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Chapter 13

Parasitism in Goats: Husbandry Management, Range Management, Gut Immunity and Therapeutics

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Abstract

Goats play a vital role in the economy of common man. It acts as pivotal point in the uplift of socio-economic status of females. The goats are such delicate and fragile animals that encounter a lot of infectious and non-infectious diseases including viruses, bacteria and gastrointestinal parasites (GIP). The goat being a range animal is selective feeder. It needs a lot of managemental practices which safeguards its health. This chapter focuses on management, impact of gastrointestinal parasites, role of intestinal immunity, various breeds reared in Pakistan, role of plant based phytochemicals to treat against GIT parasites and various models to predict the status of health in animals.

Keywords: gastrointestinal parasites, gut immunity, goat management

1. Introduction

In Pakistan the economic losses due to worm infestation either internal or external worms like tape worm, round worms, flukes, ticks and lice are very high, although no exact figure is available. Millions of rupees are lost every year in the form of reduction in milk production, rejection of poor quality meat, depreciation of wool and hair, skin and hides, delayed puberty or breeding age, slow growth rate, death of young stock, high production cost and wastage of feed, less consumption of feed and poor digestibility. It is normal routine practice throughout

the entire world to control worm infestation to maintain the health status and production in livestock (cattle, buffalo, sheep, goat, camel and horses). In Pakistan, livestock productivity is low and genetic potential is not being fully exploited due to less development in Veterinary sciences or Veterinary biotechnology. Among all, unleashed worm infestation is the most important one. It is a ubiquitous phenomenon affecting all classes of livestock especially to the goats that is hampering the development of livestock/ goat industry in Pakistan. The worm infested animals become unthrifty, lethargy, less responsive leading to chronic diseases and ultimately death of young and older animals irrespective of breed, sex and age. The gastrointestinal tracts (GIT) of animals harbor a wide variety of worms named as nematodes, cestodes and trematodes collectively called as helminthes and few species of Protozoa and externally infested with verities of ticks, lice, mites, fleas and flies. The most prevalent nematodes or round worms are identified as species of parasites included Strongyloides, *Haemonchus contortus*, *Bunostomum phlebotomum*, Oesophagostomum spp., Cooperia spp., Trichostrongylus spp., *Toxocara vitulorum*, *Ostertagia ostertagi*, and Nematodirus spp., rumen worm and lung worm. In cestodes or tape worms are *Moniezia* spp. especially *Moniezia expansa* in small animals (sheep and goats). In trematode or flukes like liver fluke or *Fasciola hepatica* is notorious among small and large ruminants. Coccidiosis is a protozoan disease that can also infect small ruminants. Among protozoa the coccidiosis *E. arloingi, E. christenseni*, and *E. ovinoidalis* are highly pathogenic in kids. *E. ninakohlyakimovae* is the commonest one followed by *E. arloingi*, *E. caprina* and *E. hirci* with prevalence while others were recorded including *Eimeria parva, E. ahsata, E. faurei, E. caprovina, E. granulosa*, and *E. crandalis*. Clinical signs include diarrhea with or without mucus or blood, dehydration, emaciation, weakness, anorexia, and death. Cause enteritis and bloody diarrhea leading to less assimilation and causing anemia and weight loss of the animals other than Giardiasis and Cryptosporidiosis. External parasites like ticks, lice, mites, fleas and flies are not lagging behind to others. They equally cause losses, low productivity, blood drain/ losses, less concentration to feed and loss in milk letdown especially during dusk and dawn and even loss of life especially in exotic animals. By the timely and effective control of worms may uplift the socio-economic position of the female farmers of Southern Punjab and even by effective communication measures could result the saving of life and money from loss. The economic losses caused by Fascioliasis (*Fasciola hepatica* and *Fasciola gigantica*) results more than US$3 billion yearly loses in worldwide by mortality, reduced production of milk, meat and wool. Parasites, both internal and external, can drastically reduce the efficiency of an entire cattle herd. Only 5–10% of internal parasites actually reside within an individual animal, and the rest are present in the pasture, infecting the animal as it grazes. Knowledge of the developmental stages of those parasites outside the animal is key in making management decisions. The easiest and fastest decision to make regarding strategic parasite prevention is pasture management. While the warmer winters the past few years have contributed to keeping grass stands high, they have increased parasite risks in other ways, Mild winters increase parasites' ability to overwinter and multiply faster in the spring. Warmer temperatures lead to higher parasite risks. We always see a spring rise, if you have high parasites in the summer and starting now, you might need to think about altering your management. Burning pastures could be a significant management decision in eliminating a majority of the parasite load in the pasture, especially in the case of an operation with a spring burning program. Dewormer choice is also essential to developing a sound parasite

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management strategy. There are three common classes of dewormers: Benzimidazoles, or the familiar white oral dewormers, cover a wide spectrum of activity but offer no residual effects. Levamisole is only effective against adult worms and has no residual effects. Macrocyclic lactones, like ivermectin, have increased residual effects and retain high blood levels over a period of time. A combination of two has been found the most effective treatment, especially against resistant parasites. Using products that do not fully eradicate an animal's parasite load can also contribute to parasite resistance. The way resistance works is primarily genetic, you are selecting for a population of parasites that are resistant. Both internal and external parasites can develop a resistance to modern parasite prevention methods, Horn and stable flies have a large yearly economic impact in terms of efficiency lost and sickness caused in cattle. In just the U.S. cattle industry horn flies alone cost $1.36 billion in losses. Those include cost of control and the economic losses they incur for individual animals. Flies and other external parasites cause reduced weight gain and stress to animals. They also reduce efficiency, causing animals to require more feed to put on a pound of gain. Horn, stable and horse flies cause the bulk of external parasite problems. If an animal has an average of 270 flies on its body over the course of a day it loses up to 65 cc of blood. The economic threshold is currently 200 flies per animal and is a good indicator for when to begin fly treatment. Pour-on products are also effective but require a substantial amount of reapplication. We are running into resistance in all forms of parasite.

2. Materials and methods

The work was done for the record of parasites prevalent in Pakistan especially in goats. The data was obtained with latest tools available for collection and searching from web. The latest regime was also recommended for developing and underdeveloped countries to avoid any undue losses by any outbreak in goat population. All the resources were utilized to get the maximum benefits for the small ruminant farmers. The gut immunity was also explored which could protect the goat from infection(s) and parasitic infestations at GIT level. The contemporary data about ethno or phyto ingredients was also obtained and incorporated in the manuscript which was possible.

2.1. Effect of rangelands on the productivity of goats

Rangeland is an exclusive source of nutritious browse and graze species of plants in the regions where there is limited or no alternative feed resource available [1]. In arid and semi-arid regions of the world where there is scarcity of water and uncertainty of precipitation, the shortage of feed for small ruminants becomes eminent. So the grazers then look forward to range resource for grazing as their only option [2, 3]. Shrubs and trees which serve as browse species for goats and other ruminants tend to adapt harsher agro climatic conditions and at the same time are able to produce forage for longer periods of time. These species require little attention after its initial establishment and will be available for feeding when other feed resources are their lowest level [3]. Besides, number of natural, biological

and technical constraints, rangelands is still the major player when it comes to world food production. This can be understood when we see that rangelands all around the world is an exquisite food resource of about 1.2 billion cattle, one million sheep and 500 million goats [4]. Goats are considered to be the very first domesticated animals in the human made farms. It is noted in many archeological evidences that they have been assisting mankind and their farms for about 10,000 years [5]. There are about 861.9 million goats in the world. Among this huge number of goats, most of it is present in the continent Asia ranging about 59.7% out of the total number available in the world [6]. China remained on top in terms of goat availability followed by India, Pakistan and Bangladesh carrying almost half of worlds goat production load. Goats are usually kept because it is not much expensive to keep, because of the low space that it occupies as well as little feeding requirement and maintenance is far cheaper than a cow [7]. Goats all around the world are producing about 15.2 million metric tons of milk. India is the leading most in terms of goat milk production while Sudan and Bangladesh are behind India in the list. In Europe, Spain and France are leading producers of goat milk [6]. While the country that was most scrumptious in producing the goat meat was again from South East Asia i.e. china. The leading goat meat producing countries are from Asia and Africa. This shows that how important is goat's meat in these regions. Due to the increasing instability of different economies all over the world, livestock feeding is somehow experiencing serious setbacks in terms of qualitative and quantitative provisions of nutrients. It is happening all due to constant increasing of feedstuff prices in the market. So, the goats and sheep usually are exposed to low quality fibrous feeds such as stubbles and straws. These feed resources are very poor in terms of nutrition. So it can cause unbalance in the provision of complements that is actually necessary for the proper maintenance and production of goats and sheep. Researches have shown that when goats and other livestock are fed with concentrate feeds such as maize, barley and soybean meal etc. The growth of the animals is considerably increased [2, 8]. But these types of strategies require large amount of capital and expenses that smallholders are unable to cope. Here comes the role of rangelands in feeding these animals. As the rangelands are vast areas with plenty of grasses, trees, shrubs and herbs. And if managed properly they can be flooded with year round nutritious forages that are extremely palatable and loved by the goats [9]. In rangelands the type of grazing in which goats are involved, in most areas of goat abundance, are called as communal system in which goats and other ruminants are free to roam all over the field. And in the process they are grazing and browse variety of forage resources [10]. They do so by using their nutritional wisdom and in this process they most of the times are successful in balancing their diet order to fulfill the requirements of their nutrition [11]. Arranged two types of feeding patterns for goats in order to check there performance in both situations. He took a herd of goats divided them in two groups. Left one of them in rangelands grazing and browsing the range forage species. While the other groups was kept in farm where they were allowed to intensively grazed in small paddocks with feed supplementation and periodic treatment against gastrointestinal worms was done. The result after a specific period of time was taken out and when the growth rates were determined the results were of minimal difference, which means that small holders that are short of capital and investment can rear out goats in such regions [12]. Made a strong opinion that goats have special inherent characteristic of resistance from dehydration. Most breeds of goats have far more wider

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choice of vegetation as compared to any other ruminant. They also have a special love for browse species which make them more favorable in those rangelands where there is scanty and erratic rainfall. It is because of their wide palatability they tend to take out far more total digestible fibers from the plantation and due to this they have far more efficient digestibility of fiber as compared to sheep and cattle. So this shows that how any rangeland would be just perfect fit for small land holders in order to use either its meat or milk productivity. Various researchers across the globe presented their findings relative to rangeland vegetation and goat productivity [13]. Proved that goats fed in rangelands can give appropriate productivity especially for landless laborers or shepherds. He further added that due to relatively smaller size of the goat's body, limited water intake, low metabolic requirements and their ability to economize the nitrogen requirements make them an efficient converter. They become the best pick for surviving in the rangelands by giving their nurturer a considerable amount of meat and milk productivity [14]. As rangelands have vast areas consisting large variety of vegetation in it for the disposals of the goats, there are considerable chances that it could also feed on the toxic plants thereby inflicting serious biochemical changes and possibly could die. But according to [15] goats have a better ability to detoxify tannins than sheep. It is because of certain kind of bacteria present in its rumen that allow the detoxification of those toxic compounds. So those poor livestock farmers having less resources can take tannin containing forage which is cheap and easily available and mix it with small amount of concentrates can easily avoid periods of feed shortage in goats [16]. Goats have higher digestibility as compared to cattle and sheep, so that's why they are able to consume those woody species that are rich in tannin and could not be either grazed nor browsed by various small ruminants and large ruminants. It is due to the secretion of specific kind of saliva that has far more quantities of nitrogen as compared to sheep. So this becomes the founding stone of their enhanced meat and milk productivity using less nutritious feeds. Chemical composition of wheat stubble and other leftovers have shown that the energy content present in these feed sources are not that as nutritious as some of those shrubs and woody species. That's why the growth of the range fed goats sometime shows an increasing trend [17]. But in order to get an increased goat milk production, there should be a clear understanding of nutritional factors that could limit the milk production [18]. Mellado et al. [19] Depicted that goats in the rangelands of Mexico were allowed to feed specific shrub species such as creosote bush, prickly pear, and tarbush and side oats gram. The goats that had more fecal p level had low milk yield which showed that could not able to digest the nutrient thus cannot produce more milk. While those goats having low quantity of fecal p level had high yield of milk. This can be concluded by simply putting in a way that Rangeland fed goats will be a little lighter in weight. They may have a little lower average daily weight [11]. But still there performances in arid or semi-arid rangelands still cannot be overlooked especially for those landless laborers and small land holding farmers.

2.1.1. Goat management

2.1.1.1. Care of pregnant goat

Keep the pregnant animals separated from other ones in an isolated pen. Proper bedding material should be there for pregnant animals. Provide them adequate nutrition with easily

digestible and laxative feed along with fresh and ample clean water. Do not allow them to fight with each other and to mix with recently aborted animals. Clip hairs around the udder, hind quarters and tail for greater cleanliness. Dry the lactating pregnant doe at least 6–8 weeks before expected kidding. One attendant must be in near surrounding the pen for any emergency. The does must be assisted in case of dystocia. After the delivery some feed material with quick energy source should be provided to the doe [20].

2.1.1.2. Care of kids

Immediately clean the nostrils and confiscate the placental membranes, with the help of dry cotton. Clear the respiratory tract by hanging down the kid for few seconds. Allow the doe to lick the kids dry. Dip the terminal part of umbilical cord in tincture iodine to avoid the contamination at the interval of 12 hours. The newborn should fed on colostrum within 30 minutes of birth.

Following points should be kept in mind regarding the proper management of kid.

- Decontaminate the umbilical cord with tincture of iodine as early as possible.
- Keep the kids protected from extreme climatic conditions, predominantly during the first 2 months of age.
- Dehorning of kids within first 2 weeks of life.
- Deworm the kids at the age 2–3 weeks
- Vaccination of kids according to suggested schedule.
- Weaning of kids up to 8 weeks of age.

2.1.1.3. Care at milking

Lactating doe must be kept away from the buck. Normally milking should be performed twice a day. To avoid the injuries to the udder, milked the animals gently by thumb and first finger, followed by third finger.

2.1.1.4. Care of young doe

They should be provided with good quality feed and fodders. Stock for breeding purposes must be weighed and recorded on weekly basis. Prevent the young doe from inactions by adopting regular vaccination schedule as **Table 1**.

2.1.1.5. Management of doe

The estrous cycle of doe is 18–24 days on an average of 21 days. The heat period is of 2–3 days. The gestation period is 151 ± 3 days. Generally, the breeding season is spread all over the year and under good feeding and management conditions, two pregnancies in a year could be possible. Prolificacy rate of goat is very high; it can have from one to five kids. Twins are the most common birth rate. Four or five is very rare.

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Sr. No.	Vaccine	Packing	Dose	Price	Month
1	CCPP	1000 ml vial	1 ml	PKR 18	May and Nov
2	Anthrax spore	300 ml	0.5 ml	PKR 402	Feb and Aug
3	Foot and mouth	300 ml	2.5 ml	PKR 454	Apr and Oct
4	Enterotoxaemia	300 ml	3 ml	PKR 67	Jan, June, Jul and Dec
5	Goat pox	1000 ml	1 ml	PKR 70	Mar and Sep

Table 1. Vaccination schedule of goat and prices in Pakistan.

2.1.1.6. Management of buck

Trim the hairs of buck from the prepuce region. Do hoof trimming of the bucks for proper functioning. Provide adequate amount of extra supplementation to the buck. Ensure the proper exercise of buck for achieving the better breeding efficiency [21].

2.1.1.7. Feeding management

Almost 70% of farm economics depends upon the cost of feeding. Goats have a high nutritional requirement. This requirement varies with stage of production, stage of growth and the type of production system. With the exception of milers, high quality browse and forage will meet mostly the goat's requirements. The intake of feed in goats is about 4.5% of the body weight, a higher value than other farm animals as they consume 4.5 pounds of dry matter per 100 pounds of body weight per day. Goat is a fastidious animal which is very selective for her feed, she is consuming one type of feed at a time may be not even interested in that at very next moment [22, 23]. Understanding the stages of maturity and how this affects forage quality is important.

2.1.1.8. Housing

Housing and its needs will base upon the production system. For fattening purpose an infrastructure that can protect the animals from seasonal extremes like heat, cold and rain is recommended. For a dairy purpose a separate place for milking parlor and to keep the kids isolated from their mothers. In range as well as confined feeding systems, the provision of housing is imperative. Shed must be built to provide shelter. Goats are afraid of rain and wetness which make them prone to pneumonia. Shed must be well ventilated, drained and should be easy to clean. Flooring should be provided and elevated at least 15° to facilitate drainage and cleaning. Separate pens should be provided for lactating, dry and pregnant does, kids and bucks. Required flooring space is 0.75–1.50 m^2 and feeder space is 15.24–25.40 cm for adult does and bucks. For growing goat the flooring [24] space is 0.50–0.75 m^2 while feeder space is 10.16–15.24 cm. 0.20–0.50 m^2 flooring space is for kids and 7.62–12.70 cm feeding space is for kids.

2.1.1.9. Management systems

Mostly there are three management systems practiced in Pakistan. First is intensive management system second is semi-intensive and third system in vogue is extensive management

system. Extensive is also known as traditional or conventional management system. Mostly the herders practice this system for goat raising. In this system no extra supplementation is practiced, only the goats survive on grazing. While some herders practice semi-intensive system in which they offer extra supplementation to the goats. The intensive management system is very rare in Pakistan, only few people practice this feedlot system in which they offer feed and water in tie system. Very few farmers available which practice this system. Mostly people offer extra supplementation in breeding season and in winter when there is shortage of food [25].

2.1.2. Mechanisms for immune regulation in gut in parasitic management

Goats are bowsers unlike other ruminants [26]. Their digestive framework makes them competent to except only plants that are not contaminated with their fellows with urine or feces. This provide them with very efficient system that protects them from ingestion of any parasite infestation [27]. Goat do not have, on the other hand, well developed acquired gastrointestinal immunity. This make them especially susceptible to nematodes for their whole life with clinical and subclinical infections [26]. The first barrier to protection against various diseases is characterized usually rapid, non-discriminating defense system – innate or non-specific immunity. Entry of any infectious agent; parasite, bacteria or virus, into animal body, make immune system sensitized resulting in functional changes. This is termed as acquired/adaptive or specific immune response [26, 27]. During this specific response, several proliferations and secretions of soluble factors are synthesized that restrict further incoming pathogen. From this activation a specific remembrance within the lymphocytes is produced that enable animal to provide enhanced protection in future invasion by same organism(s). This lymphocyte memory facilitates the immune system to respond rapidly with specificity in upcoming events [27, 28].

The immune systems both components, nonspecific and specific, is built on array of structures, cells and various secretions. The combination of these all provide effective protection surroundings within the animal [29, 30]. The synergistic effects by various substances produced and secreted by colonized microbes in gut also join hands to already task of eliminating harmful parasites. This normal microbiota provides sufficient resources in addition to above mentioned nonspecific or innate immunity. The subdued challenge at early age, moreover, enables them to fight more complex and difficult subsequent encounters of pathogens also. The same normal microbiota later also plays role in animal digestion and vitamin B synthesis [31].

In recent years, large body of literature, it is shown that presence of parasites/worms within immune competent animals basically suppress various components of immune system [32]. This results in much restrained immune response. This unperturbed immune reaction could be against various allergens, gut flora, and parasites present within the animal body [26]. It is also illustrious from other findings that sheep reproductive success and survival with parasite encumbrance are also affected besides all other abnormalities in immune system [33]. It has been well documented that with low Parasitic Fecal Egg Count (PFEC) relates to eosinophil count to infected sheep. This could be assessed with Arena test [34]. The higher number of

eosinophils suggest sensitization of cellular response to infecting larvae [35]. Previous and updated works on the topic suggest that eosinophilia during helminths infections plays a critical role in providing protective immunity [36, 37]. Results from various studies have shown that antigens of developmental stages in parasites are very important for early immunodiagnostics. Identification of immunodominant polypeptides and their immunogenicity could affect serodiagnosis of animals from field or slaughter house with their sensitivity and specificity [38]. Thus identification of an antigen from immature stages lay a cornerstone to development of amphistomosis serological detection kit for the future [39].

It is now without any doubt that T-helper type 1 (Th1) and T-helper type 2 (Th2) cells balance may lead to inappropriate inflammatory responses i.e. high Th1 (or Th17) and Th2 or vice versa [40]. It is also coined that immunoregulatory effects of parasitic worms are direct decedent of Th1 cells [41]. Whereas Th2 cells are organ specific and response to peritoneum, pleural cavity, and liver [29]. That's why, in helminthic infection, it brings about allergy and asthma in a positive imbalance to these cells (**Figure 1**).

These immune regulatory activities also increase diversification in the process of pathogenesis and then in pathology. A pattern has been recognized in matured dendritic cells that drives Foxp1, a specialized transcriptional factor, helps to develop Th3 (T-regulatory cells) – a X-linked autoimmunity allergic dysregulation syndrome (XLAAD). After the formation of Th3 cells, two mechanisms exist that foresee immune response per say to not to create needless aggressive immune response [42].This is being the "Old Friends" regulatory activation of dendritic cells that basically bystander suppressive mechanism [43, 44]. The other being adamantly work on self, gut contents and allergens in goats and sheep. This activation brings allergy, autoimmunity and

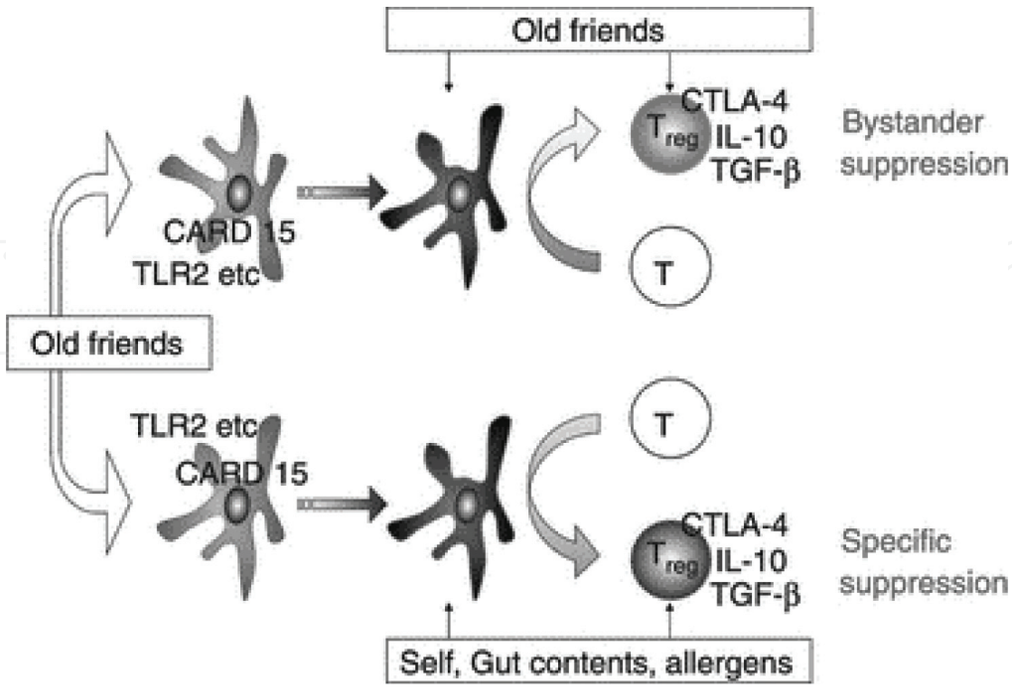

Figure 1. Immunoregulatory effects on parasitic worms.

enteropathy [40, 42]. The cellular component responding to the antigens or appears to act more vigorously in mothers than in neonates. Several cytokines specific to Th1 (IL-2, IL-12, and IFN-γ) and for Th2 cells (IL-5 and IL-10) are released into the system [45]. After the parasitic challenge, IL-2 has been estimated to be higher in neonates than their mother [56]. In the Th2 stimulation, however, IL-5 was higher in both mother and new born for intestinal helminths and filaria than bacterial sensitization [46]. Similarly, IL-10 levels were also similar [47]. After a concerted effect on the Th3 cells, they show crosstalk signaling that activated Mast cells, eosinophils and release of various cytokines [48, 49]. Presently, presence of early eosinophils is characterized with proinflammatory granulocyte that plays a key role in protection against parasitic invasion [36]. This creates a mainstay for the protective immune response to parasites as well as to allergic diseases [29]. The sensitized eosinophils produce cytotoxic cationic proteins including Major Basic Protein, Eosinophil peroxidase, and Eosinophil cationic protein [50, 51]. These proteins toil to work on both sides; protect from host prodigious infections and release of lipid mediators, oxygen metabolites and cytokines [50]. Presence of worm/parasite in sheep or goat may also trigger hyperactive immune response; reduced inflammation in the body leading to less severe autoimmune sensitization [52]. Recently, it has been demonstrated that (**Figure 2**) IL 5 is required for the blood and tissue eosinophilia in mice infected with parasites. Moreover, dendritic cells driven Th3 cells become sensitive to Myelin Basic Protein (MBP) that releases IL 10 and Transforming Growth Factor β (TGF β) [51]. Thus the presence of parasite enterprises to the autoantigen, resulting in inhibition of the process [28–42]. It is further demonstrated that parasitic infection depletes some important generalized and specialized transcriptional factors that are essential to transcription. One example of such factor is Signal transducer and Activator of Transcription 1α (STAT 1α), a key factor in IFN-γ signaling. Similar effects are exerted on epithelial C-C motif chemokine Ligand 20 (CCL20) – an anti-parasitic cytokine that is injurious to the parasite clearance [53]. In previous decades, number of factors, such as spring rise phenomenon, increased peristaltic movement were the focal point for parasitic infections. New interests are in line to enhance much appreciative strategies to control the parasite and worm

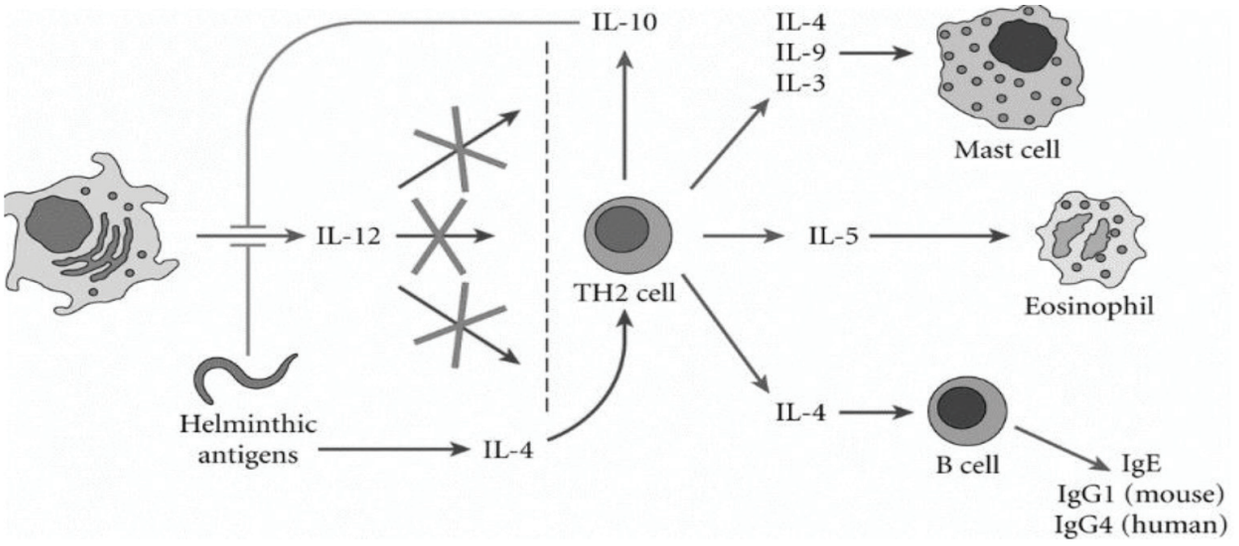

Figure 2. The cellular component responding to the antigens.

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infestations. Recent understanding on miRNA to both innate and acquired immune responses indicates its influential bearings [54, 55]. These small molecules (miRNAs) modulate immune system/cell differentiation, development, homeostasis and their functions [56]. Besides this, miRNAs also regulate a variety of developmental and physiological processes in parasites also [54]. These identities regulate effectively the development of Variant Surface Proteins (VSGs) that cover entire body of the parasite at one time and protect parasites for survival an attack by host immune sensitization [57]. Evolutionary studies on development of pathways for miRNA in parasites showed that they share different features than to other metazoan organisms [54]. This is perhaps, a finding that shed light on the miRNA induced silencing networks in the time frame of evolution [57]. In literature, a number of citations suggest that besides inflammatory response, circumventing several hundred gene products, parasites themselves can regulate their gene expression profile as well as produce effects on host genes [54]. Both these parasites and hosts encodes various miRNAs. Several miRNAs and miRNA clusters have been lined up to show specificities to T-cell helper (Th) lineages and functions. Role of miR-155 in protective responses to GI nematodes by both T and B cells is well elucidated [53, 58]. Conversely parasite on one hand make use of cellular environment for its survival and propagation (**Figure 3**). In return cellular pathways make this comfort zone unbearable/survival for the parasite [54–59]. During the parasite invasion, an alteration at host miRNA expression profile could drive parasite in infective mode or vice versa [57].Recently it has been documented that miRNAs, like miR-155, miR-146 and miR-223 control the acute inflammatory reaction after it recognizes pathogens through Toll-like receptors [57–59]. In trematodes, very high expression of miR-71a and miRNA-71b at various stages of development is one example [60]. Similar finding was gathered for cestodes but not for nematodes [61]. A special interest in *Cryptosporidium parvum*, a parasite that does not have RNA induced silencing mechanism, showed that it can reduce the expression of let-7 miRNA. In return they upregulates Toll Like Receptor 4 (TLR-4) [63]. The downregulation of let-7 involves promoter sites that is also use NFκB – p50. Other miRNAs are also active for

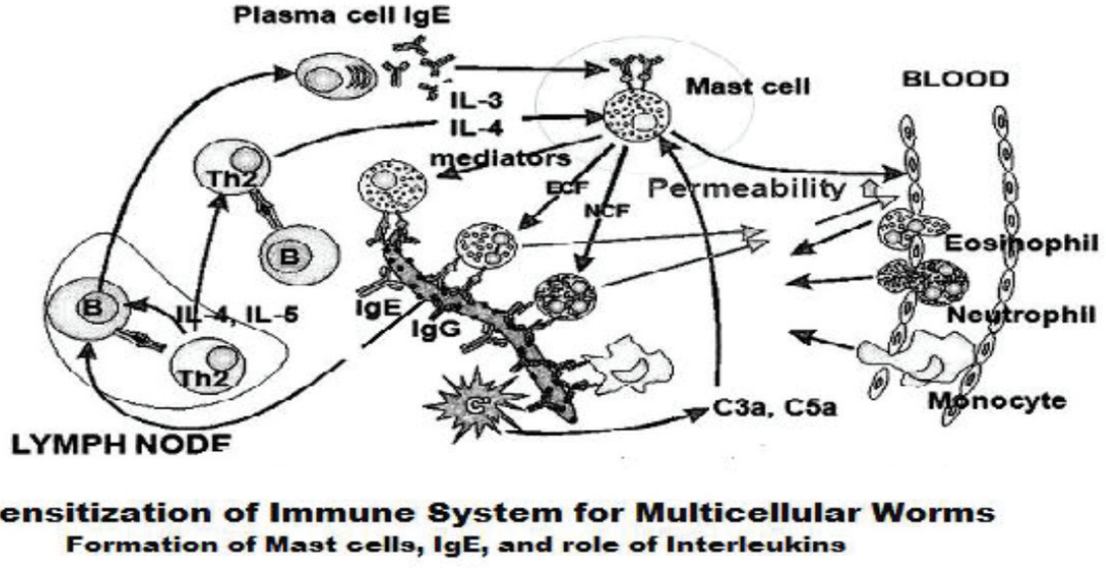

Figure 3. Immune response to multicellular worms.

NFκB – p65 in dependent and independent ways [62].The activation of these generalized transcriptional signaling leads to early epithelial responses. Consequently, mucosal immune effector cells (NK cells, dendritic cell, macrophages, CD4 and CD8 lymphocytes, and other innate lymphoid cells) invade the infection site resulting in sensitization to adaptive immunity [53]. In *C. parvum* it is shown that when miR-513 is repressed, it activation of B7-H1 expression on the surface which induces apoptosis of T-cells [68]. In *Trypanosoma brucei*, it has been suggestive that miRNA modulates expression of VSGs for the immune evasion by targeting 20S proteasome [54, 64].

2.2. Various plants and their activity on parasites of goat

2.2.1. Birdsfoot trefoil (Lotus corniculatus L.*)*

Birdsfoot trefoil is a perennial legume known for providing high quality forage with good yields on fields that have poor drainage or pH too low for alfalfa production. It yields less than alfalfa on optimal soils. BFT has a small seed size, as well as slow germination and seedling growth. Careful management is needed to allow for optimum germination and minimize competition from weeds or companion forages. BFT contains condensed tannins (CT), also called proanthocyanidins, which are naturally occurring plant compounds that significantly affect the nutritional value of forage by forming complexes with proteins, carbohydrates and minerals. Some proanthocyanidins are also detrimental to worms. Condensed tannins (CT), commonly termed as proanthocyanidins, are natural compounds originating from plants can significantly improve the nutritional value of fodder by making complex binding of proteins, minerals and carbohydrates. It has also anti-parasitic effects. Recently, Birdsfoot trefoil (*Lotus corniculatus* L.) has been recognized as auspicious CT forage, particularly for Northeast conditions. It can improve protein intake and is anti-parasitic in nature. Sanfoin (Onobrychis viciifolia) grass grown (western United States) and *Sericea lespedeza* (cold weather) are also identified as CT legume forages [65, 66].

2.2.2. Sericea lespedeza

Sericea lespedeza, a high-tannin forage (4–15% DM) has been proved to minimize parasitic burden in small ruminants. The mode of action is not yet clear but it has the properties to affect the parasites both directly or indirectly. Tannins may minimize the hatching of eggs in feces and arrest the developmental stages of larvae. It has the potential to bind with nutrients of feed and possibly block the bacterial growth that may act as source of nutrition for larvae. Tannins are helpful in reducing pasture contamination and animal worm burdens will help sheep and goats to be healthier and more productive. Previous studies have revealed that Sericea is highly efficient in controlling the endoparasites particularly when animals are grazed in open pastures or kept on dry food like hay or pellets [66–68].

2.2.3. Acacia karroo leaf meal

The nutrition value of fodders depends upon the stability of nutritive elements and digestibility of such nutrients, the metabolism and quantity of nutrients consumed by the animal.

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High nutritive feed can promote increased level of growth and production. Tropical fodders like hay and straw have low level of nutrients especially nitrogen (N), in dry season. The contents of crude protein (CP) of such fodders (20–50 g CP/kg DM) does not fulfill the least requirement of crude protein (80 g CP/kg DM). *A. karroo* is documented two to three times richer in CP than grasses and cereal grains. The use of *Acacia karroo* as dry season protein supplements has been extensively reported in literature. *Acacia karroo* leaves contain high levels of CP and minerals. The CP values for *Acacia karroo* are within the optimal range of 120–230 g/kg DM required for body weight gain, maintenance and production requirements in growing goats. *Acacia karroo* leaves, also, have moderate levels of detergent fibers which are indication of high feeding values. The variation in the nutrient composition of *A. karroo* leaves observed and can be ascribed to differences in populations, soils, climate, and season, stage of growth, browsing pressure, assay methods and presence of secondary plant metabolites, respectively. Condensed tannins are the most common type of tannins found in forage legumes, trees and shrubs such as *Lotus corniculatus* and in several Acacia species. They are more copious in the parts of the plants which are more likely to be consumed by herbivores. There have been several notions regarding the basis for CTs synthesis which include protection against herbivory, plant defense against pathogens, nitrogen conservation, etc. The presence of CTs in *Acacia karroo* has been documented by several authors. *Acacia karroo* contains high levels of extracted CTs ranging from 55 to 110 g/kg DM. Consumption of tannin rich plant materials can be beneficial or detrimental to ruminants depending on how much is ingested among other factors. The negative nitrogen balance is as a result of complexation between tannins and endogenous proteins. Fecal excretion of N is a clear proof that CTs reduce the digestibility of feed. However, further research is needed to ascertain this observation. Browsing animals secrete proline-rich proteins (PRPs) which are considered to be the first line of defense against dietary tannins. The effects of proline-rich salivary protein as a first line of defense against CTs also merit further studies. Generally, there is dearth of information on the adverse effects of CTs in *A. karroo* on goat production [69].

2.2.4. Banana extract

The **banana extract** evaluated in concentration was well accepted by the animals, since the offered material was ingested by them, demonstrating having good palatability. In the trial period, the animals showed no diarrhea and changes in clinical parameters. The results strongly suggest that the ingestion of dried ground banana does not cause any deleterious effects evaluated the efficacy in vivo of banana leaf in the control of gastrointestinal worms in small ruminants, and observed no reduction of OPG in treated animals compared to the control group. According to the authors, this fact may be due to the short period of administration of banana leaves, or the restricted supply of 1 kg/animal/day. Assessing the anthelmintic efficacy of waste from the banana crop in gastrointestinal nematodes of sheep. In the *in vivo* test, the extract showed no efficacy, while the extract of leaves showed moderate efficacy. The authors suggest that low efficacy may be related to dose, extraction process or frequency of administration. The findings in these studies also report the absence of the anthelmintic action of banana extract in vivo tests, corroborating the results found in this study. In this study, there

was a significant reduction in hatching eggs Trichostrongylus, but was not observed for Haemonchus eggs. Natural products would be helpful to reduce the biochemical residues in fodders and forages of animal origin. The use of natural crops would further decrease the presence of chemical residues in foods of animal origin, mainly in sheep and goat. The diversity of the Brazilian flora allows for the possibility of utilizing various plant products to control parasitic diseases in livestock. A collective, systematic effort is necessary to incorporate functional or therapeutic foods into feed for small ruminants to control worm infections. Results suggest that *Musa* spp. has anthelmintic properties, as treatment completely inhibited *Trichostrongylus colubriformis* larval hatchability *in vitro* at two consecutive time points. The presence of tannins Musa spp. can promote the health of the animal. However, side effects are concentration dependent manner and extraction of these metabolites. Thus, studies are needed to define how to use, methods of extraction, analysis of secondary metabolites and dose in order to facilitate the use of these compounds in nematode control properties and, consequently, increase in the productivity of sheep industry. Therefore, bio panning of bioactive compounds and the development of an anthelmintic product containing condensed tannin would have great commercial potential [70]. **Table 2** is the already provided best anthelmintics for the control of parasites.

S. No.	Name of treatment	Classes	Description of classes
1.	Anthelmintics	Three primary classes of anthelmintics	**1.** Benzimidazoles (BZ) **2.** Imidazothiazoles/tetrahydropyrimidines (I/T) **3.** Avermectin/milbemycins (AM)
2.	Smart Drenching	Different approaches	**1.** FAMACHA **2.** Know the resistance status of the worms infecting the herd **3.** Keep resistant worms off the farm **4.** Administer the proper dose: **5.** Utilize host physiology to maximize drug availability and efficacy **6.** Split and repeat dosing
3.	Combination anthelmintics	Anthelmintics with other remedies	**1.** Vaccines **2.** Nutritional supplement **3.** Nematophagous fungi, **4.** Bioactive forages, **5.** Copper oxide wire particle boluses **6.** Various genetic approaches
4..	sound pasture management		**1.** Limit exposure to larvae **2.** Good management
5..	Novel non-chemical approaches	Copper boluses Predatory fungus Good management	**1.** Copper oxide with Haemonchus
6.	New drugs		**1.** Amino acetonitrile i.e., Monepantel-Zolvix

Table 2. Followings are the best treatment options of the parasitism in goat and sheep.

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3. Conclusion

It is concluded that parasites pose a threat to goat. It is imperative to safeguard the goats and young kids what so ever the feeding/ grazing system is prevalent it must be vaccinated and dewormed regularly to avoid the helminths and protozoa prevalent in nature. The latest work which is aimed at search of phytochemicals which do not show any resistance against parasites in goat(s).

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References

[1] Tewari VP, Arya R. Degradation of arid rangelands in Thar desert, India: A review. Arid Land Research and Management. 2004;**19**(1):1-12. DOI: 10.1080/15324980590887056

[2] Salem HB. Nutritional management to improve sheep and goat performances in semiarid regions. Revista Brasileira de Zootecnia. 2010;**39**:337-347

[3] Singh DK, Kumar S, Singh NS, Singh CSP. Genetic and non-genetic factors affecting preweaning relative growth rate (RGR) in Black Bengal and its half-bred kids. Indian Journal of Animal Science. 2000;**72**:161-164. DOI: 10.1016/j.apcbee.2014.03.034

[4] Aziz MA. Present status of the world goat populations and their productivity. Lohmann Information. 2010;**45**(2):42-52. DOI: 10.1155/2017/7890183

[5] Ensminger ME, Parker RO. Sheep and Goat Science, 5th ed. Danville, Illinois: The Interstate Printers and Publishers Inc.1986; DOI: 10.1007/s11882-014-0421-0

[6] FAOSTAT. 2008. Available from: http://faostat.fao.org/default.aspx; DOI: 10.1016/j.appet.2017.08.21

[7] Mellado M, Valdez R, Lara LM, Lopez R. Stocking rate effects on goats: A research observation. Journal of Range Management. 2003;**56**:167-173. DOI: 10.1080/09712119.2004.9706515

[8] FAO (Food and Agricultural Organization of the United Nations). Asian livestock monthly technical magazine of the FAO. Animal Production and Health Commission for Asia and the Pacific (APHCA). 1991;**8**:85-87

[9] Maske SS, Phule BR. A study of goat farming in drought prone area: A case study in Solapur district. International Referred Research Journal. 2011;**2**:83-84

[10] Venereo IH, Hermosillo MDS. Small Ruminant Management and Feeding with High Quality Forages in the Caribbean. Santo Domingo: IICA; 2014. pp. 122

[11] Masika PJ, Mafu JV, Gocwana MW, Mbuti C, Raats J. A Comparison of Goat Growth Performance in a Communal and Commercial Farming System in the Central Eastern Cape Province, South Africa. Pretoria: Department of Animal and Wildlife Sciences, University of Pretoria; 1998. pp. 34-42

[12] Agrawal AR, Karim SA, Kumar R, Sahoo A, John PJ. Sheep and goat production: Basic differences, impact on climate and molecular tools for rumen microbiome study. International Journal of Current Microbiology and Applied Sciences. 2014;**3**:684-706. DOI: 10.1371/journal.pone.0154354

[13] Van DTT. Some animal and feed factors affecting feed intake, behaviour and performance of small ruminants [thesis]. Acta Universitatis Agriculturae Sueciae Doctoral Thesis No 2006

[14] Silanikove N. Why goats raised on harsh environment perform better than other domesdicated animals. Options 237–252. Me'diterrane'ennes (serie A). 1997;**34**:185-194

[15] Vaithiyanathan Q, Mishra S, Sheihk JP, Kumar R. Salivary gland tannin binding proteins of sheep and goat. Indian Journal of Animal Science. 2001;**71**:1131-1134

[16] Butter NL, Dawson JM, Wakelin D, Buttery PJ. Effect of dietary condensed tannins on gastrointestinal nematodes. The Journal of Agricultural Science. 2001;**137**:461-469

[17] Landaua S, Perevolotskya A, Bonfilb D, Barkaib D, Silanikove N. Utilization of low quality resources by small ruminants in Mediterranean agro-pastoral systems: The case of browse and aftermath cereal stubble. Livestock Production Science. 2000;**64**:39-49

[18] Merkel RC, Toerien C, Sahlu T, Blanche C. Digestibility N balance and blood metabolite levels in Alpine goat wethers fed either water oak or shining sumac leaves. Small Ruminant Research. 2001;**40**:123-127

[19] Mellado M, Rodr'ıguez S, Lopez S, Rodr'ıguez A. Relation among milk production and composition and blood profiles and fecal P and nitrogen in goats on rangeland Small Ruminant Research. 2006.**65**:230-236. DOI: 10.1186/2046-0481-59-7-391

[20] Care and Management of Goats, Tnau Agritech Portal, Animal Husbandry. Available form: www.vuatkerala.org

[21] Meat Goat Production and Management Home Study Course, Breeding and Kidding Management, Penn State Extension. Available form: www.google.com

[22] Meat Goat Production and Management Home Study Course, Production and Management, Penn State Extension. Available form: www.google.com

[23] Best Management Practices for Dairy Goat Farmers. The Wisconsin Dairy Goat Association; 2008. http://www.milkproduction.com/Library/Scientific-articles/Other-milking-animals/Best-management-practices-for-dairy-goat-farmers/

[24] Common Questions about Goat Management by B.L. Beer. Assistant Agricultural Extension Agent. 1998. Available from: www.google.com

[25] Personal communications

[26] Matthews J. Chapter 14: Diarrhoea. 4th ed. In: Diseases of the Goat. UK: Wiley – Blackwell Publishing; 2016

[27] Fthenakis GC, Menzies PI. Therapeutics and Control of Sheep and Goat Diseases Series – Veterinary Clinics of North America: Food Animal Practice. Vol. 27(1). Philadelphia, USA: Saunders-Elsevier, Inc.; 2011

[28] Gershwin LJ. Comparative immunology of allergic responses. Annual Review of Animal Biosciences. 2015;**3**:17.1-17.20. DOI: 10.1146/annurev-animal-022114-110930

[29] Powell N, MacDonald TT. Recent advances in gut immunology. Parasite Immunology. 2017;**39**:e12430. DOI: 10.1111/pim.12430

[30] Morales-delaNueza A, Castroa N, Moreno-Indiasa I, Justea MC, Sánchez-Macíasa D, Briggsa H, Capoteb J, Argüelloa A. Effects of a reputed immunostimulant on the innate immune system of goat kids. Small Ruminant Research. 2009;**85**(2009):23-26. DOI: 10.1016/j.smallrumres.2009.06.016

[31] Dongarrà M, Rizzello V, Muccio L, Fries W, Cascio A, Bonaccorsi I, Ferlazzo G. Mucosal immunology and probiotics. Current Allergy and Asthma Reports. 2013;**13**:19-26. DOI: 10.1007/s11882-012-0313-0

[32] Smith MC, Sherman DM. Chapter 7: Blood, Lymph, and Immune Systems. In: Goat Medicine. UK: Wiley-Blackwell Publication; 2009. pp. 275-317

[33] Hohenhaus MA, Josey MJ, Dobson C, Outteridge PM. The eosinophil leucocyte, a phenotypic marker of resistance to nematode parasites, is associated with calm behavior in sheep. Immunol Cell Biology. 1998;**76**:153-158

[34] McBeana D, Nathb M, Kenyona F, Zile K, Bartleya DJ, Jacksona F. Faecal egg counts and immune markers in a line of Scottish cashmere goats selected for resistance to gastrointestinal nematode parasite infection. Veterinary Parasitology. 2016;**229**:1-8

[35] Korenaga M et al. The role of interleukin-5 in protective immunity to Strongyloides Venezuelensis infection in mice. Immunology. 1991;**72**:502-507

[36] Ravin KA, Loy M. The eosinophil in infection. Clinical Reviews in Allergy & Immunology. 2016;**50**:214-217. https://doi.org/10.1007/s12016-015-8525-4

[37] MacDonald AS, Araujo M, Pearce EJ. Immunology of parasitic Helminth infections. Infection and Immunity. 2002;**70**:427-433

[38] Rupp C et al. Compositions and Methods for Immunodominant Antigens. European Patent Application EP 2 368 568 A1. Sep 28, 2011. pp. 427-433

[39] Jyoti, Prasad JA, Sigh NK. Evaluation of antibody response to various developmental stage specific somatic antigens of *Paramphistomum epiclitum* in goats. BioMed Research International. 2014;**2014**:1-6. http://dx.doi.org/10.1155/ 2014/505484

[40] Rook GAW. Review series on helminths, immune modulation and the hygiene hypothesis: The broader implications of the hygiene hypothesis. Immunology. 2009;**126**:3-11. DOI: 10.1111/j.1365-2567.2008.03007.x

[41] Ferluga J, Kouser L, Kishore U. Microbial Pathogenesis: Infection and Immunity. In: Kishore U, Nayak A, editor. Chapter 11, Immune Response Induced by Parasiteic Worms. London, UK: Springer-Landes Bioscience; 2013

[42] Liston A, Gray DHD. Homeostatic control of regulatory T cell diversity. Nature Reviews Immunology. 2014;**14**:154-165

[43] Moncrieffe H. Regulatory T cells (Tregs). British Society for Immunulogy, UK. 2012;**1**. https://www.immunology.org/public-information/bitesized-immunology/cells/regulatory-t-cells-tregs

[44] Xi F, Ippolito GC, Tian L, Wiehagen K, Oh S, Sambandam A, Willen J, Bunte RM, Maika SD, Harriss JV, Caton AJ, Bhandoola A, Tucker PW, Hu H. Foxp1 is an essential transcriptional regulator for the generation of quiescent naive T cells during thymocyte development. Blood. 2010;**115**(3):510-519

[45] Halonen M, Lohman IC, Stern DA, Spangenberg A, Anderson D, Mobley S, Ciano K, Peck MI, Wright AL. Th1/Th2 patterns and balance in cytokine production in the parents and infants of a large birth cohort. The Journal of Immunology. 2009;**182**:3285-3293

[46] Pit DSS, Polderman AM, Schulz-key H, Soboslay PT. Prenatal immune priming with helminth infections: Parasite-specific cellular reactivity and Th1 and Th2 cytokine responses in neonates. Allergy. 2000;**55**(8):732-739

[47] Dhanasekaran S, Vignesh AR, Dhinakar Raj G, Reddy YKM, Raja A, Tirumurugaan KG. Comparative analysis of innate immune response following in vitro stimulation of sheep and goat peripheral blood mononuclear cells with bluetongue virus – Serotype 23. Veterinary Research Communications Res Commun. 2013;**37**(4):319-327

[48] Conti P. Impact of cytokines in mast cells – Allergic inflammation. International Trends in Immunity. 2013;**1**(3):5-16

[49] Karaca T, Yörük M, Uslu S, Çetin Y, Uslu BA. Distribution of eosinophil granulocytes and mast cells in the reproductive tract of female goats in the preimplantation phase. Veterinary Research Communications. 2009;**33**:545-554. DOI: 10.1007/s11259-009-9203-x

[50] Bystrom J, Amin K, Bishop-Bailey D. Analyzing the eosinophil cationic protein – A clue to the function of the eosinophil granulocyte. Respiratory Research. 2011;**12**:10-30

[51] Temkin V, Aingorn H, Puxeddu I, Goldshmidt O, Zcharia E, Gleich GJ, Vlodavsky I, Levi-Schaffer F. Eosinophil major basic protein: First identified natural heparanase-inhibiting protein. The Journal of Allergy and Clinical Immunology. 2004;**113**(4):703-709

[52] Hopkin J. Immune and genetic aspects of asthma, allergy and parasitic worm infections: Evolutionary links. Parasite Immunology. 2009;**31**(5):267-273

[53] Ming Z, Zhou R, Chen X-M. Regulation of host epithelial responses to Cryptosporidium infection by microRNAs. Parasite Immunology. 2017;**39**:12408-12410. DOI: 10.1111/pim.12408

[54] Liu Q, Tuo W, Gao H, Zhu X-Q. MicroRNAs of parasites: Current status and future perspectives. Parasitology Research. 2010;**107**:501-507. DOI: 10.1007/s00436-010-1927-6

[55] Tsitsiou E, Lindsay MA. microRNA and immune response. Current Opinion in Pharmacology. 2009;**9**:514-520. DOI: 10.1016/j.coph.2009.06.003

[56] Xiao J, Yolken RH. Strain hypothesis of Toxoplasma gondii infection on the outcome of human diseases. Acta Physiol (Oxf). 2015;**213**:828-845

[57] Zheng Y, Cai X, Bradley JE. MicroRNAs in parasites and parasite infection. RNA Biology. 2015;**10**(3):371-379. DOI: 10.4161/rna.23716

[58] Gantier MP, Sadler AJ, Williams BRG. Fine-tuning of the innate immune response by microRNAs. Immunology and Cell Biology. 2007;**85**:458-462

[59] Bi Y, Liu G, Yang R. MicroRNA: Novel regulators during the immune response. Journal of Cellular Physiology. 2009;**218**:467-472

[60] Xue X, Sun J, Zhang Q, Wang Z, Huang Y, Pan W. Identification and characterization of novel microRNAs from *Schistosoma japonicum*. PLoS One. 2008;**3**:e4034

[61] Huang Y, Zou Q, Wang SP, Tang SM, Zhang GZ, Shen XJ. The discovery approaches and detection methods of microRNAs. Molecular Biology Reports. 2010;**38**(6):4125-4135

[62] Messina N, Fulford T, O'Reilly L, Xian W, Jessica L, Motyer M, Ellis D, McLean C, Lin A, Gugasyan R, Slattery RM, Grumont RJ, Gerondakis S. The NF-κB transcription factor

RelA is required for the tolerogenic function of Foxp3+ regulatory T cells. Journal of Autoimmunity. 2016;**70**:52-62

[63] Gong A-Y, Hu G, Zhou R, Liu J, Feng Y, Soukup GA, Chen X-M. MicroRNA-221 controls expression of intercellular adhesion molecule-1 in epithelial cells in response to *Cryptosporidium parvum* infection. International The Journal of Parasitology. 2010;**41**(3–4):397-403. DOI: 10.1016/j.ijpara.2010.11.011.

[64] Mallick B, Ghosh Z, Chakrabarti J. MicroRNA switches in *Trypanosoma brucei*. Biochemical and Biophysical Research Communications. 2008;**372**:459-463

[65] Jennifer WM, Griggs TC, Beuselinck PR, Grabber JH. Birdsfoot trefoil, a valuable tannin-containing legume for mixed pastures. Forage and Grazinglands. 2006;**1**:1-11. DOI: 10.1094/FG-2006-0912-01-RV

[66] Min BR, Hart SP, Miller D, Tomita GM, Loetz E, Sahlu T. The effect of grazing forage containing condensed tannins on gastro-intestinal nematode parasite infection and milk composition in angora does. Veterinary Parasitology. 2005;**151**:105-113

[67] Shaik SA, Terrill TH, Miller JE, Kouakou B, Kannan G, Kaplan RM, Burke JM, Mosjidis JA. Sericea lespedeza hay as a natural deworming agent against gastrointestinal nematode infection in goats. Veterinary Parasitology. 2006;**139**:150-157

[68] Lange KC, Olcott DD, Miller JE, Mosjidis JA, Terrill TH, Burke JM, Kearney MT. Effect of sericea lespedeza (*Lespedeza cuneata*) fed as hay, on natural and experimental *Haemonchus contortus* infections in kids. Veterinary Parasitology. 2006;**141**:273-278

[69] Brown D, N'gambi JW, Norris D. Feed potential of *Acacia karroo* leaf meal for communal goat production in southern Africa: A review. Journal of Animal and Plant Sciences. 2016; **26**:1178-1186

[70] Gregory L, Yoshihara E, Silva LKF, et al. Anthelmintic effects of dried ground banana plant leaves (musa spp.) fed to sheep artificially infected with *Haemonchus contortus* and *trichostrongylus colubriformis*. African Journal of Traditional, Complementary, and Alternative Medicines. 2017;**14**:138-144. DOI: 10.21010/ajtcam.v14i1.15