being explored to assess the potential of this method of parasites control. Research continues on these plants in order to find out the factors that affect the effectiveness of the compounds in addition to their effect on host nutrition (Waller and Thamsborg, 2004; Waller, 2006).

7. Chemotherapeutic Strategies

Three common treatment strategies that are employed are tactical, salvage and selective. A management scheme that incorporates aspects of all three strategies is recommended. In recent time programs that involve treating the whole herd excessively are very much discouraged and can be costly. **Tactical treatment** involves treating the herd based on environmental conditions. The herd is treated when conditions, such as weather (i.e. rain), have made the environment advantageous for the rise of parasite numbers. Tactical treatments might also be based on an increase in fecal egg counts. This treatment program usually involves a schedule that involves treating animals at the start of the grazing season, during pre and post monsoon season, in the fall of winter after the first frost, and when moving the animals to a "clean" pasture. The entire herd is usually treated to prevent disease (Luginbuhl, 1998).

Salvage treatment involves treating the animals that are seriously affected by disease. The animals usually already show many of the symptoms of infestation including wasting away, rough coat, anemia, bottle jaw and diarrhea. This treatment is usually done to save the life of the animal. If the animal demonstrates the symptoms of a severely diseased animal, it should be treated quickly (Luginbuhl, 1998). At times, it may be required to treat the animal before a positive diagnosis from a lab test or a veterinarian can be made. Hopefully, the animal is managed in such a way as to not allow it to reach this stage of sickness, but since many goats do not show any symptoms until they are severely affected, this type of treatment may not always be possible to avoid. **Selective** treatment involves treating only animals that are susceptible to parasite infection. Animals like females that are about to kid (2-4 weeks before kidding), young

animals, and animals that are showing symptoms of infection based on visual observation or the FAMACHA© system are treated. It is probably the best program out of the three in the long-run because it decreases the number of animals that are treated. Although this sounds counterproductive, a program based on using the least amount of anthelmintics by leaving some animals untreated (refugia) while still maintaining a healthy herd is the best approach especially to slow the rise of anthelmintic resistance (Luginbuhl, 1998; Sangster, 1999; Schoenian, 2003). Purpose of refugia concept is to keep the susceptible genes in parasite population and thus retard the pace of anthelmintic resistance.

A management plan that incorporates aspects of all three treatment strategies is recommended. One aspect of tactical treatment that may be beneficial is to closely observe the herd both visually and evaluate them using fecal egg counts or the FAMACHA© system when environmental or seasonal conditions are favorable to parasite development. However, it is not suggested that the entire herd be treated based on environmental conditions alone. Salvage treatment is needed to save an animal that is severely affected and should be done accordingly. Selective treatment involves making smart decisions based on a method of selecting individuals either by the FAMACHA© system, individual fecal egg counts, or another factor that may show symptoms of a parasite infection.

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