CHAPTER - II
REVIEW OF LITERATURE

2.1 EPIDEMIOLOGY OF GASTROINTESTINAL PARASITES OF SMALL RUMINANTS

The gastrointestinal parasites of greatest importance in small ruminants include nematodes belonging to super families *Trichostrongyloidea, Strongyloidea, Metastrongyloidea* and *Ancylostomoidea* under Order Strongylida. In trematodes, members of the Order Digenea, belonging to families *Fasciolidae, Paramphistomatidae* and *Dicrocoeliidae*. In cestodes; members of the Order *Anoplocephalidea* (Family *Anoplocephalidae*) and Order *Taeniidea* (Family *Taeniidae*). The sheep and goats are infected with a number of helminthes, whose combined clinical effect is a condition known as parasitic gastroenteritis.

The strongylid nematodes of sheep and goats in India include *Haemonchus contortus*, which are considered to be the most prevalent and pathogenic nematode followed by *Trichostrongylus colubriformis, Bunostomum trigonocephalum, Oesophagostomum* spp., *Cooperia* spp. and *Strongyloides* spp. Among trematodes; *Fasciola, Amphistomes* and *Paramphistomes* and among cestode, *Moniezia* are prevalent in small ruminants (Sanyal, 1988).

Sanyal (1991) in a study on the seasonal availability of ovine strongyle nematode larvae on pasture in Mannavanur, Tamil Nadu, reported a preponderance of *Haemonchus contortus* from June to November, whereas *Trichostrongylus colubriformis* was found on pasture throughout the year.
Singh et al. (1997) undertook a survey on ovine gastrointestinal nematodes (GINs) in an organized farm in Rajasthan. Coproculture studies indicated the presence of *H. contortus* and *Strongyloides papillosus* throughout the year, *Trichostrongylus* spp. during premonsoon and *O. columbianum* during summer and monsoon seasons. The abomasal worm counts showed predominance of *H. contortus*. The maximum worm count was recorded in August. Young sheep were shown to harbor more worms than adult sheep.

In Tamil Nadu, Meenakshisundaram (1999) reported that *H. contortus* was the predominant nematode in an organized farm at Chennai, Tamil Nadu, followed by *Trichostrongylus* spp., *Mecistocirrus* spp. and *Cooperia* spp.

Dhanalakshmi et al. (2001) undertook a survey on GINs in ten sheep farms at Karnataka. The study revealed a preponderance of *H. contortus* in majority of the farms, followed by *Oesophagostomum* spp., *Trichostrongylus* spp., *Cooperia* spp. and *Nematodirus* spp.

Rahman and Ali (2001) designed an experiment to assess the month wise prevalence of GINs in sheep and goats. They recorded the lowest nematode count in sheep in June (41.66 per cent), followed by increased in July (50 per cent) and August (58.33 per cent). In goats, the lowest nematode count was recorded in June (41.66 per cent), then increase in nematode counts during May and August (50 per cent).

Jithendran and Bhat (2001) studied the prevalence of gastrointestinal parasites in sheep and goats of Himachal Pradesh, India, and found the prevalence
in sheep and goats respectively as follows: Fasciola 9.6% and 8.8%; Amphistomes 3.8% and 2.5%; Dicrocoelium 7.2% and 2.5%; Schistosoma 1.2% and 0.6%; Moniezia 2.7% and 1.3%; Strongyles 91.6% and 100%; Strongyloides 4.8% and 5.1%; Dictyocaulus 1.2% and 1.3% and Trichuris 14.3% and 1.3%.

Magona and Musini (2002) studied the influence of age, grazing system, season and agroclimatic zone on the prevalence and intensity of gastrointestinal strongyles in Uganda goats and reported that season and agroclimatic zones were the only significant factors which influenced intensity of nematodiasis in goats.

Jeyathilakan et al. (2003) reported the presence of Haemonchus spp., Trichostrongylus spp. and Oesophagostomum spp. in sheep flocks of Chennai, Tamil Nadu. A survey on GINs in Kashmir was carried out by Khajuria and Kapoor (2003). They reported that Strongylid nematodes were predominant in sheep and goats (64.09 and 67.46 per cent) followed by Trichuris spp.

Easwaran (2004) carried out a survey on the species spectrum of GINs in sheep and goats of Western Tamil Nadu. The survey indicated the prevalence of H. contortus, T. colubriformis, O. columbianum, Cooperia spp. in the plains and T. circumcincta, O. aspersum, Nematodirus spp., H. contortus, B. trigonocephalum and Cooperia spp. in the hills.

Muraleedharan (2005) observed the gastrointestinal parasites of livestock in a central dry zone of Karnataka, India and reported the prevalence of gastrointestinal parasites among cattle (18.22%), buffaloes (20.85%), sheep (39.44%) and goats (46.12%) of southern taluks of central dry zone of Karnataka during
drought period. Strongyles were the most common nematode. Fasciola, Amphistomes, Moniezia and Entamoeba infections were low among livestock. However, Fasciola infection was not seen in sheep. Eimeria infection was found comparatively higher in sheep than goats. Ova of Gongylonema were recorded from one cattle and Strongyloides were observed only in sheep. Low incidence of Trichuris infection was noticed in cattle, sheep and goats. Strongyle infection in livestock was found higher during south west monsoon.

Yadav et al. (2005) reported the highest incidence of gastrointestinal nematodiasis in goats followed by buffalo and cattle in India. Haemonchus, Trichostrongylus, Bunostomum, Oesophagostomum and Strongyloides species were the main parasites recovered from the intestine of sheep, goats and buffaloes.

Arora et al. (2006) undertook studies on incidence and the effects of seasons on gastrointestinal parasitism in goats maintained in an organized farm in a semiarid zone, Mathura, Uttar Pradesh. The results of the study revealed an overall prevalence rate of 44.32 per cent. Thus, the author concluded that gastrointestinal parasitism in goats was mainly due to H. contortus.

Das et al. (2006) evaluated the prevalence of GINs of goats raised in five rural areas near Ranchi, Jharkhand. The nematodes observed in the study were Strongyloides spp., Oesophagostomum spp., Haemonchus spp., Trichuris spp., Ostertagia spp., Bunostomum spp., Trichostrongylus spp., Cooperia spp. and Marshallagia spp.
Yadav et al. (2006) reported that *H. contortus* was the predominant in Jammu followed by *T. ovis* and *Strongyloides* spp. and also recorded an EPG of 2302, 1720 and 1418 during rainy, summer and winter seasons, respectively.

Di Gerbo et al. (2006) carried out a survey on parasites in goat farms in Bergamo province, in northern Italy from May 2005 to January 2006. Faecal samples of 836 adult female goats from 31 dairy goat farms were examined. *Strongyloides* spp., showed higher values of prevalence in goats housed in summer. *Nematodirus* spp. was more prevalent in winter in goats at pasture. *Strongyloides* spp. occurred more frequently in autumn in stabled goats.

Bal et al. (2007) studied the parasitic gastroenteritis in sheep and goats in Punjab state, India. Chaudary et al. (2007) investigated the prevalence and seasonal trend of the *H. contortus* in sheep and goats in the Potohar areas of northern Punjab, Pakistan from December 2004 to January 2006. Faecal samples collected from 968 sheep and 961 goats of different breeds were examined. Results revealed that the infection was significantly higher (P<0.05) in sheep compared to goats. The peak infection level was recorded during rainy season (July to October). On the other hand, a low infection level was noted from December to May.

Mamatha and D’Souza (2007) carried out a survey on GINs in sheep and goats in Karnataka. The study revealed an overall prevalence of 91.33 and 78.66 per cent in sheep and goats, respectively. Also reported that the average EPG counts of GINs were 1567±144.7 and 1740±173.3, respectively in sheep and goats.
Padmina et al. (2007) reported that the most prevalent GIN was *Trichostrongylus* spp. (19.99 per cent) followed by *Trichuris* spp. in goats from Hyderabad.

Ram et al. (2007) conducted a study on seasonal nematode egg output in goats from Uttaranchal. The study revealed 96.0 per cent, 87.2 per cent and 98.3 per cent incidence of parasitic gastroenteritis during summer, monsoon and winter seasons, respectively. The author also stated that EPG was highest during monsoon seasons followed by summer and winter seasons.

Nwosu et al. (2007) carried out a survey to determine the prevalence and seasonal abundance of the egg and adult stages of nematode parasites of sheep and goats in the semi-arid zone of north-eastern Nigeria between January and December 2002. Faecal samples were collected from 102 sheep and 147 goats and examined by the modified McMaster technique. The analysis revealed that 44 (43.1%) and 82 (55.8%) of the samples, respectively, contained at least one nematode egg type. Three nematode egg types were recovered with strongyle egg type (22.5% in sheep and 35.4% in goats) being the most prevalent followed by *Trichuris* (5.9% in sheep and 4.1% in goats) and *Strongyloides* (4.9% in sheep and 4.1% in goats) egg types respectively. Mean faecal egg counts were generally moderate in both sheep (1052±922 strongyle, 1000±590 *Strongyloides* and 380±110 *Trichuris* eggs, respectively, per gm of faeces) and goats (2092±3475 Strongyle, 958±854 *Strongyloides* and 683±512 *Trichuris* eggs, respectively, per gm of faeces). The prevalence and counts of strongyle nematode eggs showed a definite seasonal sequence that corresponded with the rainfall pattern in the study.
area. In both sheep and goats, Strongyle type counts increased with the rain and reached peak levels around the peak of rainy season in September. The other egg types encountered in the study did not show much seasonal variation.

Odoi et al. (2007) investigated the burden and risk factors of GIN parasite infections in sheep and goats kept in small holder mixed farms in the Kenyan Central Highlands. 370 small ruminants were sampled from 66 small holder mixed farms in agro-ecological zones 1 (humid) and 3 (semi-humid) in the Kenyan Central highlands. Faecal samples were collected at each visit from each animal. Faecal egg counts (FEC) were performed using the modified McMaster technique. Parajuli (2007) studied the intestinal helminth parasite of goats (Capra hircus) and found 181 (81.53%) positive samples among 222 total samples from Khasi bazaar of Kalanki, Kathmandu, Nepal.

Raza et al. (2007) studied the prevalence of gastrointestinal helminthiasis in ruminants in an irrigated area of lower Punjab (Pakistan). For this purpose, 100 faecal samples were collected from sheep, goats, cattle and buffaloes. The overall prevalence of helminthiasis was 51% in cattle, 47% in buffaloes, 62% in sheep and 52% in goats, with nematodes being the most common helminthes. The prevalence of helminthes was higher in young animals compared to adults in cattle, buffaloes, sheep and goats. The prevalence of different species of helminthes was also varied in different age groups, with Toxocara vitulorum being higher in calves than adults both in cattle and buffaloes. Sex-wise prevalence of helminthes was higher in males rather than females for buffaloes and sheep in contrast to cattle and goats.
Al-Shaibani et al. (2008) conducted an epidemiological study on GINs of sheep of small farmers in Hyderabad (Pakistan) district from May 2004 to April 2005. Faecal egg counts, pasture larval counts and worm counts from permanent grazing animals were recorded for 12 months. *H. contortus* (24.6%) was found to be predominant of GIN parasites, *Trichostrongylus* spp. (18.0%) was the next most prevalent species, others, including: *Ostertagia circumcincta, Spathiger papillosus, Trichuris ovis, Oesophagostomum columbianum* and *Chabertia ovina* were found in varying percentages. The highest FECs were recorded in September, whereas the lower FECs were in February. Chavhan et al. (2008) studied the prevalence of nematode parasites of ruminants in two villages, viz. Chicholi and Bodala of Nagpur district. Out of 615 animals examined, 242 (39.34%) were positive for nematode infection. The infection rate in buffalo, cattle and goat was 41.63%, 32.18% and 51.94%, respectively. Higher infection was recorded during monsoon season (63.07%) followed by winter (32.22%) and summer (21.33%). The percentage of animals infected with *Haemonchus* spp., *Toxocara* spp., *Trichuris* spp., *Strongyloides* spp., and mixed infection was found to be 38.01%, 27.68%, 14.87%, 11.98% and 7.43%, respectively.

Gadre et al. (2008) examined 2288 faecal samples collected from dairy animals from the central zone of Vidarbha region (Maharashtra) from July 2002 to June 2003. The study revealed a 62.98% prevalence of helminthic infection. *Paramphistomum* spp. were predominant (12.28%) followed by *Toxocara* spp. (10.97%). The percentage prevalence of *Monezia, Strongyloides, Haemonchus, Fasciola, Schistosoma, Trichuris, Oesophagostomum* and *Trichostrongylus* species
were 10.16%, 8.96%, 6.99%, 5.98%, 3.81%, 1.87%, 1.00% and 0.96%, respectively. The overall prevalence of nematodes, trematodes, cestodes and mixed type of helminth infection was found to be 41.63%, 11.11%, 0.98% and 46.28%, respectively. The helminth infection was most commonly encountered during and after rainy seasons.

Mir et al. (2008) investigated the parasitological examination of 1,325 faecal samples collected among naturally grazing sheep in Kashmir Valley, India, and observed that the level of parasitism varied 28.98% in the sheep that had at least one infection. *Fasciola gigantica* (23.92%) and *Fasciola hepatica* (9.96%) were predominant, followed by *Dicrocoelium dendriticum* (4.45%) and *Paramphistomum cervi* (2.71%). Seasonal variations indicate that highest infections were recorded during the summer (13.94%) followed by autumn (7.38%), spring (6.06%) and winter (1.41%). Highest prevalence (42.80%) of trematode parasites was observed in sheep that were more than 4 years old (42.8%) followed by the 2 – 4 years (37.7%) and 0 - 2 years (18.79%) age groups. Faecal examination indicated a higher percentage of infection in exotic breeds compared to native breeds.

Pathak and Pal (2008) investigated the prevalence of gastrointestinal parasites in goats and revealed that the percentage of overall prevalence of infection was 85.22%. The majority of different parasites encountered were *Paramphistomum* spp. (80.68%), followed by *Cotylophoron* spp. (45.45%), *Moniezia* spp. (17.04%), *Avitellina* spp. (3.40%), *Haemonchus* spp. (26.13%), *Trichostrongylus* spp. (5.68%), *Cooperia* spp. (3.40%), *Oesophagostomum* spp.
(30.68%), *Bunostomum* spp. (5.68%) and *Trichuris* spp. (27.27%). Seasonal prevalence was highest in monsoon season (94.60%), moderate in summer (87.50%) and lowest in winter (63.15%).

Tariq *et al.* (2008) investigated the seasonal epidemiological prevalence of GINs in different age groups, sexes and breeds (genotypes) of sheep through necropsy and faecal analysis over a period of 2 years in Kashmir valley, India. A total of 1533 sheep were examined. The overall prevalence of GINs in sheep in year 1 was 64.76% and in year 2 was 58.37% (P=0.04). The parasites in decreasing order of prevalence (per cent) in sheep were *Haemonchus contortus* (59.6), *Ostertagia circumcincta* (38.0), *Bunostomum trigonocephalum* (37.7), *Chabertia ovina* (37.7), *Trichostrongylus* spp.(33.9), *Nematodirus spathiger* (29.4), *Oesophagostomum columbianum* (28.4), *Trichuris ovis* (23.5), and *Marshallagia marshalli* (22.1). The maximum nematode infection was observed in summer and lowest in winter (P=0.0005).

Gadahi *et al.* (2009) analyzed 400 faecal samples (90 samples from sheep and 310 from goats) from Rawalpindi and Islamabad to confirm the presence of gastrointestinal parasitic infection. 254 (63.50%) samples were found positive for endoparasites. Among the samples from sheep, 48 (53.33%) along with 206 (66.45%) samples from goats, were detected positive for gastrointestinal parasites. *Trichuris* spp., *Haemonchus* spp., *Coccidia* spp., *Nematodirus* spp. and *Fasciola* spp., were found 40.00%, 28.88%, 27.77%, 11.11% and 4.44%, respectively in sheep. In goats, the incidence of *Haemonchus* spp., *Coccidia* spp., *Trichuris* spp., *Nematodirus* spp., *Trichostrongylus* spp., *Strongyloides* spp. and *Fasciola* spp.,
were 64.19%, 43.87%, 35.48%, 13.00%, 4.51%, 3.22% and 0.66%, respectively. Qamar et al. (2009) conducted epidemiological studies on haemonchosis in sheep and goats at slaughterhouses, livestock farms and veterinary hospitals under different climatic conditions existing in the Punjab province (Pakistan). Infection rate of haemonchosis was 35.44%, 38.04% and 36.83%, respectively in slaughtered sheep and goats, sheep and goats at livestock farms and sheep and goats at veterinary hospitals. Overall, the highest seasonal prevalence in all types of sheep and goats (43.69%) was recorded in the summer followed by autumn (38.46%) and spring (37.12%), and the lowest (28.79%) during winter. It was noticed that animals of either sex are equally affected. A higher infection rate was recorded in animals below 9 months of age.

Bandyopadhyay et al. (2010) examined 250 GITs of goats slaughtered for human consumption in Shillong, Meghalaya during June of 2001 to June of 2006 and reported that the intensity of parasitic infection was maximum in rainy season and least during winter. The parasites recorded were O. venulosum, O. columbianum, Haemonchus contortus, Bunostomum trigonocephalum, Trichuris spp., Trichostrongylus colubriformis, Moniezia expansa, Moniezia benedeni, Gaigeria pachysalis, and Paramphistome species.

Sutar et al. (2010) examined the helminth parasites in the digestive system of goats in Ahmednagar District, Maharashtra from January 2009 to December 2009. Out of 400 faecal samples analyzed, 251 were positive (62.75%). In the rainy season, out of 150 faecal samples examined, 116 were positive (77.33%). In winter, out of 120 samples examined, 73 were positive (60.83%). In summer, out
of 130 samples examined, 67 were positive (51.53%). The seasonal prevalence of gastrointestinal parasites shows higher prevalence in monsoon season (77.33%), followed by winter (60.83%) and summer (51.53%). The percentage of animals with different gastrointestinal helminth parasite species viz., *Haemonchus* spp. (24.25%), *Trichuris* spp. (18%), *Strongyloides* spp. (21.25%), *Moniezia* spp. (5.50%), and *Fasciola* spp. (9.25%) was reported.

Tariq *et al.* (2010) investigated the seasonal epidemiological prevalence of GINs of goats, with respect to sex and age of the host, in the Kashmir valley. A total of 1267 goats were examined. The overall prevalence of GIN infection in these animals was 54.3%. The different parasites reported with their respective prevalences (%) were: *Haemonchus contortus* (48.3); *Bunostomum trigonocephalum* (30.1); *Chabertia ovina* (29.8); *Ostertagia circumcincta* (29.8); *Nematodirus spathiger* (25.2); *Trichostrongylus* spp. (25.1); *Oesophagostomum columbianum* (23.5); *Trichurisovis* (19.0); and *Marshallagia marshalli* (16.6). Infection rate was found highest in summer and lowest in winter.

Godara *et al.* (2011) studied the efficacy of fenbendazole, levamisole and ivermectin in twenty Jamunapari goats, naturally infected with GIN parasites. Faecal examination on day ‘0’ revealed an eggs per gram (EPG) of 930±175.1, 1350±421.1, 1060±224.9 and 800±279.7 in group A, B, C and D, respectively having five animals each. The results of larval culture examination revealed the presence of *Haemonchus* spp., *Trichostrongylus* spp., *Oesophagostomum* spp., *Bunostomum* spp., and *Strongyloides* spp. in these animals. Faecal egg counts of the animals treated with fenbendazole (group A), levamisole (group B) and
ivermectin (group C) were reduced by 23.66%, 63.70% and 98.11%, respectively on day 14 post-treatment. Lone et al. (2011) studied the prevalence of coccidia and GIN infections in goats of Baramullah District of Kashmir Valley. *H. contortus* was found to be most prevalent as it showed prevalence of 60% followed by *Trichuris ovis* (51%), *Oesophagostomum* spp. (45%) and *Chabertia* spp. (1%).

Kuchai et al. (2011) conducted the prevalence and various risk factors associated with helminth parasitism in small ruminants of Ladakh (India) from 2007-2008 and examined a total of 581 small ruminants including 313 sheep and 268 goats. They reported that the overall prevalence of 69.70% with 68.37% and 71.26% in sheep and goats, respectively. A significant difference was observed in prevalence of helminth parasites with respect to season, where in higher prevalence (76.50%) was observed during the wet season as compared to dry season (58.13%).

Nabavi et al. (2011) observed that GINs of small ruminants are one of the major causes of productivity loss. This study was carried out to determine the correlation between the prevalence, seasonal incidence and geographical distribution of abomasal worm infection of native sheep in 3 different climatic zones of Iran, suitable for animal husbandry. The overall percentage of infection was 30.98%. *Haemonchus contortus*, *Teladorsagia circumcincta*, *Marshallagia marshalli*, *Ostertagia occidentalis*, *Ostertagia trifurcata* and *Parabronema skrjabini* were identified in all three studied areas. Although, *Teladorsagia circumcincta* was the most prevalent and frequent worm species found than others.
Naem and Gorgani (2011) studied to determine parasitic infection of sheep with gastrointestinal helminthes in a slaughter house in Fereidoonkenar city, Iran. A total of 50 sheep were examined and the results showed that 70% of examined animals were infected as with: *Ostertagia circumcincta* (38%) and *Marshalla giamarshalli* (38%), *Trichostrongylus colubriformis* (16%), *Nematodirus spathiger* (14%), *Skrjabinema ovis* (12%), *Haemonchus contortus* (10%), *Camelostrongylus mentolatus* (4%), and *Gongylonema pulchrum* (2%), *Cooperia punctate* (2%), *Bunostomum trigonocephalum* (2%), *Chabertia ovina* (2%). Among examined animals, 14% infected with *Moniezia expansa*, 10% with *Avitellina centripunctata* and 2% with *Helicometra giardi*. The infection rate in younger animals was higher than in adults.

Tambe et al. (2011) studied the prevalence of helminthic infection in *Capra hircus* during July 2008 to June 2009 from Ahmednager district (M.S.) and reported that out of 300 faecal samples examined, 255 (85%) found to be infected with the helminth parasites. Also reported higher prevalence in monsoon (95%), followed by winter (87%) and summer (73%), because of easy dispersal of larvae in pasture increased contact with the host and the parasites. Among the helminth parasites found, the maximum incidence was of cestode parasites in all seasons (48.33%) followed by nematodes (26.66%) and trematodes (10%), respectively.

Bhat et al. (2012) reported that the overall prevalence rate of gastrointestinal parasitic infection was 62.9% in sheep of Kashmir valley of India and that the most commonly encountered parasites were strongyle spp., *Strongyloides* spp., *Eimeria* spp., *Nematodirus* spp., and *Monezia* spp. was 24.61, 15.5, 9.8, 9.0 and 3.3%, respectively.
They also reported that highest prevalence of gastrointestinal parasites was recorded during monsoon season (March-May) followed by summer season (June - August) whereas the lowest prevalence was recorded during winter season.

Farooq et al. (2012) carried out to assess the prevalence of gastrointestinal helminthes infections among wild and domestic ruminants in Cholistan desert of Pakistan. For this purpose, 1010 faecal samples of different species of ruminants including cattle (n=300), sheep (n=250), goat (n=100), camels (n=200), chinkaras (n=150) and blackbucks (n=10) were examined using standard parasitological procedures. The highest prevalence was recorded in cattle (44.7%) followed by sheep (43.6%), goats (39%), camels (37%), chinkara (26.7%) and black bucks (20%). The maximum number of the helminth species were recorded in sheep (n=14) followed by camels (n=13), cattle (n=09), goats (n=08), chinkara (n=07) and black bucks (n=02). Nematodes were the predominantly occurring (n=18) helminths followed by trematodes (n=6) and cestodes (n=3). *Haemonchus* and *Trichostrongylus* were the most frequently recorded genera. They concluded that wild and domesticated ruminants of the Cholistan desert of Pakistan suffer with heavy infections of a variety of helminthes including those of high economic significance.

Lone et al. (2012) compared the prevalence of infections with flukes, tapeworms and nematodes parasitizing gastrointestinal tract in small ruminants from various regions of District Ganderbal Kashmir. Visceral examinations of 284 sheep and 318 goats indicated a marked variation in the level of parasitism in animals raised in different geographic areas. It was found that the prevalence of
gastrointestinal helminthic infections was higher in goats than in sheep. The most common prevalent nematode species were *Haemonchus* (82%), *Trichuris* (74%), *Nematodirus* (60%), *Trichostrongylus* (58%), *Chabertia* (52%), *Strongyloides* (42%) and *Oesophagostomum* (46%). Among cestodes, *Monezia* (48%), *Avitellina* (42%) and *Thysenezia* (28%) were reported. Among trematodes, *Fasciola* (60%), *Dicrocoelium* (52%) and *Paramphistomum* (46%) species were more prevalent.

Palanivel *et al.* (2012) studied the helminth parasites of Madras Red sheep during the period of January - 2008 to February - 2009 by examining the faecal samples by worms’ eggs per gram (EPG) of faeces. Out of 95 faecal samples examined, 87 (91.58%) were positive for one or more species of helminth worm eggs and infected with five species of trematode, namely *Fasciola hepatica, F. gigantica, Paramphistomum cervi, Cotylophoron cotylophorum* and *Gastrothylax crumenifer*, two species of cestodes, namely *Moneiza expansa, M. benedeni* and five species of nematodes, namely *Haemonchus contortus, Trichostrongylus* spp., *Oesophagostomum columbianum, Strongyloides papillosus*, and *Trichuris ovis*. Relatively higher occurrence was recorded in winter (94.29%) followed in summer (87.50%) and rainy (86.11%) seasons.

Khajuria *et al.* (2013) examined a total of 1920 faecal samples of sheep (960) and goats (960) of stationary flocks of the middle agro-climatic zone of Jammu province, and reported 67.24% animals were positive for helminthic infections. The different nematodes observed were strongyles (50.1%), trichurids (12.1%) and *Strongyloides* spp. (4.2%). Trematode ova recorded were of *Amphistomes* (8.3%), *Fasciola* spp. (8.2%) and *Dicrocoelium* spp. (5.4%). No
significant difference was observed between the infection level in sheep (68.54%) and goats (65.94%) which could be attributed to mixed grazing and sharing of pastures/sheds.

Lone et al. (2013) studied the seasonal prevalence of helminthes of gastrointestinal tract in sheep for the period from April 2010 to April 2012 in both organized and unorganized sector of Kashmir valley by examining 5836 faecal samples and observed that the overall prevalence of 51.21%. The most common prevalent nematodes were strongyle group of worms. Among cestodes, Moneizia and Avitellina were reported. Among trematodes, Fasciola, Dicrocoelium, Amphistomes and Paramphistomum were the most prevalent. The highest prevalence of helminth parasites was recorded during spring season (60.34%) and the lowest in winter (42.86%)

Singh et al. (2013) examined a total of 240 faecal samples of sheep and goats collected from three different farms in and around Mathura, India and observed that 165 samples were positive for gastrointestinal parasites with the overall prevalence of 68.75%. Also reported that the most common gastrointestinal parasites were Haemonchus, Moniezia and Coccidia spp.

Minnat (2014) studied the prevalence of gastrointestinal parasite infection in sheep and goat in 4 districts of Diyala province in Iraq from December 2012 to June 2013 and observed that out of 220 faecal samples (143 from sheep and 77 from goats) analyzed, 187 (85.0%) were positive for gastrointestinal parasites. He also reported that the prevalence of gastrointestinal parasitic infection were higher
(86.71%) in sheep when compared to goats (81.81%). Parasites identified in this study included: *Eimeria* spp. (86.09%), strongyle type of eggs (72.72%), *Strongyloides* spp. (67.37%) and *Monezia* spp. (59.89%).

### 2.2 EVALUATION OF BROAD SPECTRUM ANTHELMINTICS AGAINST GASTROINTESTINAL NEMATODES OF SMALL Ruminants

Garg *et al.* (2004) conducted study on efficacy of fenbendazole in 47 Barbari goats at Mathura, India and reported that fenbendazole at 7.5 mg/kg was completely effective in reducing the EPG load to zero and no worms could be seen in the abomasum of treated animals. They also suggested that fenbendazole may be used at the rate of 7.5 mg/kg body weight to treat natural nematodiasis in goats. Animals may be dewormed at least three times in a year, before monsoon, after monsoon and before the onset of winter, to minimize the chances of nematodal infection in goats.

Kumsa and Wossene (2006) studied the efficacy of albendazole and tetramisole against Ogaden isolate of *H. contortus* in experimentally infected lambs in Ethiopia. The efficacy of the drugs was evaluated *in vivo* by faecal egg count reduction test (FECRT) and controlled anthelmintic efficacy test. *In vitro* egg hatch assay was performed using different concentrations of albendazole on eggs of *H. contortus* (Ogaden isolate) and the result was compared with eggs from known susceptible and resistant reference strains of *H. contortus*. All the drugs were found to possess a 100% efficacy against Ogaden isolate of *H. contortus* at the dose recommended by manufacturers using the FECRT and controlled anthelmintic efficacy evaluation tests.
Sissay et al. (2006) conducted FECRT in May 2003 to determine the efficacy of anthelmintics used for treatment against nematode parasites in separately managed sheep and goat flocks at Alemaya University in eastern Ethiopia. These tests revealed high level of anthelmintic resistance to albendazol, tetramisole, the combination of these two drugs, and to ivermectin in the goat flock (predominantly infected by *Haemonchus contortus* and *Trichostrongylus* spp.), whereas all drugs were highly efficacious in the sheep flock.

Ram et al. (2007) conducted a trial using albendazole, albendazole plus rafoxanide combination, ivermectin and doramectin in Pashmina goats having history of fenbendazole resistance to *Haemonchus* spp. and maintained at high altitude (>2350 m above sea level). Day ‘0’ infection level was variable in different groups of animals and their larval cultures indicated *Haemonchus, Trichostrongylus, Ostertagia and Oesophagostomum* spp. infection, in addition to *Nematodirus* spp. as observed in egg counts. Efficacy of drugs was calculated on day ‘14’ post treatment by FECRT. Albendazole was least effective (14%) followed by its combination with rafoxanide (54%). However, ivermectin and doramectin were 96% and 94% effective against GINs of Pashmina goats. Concluded that use of albendazole and its combination with rafoxanide are ineffective in controlling the nematodes of goats in this farm.

Nasreen et al. (2008) studied the comparative efficacy of six different commercial anthelmintic formulations against natural helminth infestations in sheep. Pre- and post- treatment EPG results showed that a combination of ivermectin and clorsulon in injectable form gave the overall highest curative rate against the helminth infestation in sheep at the Sheep Breeding Farm, Dachigam, Srinagar.
Kumsa *et al.* (2010) conducted a study to determine and compare the efficacy of the albendazole, tetramizole and ivermectin against GINs in naturally infected goats in Ziway in southern Oromia. Faecal samples were collected on day ‘0’ before treatment and again on day ‘12’ post treatment. Efficacy for each anthelmintic was determined by the FECRT. About 100% efficacy against strongyle and *Trichuris* spp. was recorded in goats treated with albendazole and ivermectin. On the contrary, low efficacy of 90% and 63% against strongyle and *Trichuris* spp. was observed, respectively in goats treated with tetramisole. Likewise, low efficacy of 62%, 38% and 44% against *Moniezia* spp. was recorded in goats treated with albendazole, tetramisole and ivermectin, respectively.

Ahmad *et al.* (2010) studied the comparative anthelmintic efficacy of doramectin, albendazole and levamisole in 40 sheep naturally parasitized with *Haemonchus, Trichostrongylus, Oesophagostomum* and *Ostertagia* species. Doramectin, albendazole and levamisole were found 100%, 97.88% and 99.83% effective, respectively in reducing EPG of feces. The animals treated with these anthelmintics gained more weight gain as compared to untreated control. It was recommended that doramectin as the drug of choice followed by levamisole and albendazole against nematodes of sheep.

Godara *et al.* (2011) studied the efficacy of fenbendazole, levamisole and ivermectin in twenty Jamunapari goats, naturally infected with GIN parasites. Faecal examination at day ‘0’ revealed an EPG of 930±175.1, 1350±421.1, 1060±224.9 and 800±279.7 in group A, B, C and D, respectively having five animals each. The results of larval culture examination revealed the presence of
Haemonchus, Trichostrongylus, Oesophagostomum, Bunostomum and Strongyloides spp. in these animals. FECs of the animals treated with fenbendazole (group A), levamisole (group B) and ivermectin (group C) were reduced by 23.66, 63.70 and 98.11%, respectively on day ‘14’ post-treatment.

Hassan et al. (2011) assessed the efficacy of selective anthelmintics against ecto and endo parasites of Black Bengal goats and their treatment effects on bodyweight gains and hematobiochemical indices conducted at Pahartali Thanain Chittagong district. The study was performed during the period from February 2006 to January 2007. Goats were treated with CEVAMEC®-1% (ivermectin) (T1), ENDEX®-1500 (triclabendazole along with levamisole) (T2), and a placebo (T3, untreated). A reduction of EPG count was very significant from day ‘7’ (91.3% reduction) through day ‘28’ (100%) with the treatment of ivermectin. The reduction rate of EPG was also significant with the treatment of triclabendazole along with levamisole (75.8% - 94.7%). Both of the drugs were equally significant against endoparasitic infections of goats in this study (P<0.05; t-test). The percentage efficacy of ivermectin was also recorded against ticks and lice of goats from day ‘7’ through day ‘28’ of the trial period.

Sibhatu et al. (2011) conducted a study to determine the prevalence of helminths in sheep and to evaluate the efficacy of one brand of albendazole, two brands of tetramisole and one brand of tetraclozan against GINs of sheep in Jeldu district, west Showa Zone of Oromia Regional State, Ethiopia. Coprological investigation revealed that sheep in the district were infested by a variety of helminth parasites; 67.4% with strongyle, 20.2% with Moniezia, 11.63% with
**Fasciola**, 8.5% with *Paramphistomum* and 0.8% with *Trichuris* parasites. Based on their initial FEC, animals were allocated into four treatment groups: albendazole (Albendazole 300mg, Chengdu Qiankun Vet. Pharmaceuticals Co. Ltd, China), tetramisole (Rangtetra-600, Cipla Ltd. Mumbai Central, India), tetramisole (Chengdu Qiankun Vet. pharmaceuticals Co. Ltd, China), tetraclozan, (Tetracozash-900, Ashish Life Science Pvt. Ltd., India) and an untreated control group of 15-16 animals per each group with a uniform mean FEC and treated with the respective drugs according to the manufacturers recommendation. FECRT was used to determine the efficacy of each anthelmintic drug 10 days post treatment and all of the anthelmintics were found to be highly effective and reduction of 98.77-100% FEC of nematode parasites.

*Akanda et al.* (2012) reported that albendazole, ivermectin and fenbendazole were effective for reduction of EPG of GINs in Black Bengal goats at Bangladesh.

*Byaruhanga and Okwee-Acai* (2013) conducted a study between April and July 2011 to determine and to compare the efficacy of albendazole, levamisole and ivermectin against GINs in naturally infected Mubende and Boer crossbred goats at the National Semi-arid Resources Research Institute in Serere, Uganda and reported that in Mubende goats, albendazole, levamisole, and ivermectin reduced FEC by 28.5%, 91%, and 98%, respectively. In Boer crosses, albendazole, levamisole, and ivermectin reduced FEC by 11%, 84.88% and 78.47%, respectively.
Regassa et al. (2013) studied the efficacy of commonly used anthelmintics (Albendazole, tetramisole and ivermectin) against GINs of naturally infected sheep and goats in central Oromia, Ethiopia by the FECRT and observed that the efficacy of albendazole was 100% in both sheep and goats; ivermectin was 100% effective in goats but 95.7% in sheep whereas efficacy of tetramisole was 96.6 and 97% for sheep and goats, respectively.

Sheferaw et al. (2013) studied the anthelmintic resistance status of GINs of small ruminants owned by small holder farmers in the Dale district, Southern Ethiopia by FECRT in traditionally managed and naturally infected goats and sheep. They observed that in sheep, the percentage reduction in FECs (95% confidence intervals) for albendazole, tetramisole and ivermectin were 95.0% (86.5 to 98.2%), 97.5% (93.2 to 99.1%) and 96.7% (91.0 to 99.1%), respectively and in goats, the percentage reduction in FECs (95% confidence intervals) for albendazole, tetramisole and ivermectin were 96.6% (88.3 to 99.0%), 97.7% (90.6 to 99.4%) and 97.1% (91.0 to 99.1%), respectively. All the anthelmintics were found to be effective, but resistance to albendazole was suspected.

Terefe et al. (2013) conducted the anthelmintic efficacy and associated risk factors for anthelmintic resistance in sheep at Bedelle District of Oromia Region, Ethiopia and observed that egg count reduction levels of 96%, 99% and 97% respectively for albendazole, tetramisole and ivermectin by FECRT. However, post-treatment faecal cultures and postmortem adult worm recovery showed that some *H. contortus* worms have escaped the treatments. They concluded that no anthelmintic resistance was detected from clinical cure point of view but the
population of *H. contortus* that has escaped the treatments deserves further scrutiny as this parasite is the most prolific and highly pathogenic in sheep.

Akhter *et al.* (2014) studied the efficacy of Valbazen, Levamisole and Dectomax against *H. contortus* in goats of Sindhu, Pakistan, using FECRT and egg hatch assay (EHA) and reported that the overall mean per cent on day 10th and 14th post treatment showed significant decrease (P<0.05) in FEC. About 91.8% efficacy against *H. contortus* was recorded in goats with Dectomax followed by Valbazen (88.6%) and Levamisole (83.4%) on day 14th post treatment suggesting Dectomax as the most effective of the three anthelmintics.

Hamdullah *et al.* (2014) investigated the efficacy of oxfendazole, levamisole and ivermectin against GINs of sheep in Balochistan, Pakistan by FECRT and EHA. The arithmetic FECR with oxfendazole, levamisole and ivermectin were recorded 97%, 98% and 99%, respectively, which indicated the susceptibility of these GINs against anthelmintics. The results of EHA indicated that LC50 were 0.09931, 0.0894, 0.09302 and 0.086 ug/ml respectively for four sheep breeds, which are less than 0.1ug/ml of oxfendazole. Result indicates that no resistance was found in the eggs with oxfendazole. The EHA also confirmed the result of FECRT. The qualitative examination of faecal samples after coproculture revealed the presence of four GINs genera i.e., *Haemonchus, Trichostrongylus, Nematodirus* and *Ostertagia*.

Meenakshisundaram *et al.* (2014) evaluated anthelmintic efficacy of albendazole (5mg/kg), fenbendazole (7mg/kg), levamisole (7.5mg/kg) and
closantel (10mg/kg) separately in 4 groups of naturally infected Madras red sheep lambs. The anthelmintic resistance was evaluated by in vivo FECRT, post-treatment larval culture and in vitro EHA. They reported that albendazole reduced the FEC by 86.50%, 84.81%, 85.28% and 84.47%, respectively, for 4 weeks after treatment. FECR using fenbendazole was 92.64%, 93.04%, 90.80% and 90.06%, respectively for 4 weeks after treatment. The percent efficacy for levamisole and closantel was more than 95%. The post-treatment larval culture contained only Haemonchus contortus. In the in vitro EHA, the ED$_{50}$ value for benzimidazole was 0.299 μg albendazole/ml and levamisole showed an ED$_{50}$ value of 0.283 μg/ml.

### 2.3 ANTHELMINTIC RESISTANCE

Anthelmintic resistance in nematodes has been recorded for over 50 years and is possibly associated with the increased use of intensive husbandry/management systems. Anthelmintic resistance can be described as a heritable change in the ability of individual parasites to survive the recommended therapeutic dose of an anthelmintic drug. Resistance has to be distinguished from tolerance. Tolerance describes the situation where the population of a worm previously unexposed to an anthelmintic, is not removed completely by it while, resistance describes the situation where a population of nematodes, originally sensitive to an anthelmintic, inherits the ability to survive treatment after repeated exposure to the drug. Two other terms frequently used in association with resistance are cross resistance and side resistance. Cross resistance describes the ability of parasites strains to survive therapeutic doses of chemically unrelated drugs or drugs with a different mode of
action, while side resistance is resistance between chemically related groups of anthelmintics.

Anthelmintic resistance has been detected most commonly among the GINs of sheep and goats, particularly *H. contortus* and *Teladorsagia (Ostertagia) circumcincta, Trichostrongylus* spp., *Cooperia* spp. and *Nematodirus* spp. (Hunt and Taylor, 1989). *Haemonchus contortus* has, to date, shown resistance to phenothiazine, various benzimidazoles (including the probenzimidazole drugs), levamisole, morantel, rafoxanide, naptholphos, closantel and most recently, ivermectin, i.e, representatives of each of the major groups of anthelmintic drugs.

### 2.3.1 Worldwide incidence

Anthelmintic resistance was first reported in *Haemonchus contortus* against phenothiazine (Drudge *et al.*, 1957). Problems of anthelmintic resistance began to appear after the introduction of thiabendazole and the first case of benzimidazole (BZ) resistance in a population of *H. contortus* was recorded in Australia (Smeal *et al.*, 1968). Berger (1975) reported parbendazole resistance in a strain of *H. contortus* in sheep flocks of South Africa, where the anthelmintic was exclusively used for six years. The strain also showed moderate to marked resistance to the rest of benzimidazoles but was susceptible to levamisole.

In Australia, Whitlock *et al.* (1980) reported that both *T. colubriformis* and *Ostertagia* spp. were highly resistant to levamisole and morantel with low level resistance to thiabendazole. In the United Kingdom, anthelmintic resistance was first recorded in a population of *Teladorsagia (Ostertagia) circumcincta* in sheep
in Cheshire (Britt, 1982) about 20 years after thiabendazole was first introduced. As a consequence of this report, studies were initiated in south of England and the study identified *T. circumcincta* populations resistant to thiabendazole, fenbendazole, oxfendazole and albendazole, demonstrating the presence of side resistance (Cawthorne and Whitehead, 1983). Subsequently, Cawthorne and Cheong (1984) investigated 52 commercial sheep flocks in the south of England using *in vivo* and *in vitro* tests and found evidence of resistance to thiabendazole on 13.5 per cent of the farms. *H. contortus* was observed to be the predominant resistant species of nematode.

In France, Kerboeuf and Hubert (1985) recorded benzimidazole (BZ) resistance in field strains of nematodes from goats. Edwards *et al.* (1986) undertook a survey on anthelmintic resistance in sheep flocks in Western Australia and found resistant populations against both benzimidazole and levamisole. The predominant BZ resistant species was *Trichostrongylus* spp., (48 per cent) followed by *Teladorsagia* spp., (41 per cent) and *H. contortus* (18 per cent). Levamisole resistant populations included *Teladorsagia* spp., (41 per cent), *Trichostrongylus* spp., (24 per cent), *H. contortus* (10 per cent) and *Nematodirus* spp., (10 per cent). Multiple anthelmintic resistant populations were also recorded on 17 per cent of the farms. Strains of *H. contortus* resistant to rafoxanide and closantel were described by Van Wyk and Malan (1988) in South Africa.

resistance in *Teladorsagia* spp., *T. colubriformis* and *T. vitrinus* in sheep in South Australia. Maingi (1991) surveyed anthelmintic resistance in sheep farms in Kenya and found resistance to all three broad spectrum anthelmintics in *H. contortus* while only thiabendazole resistance was detected in *Trichostrongylus* spp.

Sivaraj *et al.* (1994) undertook a survey on a sheep farm in Malaysia and the results of the study indicated resistance in *H. contortus* against benzimidazole and ivermectin and in *T. colubriformis* against benzimidazole and levamisole on the same farm. A high level of multiple anthelmintic resistance (benzimidazole, levamisole and ivermectin) against GINs of sheep in South America was reported by Waller *et al.* (1995).

BZ resistance was confirmed in *H. contortus, T. circumcincta, Cooperia curticei* and *T. colubriformis* in Angora and Anglo Nubian goats in a controlled test in Netherlands (Borgsteede *et al.*, 1996). Coles and Simkins (1996) reported the prevalence of levamisole resistant *Teladorsagia* spp. in a sheep farm in South west England. Another survey was undertaken in 138 sheep farms in England and the study revealed the presence of BZ resistant strains on 44 per cent of farms with *T. circumcincta* being the predominant species (Hong *et al.*, 1996).

Chartier *et al.* (1998) recorded the prevalence of anthelmintic resistant nematodes in sheep and goats in Western France. In sheep, anthelmintic resistance was reported to occur in 83 per cent and 50 per cent of farms for benzimidazole and levamisole, respectively. In goats, all 15 farms examined showed the
occurrence of BZ resistant nematodes. Gopal et al. (1999) recorded the first case of resistance in a field strain of *T. colubriformis* against ivermectin in Australia.

Bartley et al. (2001) observed a marked increase in the prevalence of BZ resistant nematodes in Scotland sheep over the past 10 years and reported that 24 per cent of 37 sheep farms had benzimidazole, imidazothiazole / tetrahydropyrimidine and macrocyclic lactone resistant *Teladorsagia* spp.

Papadopoulos et al. (2001) conducted a survey on anthelmintic resistance in sheep and goat flocks in Greece using *in vivo* and *in vitro* tests. The results indicated resistance in *T. circumcincta* against benzimidazoles. Mortensen et al. (2003) reported high prevalence of multiple anthelmintic resistance in GINs of goats in Southern United States. Sheep worm infections increasingly threaten the profitability of the Australian sheep industry as the prevalence and severity of anthelmintic resistance continues to rise (Besier and Love, 2003).

Ancheta et al. (2004) concluded that resistance to benzimidazole anthelmintics in the Philippines among nematodes of goats and sheep is widespread. A suspected case of multiple anthelmintic resistance on a farm in the canton of Zurich, Switzerland, where South African Boer goats had previously been imported, was confirmed in a controlled test (Schnyder et al., 2005). Anthelmintic resistance in parasitic nematodes of sheep was common in New Zealand; not only resistance to albendazole and levamisole but also resistance to the ML, ivermectin, was at a higher prevalence than expected (Waghorn et al., 2006). Borgsteede et al. (2007) observed that doramectin and albendazole resistance was
still widely spread in sheep in The Netherlands and not only concerned with *H. contortus*, but also *T. circumcincta* and/or *Trichostrongylus* spp.

Howell *et al.* (2008) observed that anthelmintic resistance was a serious problem on small ruminant farms throughout the southeastern United States. Kumsa and Abebe (2009) conducted a study to determine the presence of anthelmintic resistance on Hawassa University goat farm in southern Ethiopia and reported that multiple anthelmintic resistance in *Haemonchus* spp. against albendazole, tetramisole and ivermectin was recorded in all age categories of the goats. Vernerova *et al.* (2009) observed the resistance of BZ type drugs on 14 sheep farms in the Czech Republic.

Melo *et al.* (2013) observed that the GINs of goats and sheep from Agreste of Paraíba State, Brazil are highly resistant to ivermectin. Severe anthelmintic resistance against four anthelmintic from the group; Benzimidazoles, Imidazothiazoles, Macrocyclic Lactones and Salicylanilides in two free grazing small holder goat farms in Malaysia (Chandrawathani *et al.*, 2013).

2.3.2. Status of anthelmintic resistance in India

Varshney and Singh (1976) were the first to record the prevalence of phenothiazine and thiabendazole resistant *H. contortus* in sheep at Central Sheep and Wool Research Station, Dehradun, Uttar Pradesh and Yadav (1990) was the first to record BZ resistant *H. contortus* in sheep. Uppal *et al.* (1992) recorded multiple resistance against benzimidazole, levamisole, morantel tartrate and thiophanate in *H. contortus* from goats in Hissar and, later, Yadav and Uppal (1992) identified levamisole resistant strains of *H. contortus* in goats for the first time in India. In Uttar Pradesh, fenbendazole, levamisole and oxyclozanide resistant *H. contortus* was observed in sheep in a breeding farm (Srivastava *et al.*, 1995).


Dhanalakshmi *et al.* (2003) detected resistance to BZ in 9 out of 10 farms examined in Karnataka, India. However, resistance to levamisole was not observed in the farms. Gupta *et al.* (2003) identified resistance in *H. contortus* against closantel, which was earlier resistant to benzimidazole, morantel tartrate and levamisole indicating the emergence of multiple resistance in that strain.
Prevalence of fenbendazole resistant *H. contortus* in two sheep flocks at Chennai, Tamil Nadu was reported by Jeyathilakan *et al.* (2003). Easwaran (2004 and 2009) recorded the prevalence of benzimidazole and levamisole resistant nematodes in northwestern Tamil Nadu. Deepa and Devada (2011) studied specific resistance to benzimidazole group in GINs of goats maintained in the Kerala Agricultural University Goat Farm, Mannuthy.

Buttar *et al.* (2012) observed the anthelmintic resistance against commonly used anthelmintics (ivermectin, levamisole, morantel and fenbendazole) in naturally occurring GINs in adult sheep of Government Sheep Breeding Farm at Mattewarain district Ludhiana (Punjab).

GINs of goats in semi organized farm of Mathura district, India were found to be resistant to fenbendazole, but were susceptible to Levamisole. They were also suspected to be resistant to ivermectin. This seems to be the first documentation of ivermectin induced anthelmintic resistance against gastrointestinal helminths in goats in the Indian subcontinent (Jaiswal *et al.*, 2013).

Anthelmintic resistance to albendazole and ivermectin in small scale goat rearing units in Vallachira Panchayath of Thrissur District, Kerala observed by Rajagopal *et al.* (2013). Rialch *et al.* (2013) observed the status of BZ resistance in GINs of sheep and goats of different agro-climatic zones of sub-Himalayan region of northern India.

Meenakshisundaram *et al.* (2014) observed that *H. contortus* resistance to BZ in sheep was detected in Livestock Research Station, Kattupakkam, a research unit of Tamilnadu Veterinary and Animal Sciences University.
2.4 DETECTION OF ANTHELMINTIC RESISTANCE

When anthelmintic resistance occurs, there is invariably a reduction in anthelmintic efficiency which may be measured as information on the reduction of either faecal egg output / worm numbers. A number of tests can be used to evaluate the efficiency of anthelmintics on a mixed population of GINs. Methods for detecting anthelmintic resistance can be divided into \textit{in vivo} and \textit{in vitro} techniques. \textit{In vivo} methods are suitable for all types of anthelmintics, including those that undergo metabolism in the host, while, \textit{in vitro} techniques are rapid, sensitive and considerably more economic (Coles \textit{et al.}, 1992).

2.4.1 \textit{IN VIVO} ASSAY

2.4.1.1 Faecal egg count reduction test (FECRT)

The FECRT was the first test developed for evaluating anthelmintic efficacy, using faecal egg counts to estimate potential worm burdens. It still remains the most widely used test for routine diagnosis in commercial flocks. The test estimates anthelmintic efficacy by comparing the FEC of animals before and after treatment (Boerseema, 1983).

The test estimates anthelmintic efficacy in terms of nematode egg output and does not necessarily rely on worm numbers, because it only measures the effect on adult female worms. Each group should consist of at least 10 animals with positive eggs with a mean egg count of over 200 EPG of faeces before treatment (Presidente, 1985). He also opined that FECRT may not provide
sufficient information for correct interpretation and therefore larval cultures need to be done to determine the species involved.

Waller (1987) stated that FECRT is relatively cheaper since there is no requirement for highly skilled personnel, expensive resources or sophisticated equipment and facilities.

Dash et al. (1988) and Martin et al. (1988) argued that the use of arithmetic mean was more appropriate in FECRT in estimating the efficiency of anthelmintic mean in view of the fact that the arithmetic mean derived from the sum of individual worm egg count is directly proportional to the total egg output while, the geometric mean will be lower than arithmetic mean.

Martin et al. (1989) opined that the FECRT, using an established efficacy threshold of 95 per cent, is arguably the most traditional field test for detection of anthelmintic resistance, but is insensitive when used as an undifferentiated test. The authors also expressed the opinion that FECRT lacks the sensitivity to detect levels of resistance below 25 per cent.

Taylor and Hunt (1989) stated that FECRT estimates the anthelmintic efficacy in terms of nematode egg output and does not necessarily relate to worm numbers.

2.4.1.2 Detection of anthelmintic resistance through FECRT in India

Uppal et al. (1992) recorded multiple anthelmintic resistance in a field strain of *H. contortus* by FECRT and the study revealed egg count reduction of 52.13%,
23.68%, 48.22%, 29.42% and 22.3% against levamisole, morantel, fenbendazole, mebendazole and thiophanate, respectively.

Yadav and Uppal (1992) recorded levamisole resistant *H. contortus* in goats by FECRT. The trial revealed reduced faecal egg counts by 83.4 per cent.

Yadav *et al.* (1993) recorded fenbendazole and morantel resistant *H. contortus* and closantel, ivermectin and levamisole susceptible *H. contortus* in a flock of 150 crossbred lambs by FECRT. Fenbendazole and morantel reduced FECs by 87% and 69%, respectively and levamisole showed an efficacy of 95 per cent whereas, closantel and ivermectin were 100% effective against *H. contortus*.

Yadav and Kumar (1994) reported levamisole resistant strain of *H. contortus* in sheep by FECRT. The trial confirmed a reduced FEC of 69.82 per cent in levamisole treated sheep.

Singh *et al.* (1995) detected albendazole resistant *H. contortus* using FECRT in naturally infected sheep. The per cent efficacy was 80 per cent indicating resistance to albendazole.

Gill (1996) observed resistance to albendazole and levamisole in sheep with reduced FECs of 0 – 73% and 0 – 61%, respectively after treatment.

Yadav *et al.* (1996) identified benzimidazole and probenzimidazole resistant *H. contortus* in sheep and goats. Fenbendazole and thiophanate reduced FECs by 55 per cent and 39 per cent, respectively in sheep while, fenbendazole at the same dose rate reduced egg output by 50 per cent. Levamisole reduced worm
egg counts in both sheep and goats by 99 -100 per cent at 10 days post treatment indicating susceptibility to levamisole.

Meenakshisundaram (1999) conducted a trial to detect anthelmintic resistance using FECRT in an organized farm in Tamil Nadu against albendazole, fenbendazole, levamisole and closantel. The results revealed reduced FECs of 86.5% and 92.6% after treatment with albendazole and fenbendazole, respectively with less than 90% lower 95% confidence limit while, the FECs reduction were 98.7% and 100% after treatment with levamisole and closantel, respectively indicating the presence of resistance to albendazole and fenbendazole and susceptibility to levamisole and ivermectin.

Swarnkar et al. (1999) reported that fenbendazole and tetramisole reduced FECs by 0% and 25%, respectively with less than 90% lower 95% confidence limit indicating resistance. Pre treatment and post treatment faecal culture revealed the predominance of *H. contortus* in treated groups.

Dhanalakshmi et al. (2003) reported that fenbendazole, albendazole and rafoxanide reduced faecal egg counts by 67-73%, 56-77% and 92-94%, respectively with less than 90% lower 95% confidence limit. Whereas, in levamisole there was 98-99 per cent reduction in FECs with lower 95 per cent confidence limit of 90 - 94 per cent. The study indicated the presence of resistance to fenbendazole, albendazole and rafoxanide, as well as no resistance to levamisole.
Jeyathilakan et al. (2003) detected resistance to fenbendazole and suspected resistance to tetramisole in GINs of sheep in Tamil Nadu. The study showed egg count reduction of 71% and 92% with 95% lower confidence limit of 45% and 93% for fenbendazole and tetramisole, respectively.

Easwaran (2004) recorded resistance to benzimidazole and levamisole in three organized farms of Tamil Nadu. The study revealed egg count reduction of 89%, 85% and 92% with 95% lower confidence limits of 82%, 78% and 88%, respectively. In levamisole treated groups, the egg count reduction was 79%, 88% and 93% with 95% lower confidence limits of 65%, 81% and 88%, respectively.

Yadav and Garg (2004) reported that the lower limits of 95 per cent confidence limit in FECRT in sheep treated with rafoxanide, levamisole and fenbendazole were less than 55 per cent whereas, the lower limits of 95 per cent confidence levels in sheep treated with closantel and moxidectin were above 90 per cent. The authors inferred that *H. contortus* in sheep showed resistance to rafoxanide, levamisole, fenbendazole and morantel and no evidence of resistance to closantel and moxidectin in sheep was observed.

Das and Singh (2005) identified moderate to severe fenbendazole resistant *H. contortus* in all sheep and goat farms at Hissar. The reduction in FECs for fenbendazole ranged from 59.8 to 92.14 per cent.

Easwaran et al. (2009) reported the occurrence of anthelmintic resistance on three institutional sheep farms in Tamil Nadu, India using the FECRT for both benzimidazoles and levamisole and observed that the result indicated multiple
resistance in *H. contortus* and *Teladorsagia* spp. to benzimidazoles and levamisole in farm I, simultaneous resistance in *Teladorsagia* spp. to benzimidazoles and levamisole in farm II and simultaneous resistance in *H. contortus* to benzimidazoles and levamisole in farm III.

The status of anthelmintic resistance in GINs against commonly available anthelmintics (benzimidazole, tetramisole and closantel) was determined through FECRT, and results were correlated with flock management practices and there is high prevalence of benzimidazole resistance (86.4%) and moderate prevalence of tetramisole resistance (55.7%) with distinct regional variation (Swarnkar and Singh, 2010).

Buttar *et al.* (2012) studied the anthelmintic resistance against commonly used anthelmintics (ivermectin, levamisole, morantel and fenbendazole) in naturally occurring GINs in adult sheep of Government Sheep Breeding Farm at Mattewarain district, Ludhiana (Punjab) through qualitative and quantitative screening of faeces. They reported that multiple resistance against all the four class of anthelmintics used was recorded from sheep against GINs.

Swarnkar and Singh (2012) conducted a study was to ascertain the extent of variation in the efficacy of anthelmintics in different seasons and its correlation with status of anthelmintic resistance in GINs of sheep in different agro climatic regions of Rajasthan. The efficacy of anthelmintics was determined by FECRT. The seasonal analysis of data on% FECR exhibited that overall efficacy ranged from 56.80±3.99 (June-August) to 79.76±2.23 (December – February) and from
72.65±6.83 (March – May) to 91.46±2.07 (December – February) for benzimidazole and tetramisole, respectively. No seasonal variation was observed for efficacy of closantel against *H. contortus* in sheep and it remained > 99%.

Jaiswal *et al.* (2013) reported that frequent and indiscriminate use of anthelmintic drugs has led to anthelmintic resistance in animals by *in vivo* test, FECRT and found that GINs were found to be resistant to fenbendazole, but susceptible to levamisole, while they were suspected to be resistant to ivermectin. This seems to be the first documentation of ivermectin induced anthelmintic resistance against gastrointestinal helminths in goats in the Indian subcontinent.

Rajagopal *et al.* (2013) conducted FECRT the *in vivo* detection of anthelmintic resistance to albendazole and ivermectin in small scale goat rearing units in Vallachira Panchayath, Thrissur District, Kerala and reported that resistance was detected against albendazole with per cent egg count reduction of 71 per cent and lower 95 per cent confidence interval less than 90%. Ivermectin was found effective with per cent egg count reduction of 97 per cent. Resistance to albendazole can be attributed to the prolonged and intensive use of the drug. The use of ivermectin orally for deworming has been introduced recently and the drug is still efficacious. Detection of resistance in small holder farmers flocks warrants judicious use of these drugs to prevent further selection for resistance. *H. contortus* was the predominant species among GINs identified by coproculture and this factor also contributed to the rapid selection for resistance.
Rialch et al. (2013) studied the status of BZ resistance in GINs of sheep and goats of different agro-climatic zones of sub-Himalyan region of northern India using in vivo FECRT and in vitro tests namely EHA and LDA and reported that FECRT and EHA gave comparable results with regard to detection of BZ resistance in GINs in sheep and goats and indicated the presence of low level of resistance in GINs of both sheep and goats. They also suggested that for effective worm control, regular monitoring for anthelmintic resistance is important to know the status of anthelmintic efficacy in a particular agro-climatic zone.

Meenakshisundaram et al. (2014) evaluated the anthelmintic resistance by in vivo FECRT and observed that albendazole and fenbendazole reduced the FEC by 85.28% and 91.00%, respectively for 4 weeks after treatment. The percent efficacy for levamisole and closantel was more than 95%.

2.5. IN VITRO ASSAYS

In vitro assays offer rapid, sensitive and considerably more economic methods of anthelmintic screening. They involve parasitological, biochemical and genetic assays for screening anthelmintics. They are more precise as they do not involve host as a source of primary data. However, their dependence on pharmacodynamics of specific anthelmintic groups limit their widespread adoption (Kaplan, 2004).

2.5.1 Egg hatch assay (EHA)

This assay is based on the ovicidal properties of benzimidazole and the ability of the eggs from resistant parasites to embryonate and hatch at higher drug
concentration than the susceptible parasites. In this test, the ability of an anthelmintic to inhibit or prevent embryonation and hatching of nematode eggs is evaluated. This test was first described by Le Jambre (1976).

Coles and Simpkin (1977) opined that EHA requires undeveloped eggs because benzimidazoles only act on the eggs during the early part of development. Hall et al. (1978) stated that the EHA has shown great potential for determining the level of benzimidazole resistance.

Various modifications of EHA have been described (Coles and Simpkin, 1977; Hall et al., 1978). Prichard et al. (1980) opined that EHAs are inexpensive, sensitive and less time consuming and repeatable.

Whitlock et al. (1980) stated that eggs from susceptible nematodes rarely hatch at drug concentration of more than 0.1 µg / ml of thiabendazole. This concentration was often used as the discriminating dose for determining susceptibility or resistance to BZ group of anthelmintics. The authors also claimed that EHA has been the only practical test for confirming BZ resistance.

Smith et al. (1986) recommended transportation of faecal samples in ice to prevent development of eggs. Later, Taylor and Hunt (1989) reported that anaerobic storage of faeces for up to 7 days had little effect on the effectiveness on the technique and hence faecal samples could be sent by post for screening of drug resistance in worm populations.

Johansen (1989) described several intrinsic variables of EHA viz., single or mixed species, fresh or embryonated eggs, pure or commercial drug, drug dilutions
or fixed drug concentration, incubation temperature and time, larva plus embryonated eggs or larvae which affect the results and make its objective assessment difficult to interpret.

Borgsteede and Couwenberg (1987) and Maingi (1991) observed variation in LC$_{50}$ values during patency of infection and concluded that the time to conduct EHA during patency had little or non-conclusive effect on the results.

Rahman (1993) recorded thiabendazole resistant *H. contortus* in 19 per cent of goat farms in Malaysia through EHA. Meenakshisundaram (1999) undertook a survey to determine the status of resistance against thiabendazole and levamisole in GINs of sheep in an organized farm in Tamil Nadu by EHA. The study showed ED$_{50}$ values of 0.299 µg / ml and 0.283 µg / ml for thiabendazole and levamisole, respectively in resistant strains.

Swarnkar *et al.* (1999) observed no resistance to either fenbendazole or levamisole in nematodes of sheep through EHA. The LC$_{50}$ values recorded were from 0.074 ± 0.015 µg / ml.

Dhanalakshmi *et al.* (2003a) recorded ED$_{50}$ values of 0.07 µg/ml and 0.08 µg/ml for albendazole and fenbendazole in one farm and 1.45 to 6.53 µg/ml in another farm and for levamisole it ranged between 0.08 to 0.90 µg/ml in EHA. The results indicated resistance to benzimidazole and absence of resistance to levamisole in nematodes of sheep.

Easwaran (2004) carried out EHA to detect anthelmintic resistance against thiabendazole in three organized farms and small holder flocks at Tamil Nadu. The
ED$_{50}$ values ranged from 0.388 to 0.678 µg / ml suggestive of resistance in three sheep flocks while, the small holder flocks were susceptible to benzimidazole.

Lourderaj (2005) reported benzimidazole resistance in *H. contortus* in seven agroclimatic zones of Tamil Nadu using EHA. The study revealed an ED$_{50}$ value of 0.7 and 0.5 µg thiabendazole / ml in two small holders flock out of five examined.

Ponnudurai *et al.* (2005) conducted EHA on samples from two sheep flocks in Tamil Nadu and the results showed an egg hatch of 9 and 26 per cent with LC$_{50}$ values of 0.0631 and 0.0711 µg thibendazole / ml at 0.3 µg thiabendazole / ml, whereas, at a concentration of 0.1 µg thibendazole / ml, the LC$_{50}$ values ranged from 0.0360 to 0.0502 µg / ml. They also added that LC$_{50}$ value of BZ resistant flock was 0.32 µg / ml and the BZ susceptible *H. contortus* flock was 0.02 µg / ml.

Easwaran *et al.* (2009) studied the occurrence of anthelmintic resistance on three institutional sheep farms in Tamil Nadu by the EHA for BZ and observed that ED$_{50}$ values for thiabendazole in EHA for isolates from three farms were 0.627, 0.678 and 0.388 µg/mL of thiabendazole.

Deepa and Devada (2011) studied specific resistance to BZ group in GINs of goats maintained in the Kerala Agricultural University Goat Farm Mannuthy by EHA and reported that test revealed ED$_{50}$ value (µg/ml) to be 0.211556 which was much higher than the prescribed value (0.1µg/ml) for albendazole. EHA gives a quantitative estimate of BZ resistance and suggested that it may be used in field surveys along with FECRT to monitor the development of anthelmintic resistance.
Rialch et al. (2013) studied the status of BZ resistance in GINs of sheep and goats of different agro-climatic zones of sub-Himalyan region of northern India using EHA and observed that the GINs of eight farms which were found resistant by FECRT were also detected resistant by EHA with ED50 value greater than 0.1 µg/ml.

Dolinska et al. (2014) detected the occurrence of BZ and ML resistance on sheep farms in Slovakia by using in vitro EHA and observed that majority of the farms in 2013 had hatching percentages below 40%, which estimated ED50 to be below 0.1 µg·ml⁻¹ thiabendazole. Iliev et al. (2014) reported that benzimidazoles are the most commonly used anthelmintic drugs for the chemical control of sheep strongyloidosis in Bulgaria and pointed that two of 13 sheep flocks examined, a BZ resistance was detected with values of ED50 between 0.1132 and 0.2023µg/ml and for LD50 between 0.2940 and 0.5817µg/ml thiabendazole.

Meenakshisundaram et al. (2014) evaluated the anthelmintic resistance by in vitro EHA in Madras red lambs and reported the ED50 value for BZ was 0.299 µg albendazole/ml and levamisole showed an ED50 value of 0.283 µg/ml.

2.5.2. Larval development assay (LDA)

This test was developed by Georgi and Le Jambre (1983). It is the only in vitro test that can be used to detect resistance against all types of anthelmintics.

The LDA was modified subsequently by Coles et al. (1988) where first stage larvae were cultured to third stage larvae in the presence of lyophilized Escherichia coli as a food source and the anthelmintics under test.
Lacey et al. (1990) and Hubert and Kerboeuf (1992) later modified this test system. Nematode eggs were added to an agar matrix containing drug and developed through infective larvae in the presence of nutritive medium. The test is based on the assumption that first sites of action of the drug that exists in the developing larvae are similar to that of adult parasites, secondly, role of site of action in maintaining viability in developing larvae and adult is either unchanged or comparable, thirdly, a free equilibrium of the drug between the agar matrix and larvae is maintained, and finally the active constituent *in vivo* is the drug used *in vitro*.

Taylor (1990) defined specific cut-off minimum inhibitory concentration values for thiabendazole (0.1 µg ml⁻¹) and levamisole (1.0 µg ml⁻¹) for the LDA.

The LDA appears to be a very useful assay which is able to detect resistance in *Ostertagia circumcincta* to BZ and levamisole anthelmintics, but appears to require the use of a ML other than ivermectin to be particularly useful at detecting ivermectin resistance in *O. circumcincta* in New Zealand (Amarante *et al.*, 1998).

Comparison of six *in vitro* tests in determining BZ and levamisole resistance in *H. contortus* and *O. circumcincta* of sheep, Varady and Cobra (1999) observed that the LDA was most sensitive. Also observed that the RF for thiabendazole and levamisole was 14.3 and >32.5, respectively in *H. contortus* strains and 21.1 and 3.5 in strains of *O. circumcincta*.

Terrill *et al.* (2001) reported that DrenchRite® LDAs were also used along with FECRTs to find the efficacy and resistance of anthelmintics in goats in the southeastern United States.
Bartley et al. (2001) studied the state of anthelmintic resistance in Scottish sheep flocks during April–August 2000 using in vitro bioassays, EHAs for detecting thiabendazole resistance and LDAs for levamisole, ivermectin and thiabendazole resistance. Anaerobic sampling kits and detailed questionnaires outlining farm demographics and management practices were mailed to 227 Moredun Foundation member farms and replies were received from 98 farms. Kits received sufficient material to conduct one or more of the assays from 90 farms. A majority of the farms examined (64%) exhibited thiabendazole resistance but there were both farm locality and regional variations in the percentage of resistant farms. Teladorsagia spp. was the predominant genera detected from farms. No resistance to levamisole or ivermectin was detected in any of the samples. There was no strong evidence from this survey that any of the management practices examined greatly affected thiabendazole resistance.

Dhanalakshmi et al. (2003a) recorded a minimum inhibitory concentration (MIC) value of 0.08 µg/ml for albendazole and 0.16 to 6.19 µg/ml for fenbendazole. In levamisole treated flocks, it ranged between 0.169 to 0.979 µg/ml in LDA. The results indicated resistance to benzimidazole and absence of resistance to levamisole in nematodes of sheep.

Singh et al. (2003) standardized LDA to detect anthelmintic resistance against thiabendazole. The study revealed 61.92 per cent to 77.09 per cent development of infective larvae (L₃) at a concentration of thiabendazole from 0 to 0.078 µM/ml and the L₃ development was significantly inhibited in more than 50 per cent of eggs with dose rate of more than 0.078 µM thiabendazole /
ml. They also observed a linear dose response relationship between the probit of larval development and the logarithms of anthelmintic concentration.

Easwaran (2004) conducted LDA to detect anthelmintic resistance in sheep and goat flocks of organized farms in Tamil Nadu. The results showed LD$_{50}$ values of 0.428 and 0.562 µg / ml of thiabendazole and levamisole, respectively in sheep and LD$_{50}$ values of 0.0462 and 0.023 µg / ml of thiabendazole and levamisole, respectively in goats.

Kaplan (2004) reported that the LDA was routinely used to diagnose ivermectin resistance in *H. contortus* but laboratory diagnosis of moxidectin resistance was hampered by the lack of any validated *in vitro* tests on goat farms in Georgia and observed that moxidectin resistance was diagnosed both in *Haemonchus* spp. and *Trichostrongylus* spp. on almost half of the farms tested, despite this drug only being used on these farms for 2–3 years.

Varady *et al.* (2006) surveyed the prevalence of anthelmintic resistant nematode populations in 32 sheep farms in the Slovak Republic by EHTs and LDTs for detection of resistance to BZ anthelmintics and reported that the LD$_{50}$ values were higher than 0.1 mg thiabendazole / ml, indicating resistance.

Varady *et al.* (2007) compared the EHT and LDT as *in vitro* tools for detection of BZ resistance in *H. contortus*, a nematode parasite of small ruminants. Comparisons were made during a course of infection and changes in both EHT and LDT were monitored to measure the correlation between resistance and susceptibility in different parasite stages (eggs and larvae). In addition, mixed
doses of known numbers of susceptible and BZ resistant \textit{H. contortus} eggs were used to assess the sensitivity of LDT for the detection of low levels of resistance. The degree of resistance for each test was expressed as resistance factors (RFs). The LDT showed a greater ability to distinguish between four susceptible and four resistant isolates of \textit{H. contortus} with higher resistance factors compared to the EHT. For the EHT, the RF by using ED$_{50}$ criterion ranged from 3.2 to 13.3 and from 7.4 to 25.2 by using LC$_{99}$. For LDT the resistant isolates were 4.3–63.1 tolerant than the susceptible isolates using the ED$_{50}$ criterion and 91.1–1411.0 tolerant using the LC$_{99}$ criterion. The LDT was also able to clearly indicate the presence of low level (4\%) of resistant larvae amongst a susceptible background population.

Demeler et al. (2012) studied the anthelmintic resistance using two well established \textit{in vitro} assays: the LDA and the larval migration inhibition assay (LMIA) in sheep. These were performed on free-living stages of susceptible and ML - resistant isolates of three trichostrongyloid nematode species of sheep. In general, dose response curves shifted to the right in the resistant isolates. Data showed that resistance was present to ivermectin and its two components suggesting that both components contribute to action and resistance. There were no consistent patterns of potency and resistance of the tested substances for the different isolates in the LDA except that moxidectin tended to have lower resistance ratios than ivermectin.

Kumar et al, (2014) reported that the faecal samples of 264 sheep from 4 different sheep farms belonging to three different districts of Karnataka were
screened to note the incidence of GINs. It was found that 93% of the sheep harboured strongyle infection. The faecal egg counts were found to be light to moderate. The \textit{in vitro} EHA was employed to assess the resistance of strongyles in 4 sheep farms. The ED\textsubscript{50} value for albendazole ranged between 2.5\(\mu\)g/ml to 6.9 \(\mu\)g/ml which indicated the resistance of the gastrointestinal nematodes. All the samples were also subjected to another \textit{in vitro} test, \textit{viz.}, LDA. The values ranged between 3-2\(\mu\)g to 4.2\(\mu\)g / ml which also indicated the development of resistance to albendazole.

\textbf{2.6 PARASITE CONTROL PRACTICES}

Maingi \textit{et al.} (1996) conducted a questionnaire survey in sheep farms in Denmark on sheep management and worm control practices and observed that the majority (97%) of the 183 farmers used anthelmintics. The mean number of doses per year for lambs (< 12 months old) and adult sheep (> 12 months old) were 1.9 and 2.3, respectively. Only 42% of the farms followed predetermined drenching programmes.

Maingi \textit{et al.} (1996a) conducted a questionnaire survey to examine worm control practices on Angora and other goat farms in Denmark and observed that anthelmintics were used in more than 80% of the farms and 51% of the farms, no predetermined drenching programmes were followed. 72% and 64% of the farms, kids were drenched 1-3 times per year, while the adult goats were drenched two or three times per year.
Hoste et al. (2000) conducted a questionnaire survey on the use of antiparasitic drugs in dairy goat farms of France. Information was collected from 73 farms in two main areas of dairy goat production. The data referred to three years. Anthelmintics were used in 69 farms, the mean number of treatments per year being 2.74. Changing the drug from one year to another was not practiced. Moreover, of the 58 farms using two or more treatments per year, only 37% used anthelmintics from different classes in the lactation and drying periods. Benzimidazoles and probenzimidazoles were given in all but two farms and these substances represented more than 80% of all the treatments. Levamisole/pyrantel or avermectins were used in 15% and 27% of the farms, respectively. Double the ovine dose, as recommended in goats to ensure the efficacy of benzimidazoles, was applied in 55% of the farms. In addition, in all the flocks, the substances were given on the basis of a mean estimated live weight and not by reference to the heaviest animal. These results indicate that errors in the use of anthelmintics are still frequent in dairy goat farms in France, with probable consequences for the spread of anthelmintic resistance in the populations of parasites.

Information concerning worm control practices of sheep and goat farmers in the region of Trikala (central Greece) was collected through a questionnaire survey by visiting farms and interviewing farmers. Questionnaires from 57 farmers residing in 23 rural communities were collected. Anthelmintics were used by 89% of the farmers. On average, lambs, kids and goats were treated once annually, while sheep were treated either once or twice annually. Only 2% of farmers
reported treatment of animals with anthelmintics when moving to new pastures. The most common broad-spectrum anthelmintics used were those belonging to the benzimidazoles and probenzimidazoles (Theodoropoulos et al., 2000).

Cernanska et al. (2008) conducted a questionnaire survey to obtain information on worm control practices and sheep management on 49 sheep farms in 2003 and 2004 in Slovakia and observed that mean drenching rate for lambs and yearlings/adults was 1.76 and 1.70, respectively. The most frequently used drugs during period from 1999 to 2004 were albendazole and ivermectin.

Swarnkar and Singh (2010) studied the worm control practices, anthelmintic use and its implication on anthelmintic resistance in GINs of sheep in Rajasthan and observed that lack of knowledge about worm control strategies, anthelmintic use and the problem of anthelmintic resistance among the majority of sheep farms. The existing drench frequency was not justifiable and there was a high opportunity to harvest the benefits of agro-climatic conditions, grazing resources and practices to save money by avoiding unnecessary en-mass treatments in sheep flocks of Rajasthan.

A questionnaire survey was undertaken with 707 sheep farmers in Rajasthan to obtain information on sheep husbandry and worm management practices in order to formulate effective and sustainable strategy that can prolong the life of existing anthelmintics. Majority of farmers were found to use commonly available benzimidazole and imidothiazole groups of anthelmintics without any planned rotational use. A total of 71.5% of farmers were reported to select
anthelmintics either using their own wisdom and experience or on the advice of chemists. The criteria used for dose determination was found faulty. The study indicated lack of knowledge about worm epidemiology, worm control strategies, anthelmintic use and problem of anthelmintic resistance among the majority of sheep farmers in Rajasthan. Use of anthelmintics in flock was dependent on the availability of money and drug in the nearby market and not on the epidemiology of parasites (Swarnkar and Singh, 2010a).

Domke et al. (2011) conducted a questionnaire survey regarding worm control practices in small ruminant flocks in Norway and observed that the mean yearly drenching rate in lambs and ewes were $2.5 \pm 1.7$ and $1.9 \pm 1.1$, respectively, whereas it was 1.0 (once a year) in goats. However, these figures were higher in sheep in the coastal area with a rate of 3.4 and 2.2 in lambs and ewes, respectively. Benzimidazoles were the predominant anthelmintic class used in sheep flocks (64.9% in 2007), whereas benzimidazoles and macrocyclic lactones were both equally used in dairy goat flocks. During 2005-2007, 46.3% of the sheep flocks were never changed the anthelmintic class. The dose and move strategy was practiced in 33.2% of the sheep flocks.

Saddiqi et al. (2012) conducted a questionnaire survey to determine the worm control practices and anthelmintic usage of 150 key respondents involved in sheep and goat production in the arid Thal area of Pakistan and reported that the farmers had the lowest level of knowledge about parasitic infections. They used modern anthelmintics at low frequencies (every six months) following an unusual practice of diluting the medicine.
Regassa et al. (2013) performed a questionnaire survey to gather information on control practices of GINs of small ruminants in Central Oromia, Ethiopia and observed that lack of basic awareness among owners about the correct use and efficacy of anthelmintics. In addition, it indicated that farmers in the study area apply many practices that may lower the efficacy of anthelmintics and favor the emergence of anthelmintic resistance.

Terefe et al. (2013) performed a questionnaire survey in sheep farms at Bedelle District of Oromia Region, Ethiopia, and observed that albendazole was the most commonly used drug followed by tetramisole. All sheep owners responded that they use anthelmintic only when animals show symptoms like poor body condition, diarrhea or coughing. Where the anthelmintic was not prescribed by animal health personnel, most of the respondents indicated that they selected their drug of choice by colour from what was available in the local markets. The survey indicated that farmers prefer green colour/albendazole followed by white/tetramisole, and the difference is statistically significant (P< 0.05). Significantly higher percentage of sheep owners use anthelmintics prescribed by animal health personnel than those who buy them from private drug stores or open markets (P< 0.05). The frequency of treatment with anthelmintics was, on average, twice per year. Significantly higher number of the farmers also indicted that their animals had shown improvements in clinical signs and body condition after AH treatment.
A questionnaire survey conducted in 110 farmers to acquire information about farm management and drenching practices against GINs in dairy goats in northern Italy. It was found that treatments against helminths were performed once annually in 73.63% of the flocks. However, 20.00% of farmers declared that they did not regularly treat their goats every year. Annual treatment usually conducted in autumn or winter. (Zanzani et al., 2014).