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Influence of prevailing weather parameters on population dynamics of gastrointestinal parasites in different geographical regions of Maharashtra

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Abstract
A total 667 goats and 669 sheep faecal samples were randomly collected in every season during the period of October 2017 to September 2018 at Department of Veterinary Parasitology to ascertain the influence of weather parameters on population dynamics of gastrointestinal parasites in different geographical regions of Maharashtra**.** The highest Egg per Gram [EPG] was recorded during monsoon **[**7320±338.23] in sheep and [6060±17.35] in goats during the monsoon season and lowest in summer season [440±120.83] and [600±277.48] respectively in sheep and goat. The severity of GI parasitism in goats and sheep were measured in terms of Egg per Gram [EPG] which showed significant seasonal correlation in all three seasons with rainfall, temperature and relative humidity**.** Ova of *Strongyle* spp, *Strongyloides* spp. *Trichuris* spp, *Paramphistomum* spp. sp. and oocyst of *Eimeria* spp, were found in [50.52%, 29.29%, 11.50%, 2.54%, 20.62%] and [59.22%, 24.28%, 24.28%, 6.44%, 34.18%] in sheep and goats respectively. The other GI parasitic ova/ oocyst in descending order were of *Strongyle* 50.52 percent, *Eimeria* 20.62 percent, *Trichuris* 11.50 percent in sheep and same pattern *Strongyle* 59.22 percent, *Eimeria* 34.18 percent, *Trichuris* 24.28 percent in goats.
Not only seasonal prevalence of GI parasitism in sheep and goats varies significantly during three seasons but also the severity of infection recorded in terms of EPG also shows at par trend of seasonal parameters. The variation in weather parameter also recorded and it was noted that highest rainfall, temperature and humidity were 3028 mm, 39 ^{0}C and 94.37 percent during the study period. Correlation of parasitic load data with meteorological parameters and drawing of prediction models for every year is essential for control the parasitic infection.

Keywords: Gastrointestinal parasites, agro climatic zones, *Strongyle, Eimeria* sp

Introduction
India stands first in goat milk production and second in population having most important goat industry as compare to dairy industry. Also, it contributes 3% share in total meat production of the world. Small ruminants play a vital role in livelihood provisions by providing milk, meat, wool, skin and organic manure to generate cash income and play various roles in rural economy. The production and productivity of meat industry is mainly hampered by internal parasites amongst which, a group of strongyle worm parasites plays a crucial role in overall performance of small ruminants. The prevalence study of gastro-intestinal parasites in small ruminants depends on local agro climatic conditions; such as temperature, humidity, rainfall, grazing pastures and managemental practices. These factors mainly determine the incidence and severity of various parasitic infections in a particular region. (Takelye 1991) [17] The prevalence study covering different parts of country revealed that incidence of strongyle worms in goats and sheep varied from 59 – 94 percent (Balasubramaniam *et al.* 2001, Khajuria and Kapoor 2003, Nasreen *et al.* 2005, Dixit *et al.* 2017 and Brahma *et al.* 2018) [1, 9, 11, 4, 2]. GI parasitism is mainly responsible for stunted growth and increased risk of susceptibility to other diseases. They mainly attack on digestive system and severally damage health of small ruminants by its injurious effects. These economical losses can be minimized by early diagnosis and strategic use of anthelmintic drugs. The detail prevalence study of GI parasitic infections in small ruminants of Maharashtra was not conducted except few sporadic reports from Marathwada and Vidarbha region.

Materials and Methods

Study area

The study area was covered different geographic regions of Maharashtra divided into four regions viz. Western Maharashtra, Vidarbha, Marathwada and Konkan. These regions comprised of eight collection centers [Dahiwadi, Rahuri, Konti, Chandol, Sillod, Jafrabad, Goregaon and Dadade/Alonde]

Faecal sample examination

A total 667 goats and 669 sheep faecal samples were randomly collected in every season during the period of October 2017 to September 2018. The faecal samples were collected per rectally by using protective disposable hand gloves, labeled properly and brought to the laboratory for processing for presence / absence of ova/eggs of gastrointestinal parasites and processed by sedimentation technique in the department of Veterinary Parasitology, Mumbai Veterinary College, Mumbai. In the present study, to estimate the severity faecal egg count egg per gram [EPG] was carried out for those samples which EPG was more than 500 were subjected to the quantitative examination by Stoll's dilution method. The remaining quantity of faeces were pooled together and further used for coproculture at room temperature. The larvae were harvested and used for morphometry identification [Soulsby 1965] [14]. The infected animals were dewormed with available dewormer with the livestock owners. The 7th day post treatment, the faecal samples were collected to note the reduction in faecal egg count and resistance study.

Farmers questionery

The basic information regarding commonly used dewormer and routine managemental practices adopted in respective regions of Maharashtra were noted at the time of collection of samples in the form of questionery prepared for livestock owners.

Meteorological data

Simultaneously, the monthly meteorological data on different weather parameters was procured from different regions of Maharashtra. *viz*. Department of Agro Meteorology of Mahatma Phule Krishi Vidyapeeth, Rahuri, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola**,** Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and Official web site of Department of Agriculture and Horticulture, Government of Maharashtra to study the effect of weather parameters on the population dynamics GI parasitism in small ruminants.

Statistical analysis

The data generated was analyzed statistically using suitable statistical design and online ICAR software.

Results and Discussion

Correlation of data with environment parameters

The environmental data was collected from four different regional agricultural universities situated at different geographical regions viz. 1] Department of Agro Meteorology -MPKV, Rahuri 2] Dr. P.D.K.V. Akola 3] V.N.M.K.V., Parbhani 4] Dr. B.S.K.K.V. Dapoli and 5] Web site Department of Agriculture and Horticulture, Government of Maharashtra for the period October 2017 – September 2018 parameters like minimum and maximum temperature, rainfall, humidity, etc.

The total animals [667 goat & 669 sheep] examined, 83.00% and 68.00% were found positive for GI parasite infections by sedimentation method. Ova of *Strongyle* spp, *Srtongyloid* spp. *Trichuris* spp, *Paramphistomum* spp. sp and oocyst of *Eimeria* spp, were found in [50.52%, 29.29%, 11.50%, 2.54%, 20.62%] and [59.22%, 24.28, 24.28%, 6.44%, 34.18] in sheep and goats respectively. The other GI parasitic ova in descending order were of *Strongyle* 50.52 percent, oocyst of *Eimeria* spp. 20.62 percent, *Trichuris* spp. 11.50 percent in sheep and same pattern strongyle 59.22 percent, oocyst of Eimeria 34.18 percent Trichuris 24.28 percent in goats. [Table No. 4 and 5].

Table 1: Correlation between EPG in Sheep and seasonal meteorological parameters in different agro climatic zones of Maharashtra

Agro climatic zone no.	Agro climatic zone of Maharashtra	Study area (collection center)	Season	EPG Mean ± SE	Total Rain Fall (mm)	Temperature (O^0 C)		Humidity (%)	
						Max.	Min.	Max.	Min.
2	Very high rainfall zone with non lateritic soil	Part of Mumbai Suburban (Goregaon)	Monsoon	7320± 338.23	3028.00	28.87	23.05	94.37	89.46
			Winter	2640± 664.52	159.3	31.83	16.94	94.18	61.52
			Summer	780± 131.90	00	33.01	18.85	92.41	69.73
		Part of Palghar District (Alonde)	Monsoon	4840 ±704.69	3028.00	28.87	23.05	94.37	89.46
			Winter	1480± 488.26	159.3	31.83	16.94	94.18	61.52
			Summer	600 ± 176.06	00	33.01	18.85	92.41	69.73
3	Ghat Zone	Part of Satara District (Dahiwadi)	Monsoon	2760 ± 184.67	289.60	31.51	22.52	73.74	56.29
			Winter	1560 ± 233.66	49.4	30.13	14.35	66.64	38.11
			Summer	920 ±198.49	1.00	36.32	19.05	44.67	20.80
6	Scarcity zone	Part of Ahmednagar District Rahuri)	Monsoon	2680 ± 203.46	289.60	31.51	22.52	73.74	56.29
			Winter	2120 ± 356.93	49.4	30.13	14.35	66.64	38.11
			Summer	960 ± 317.17	1.00	36.32	19.05	44.67	20.80
7	Assured rainfall zone	Part of Aurangabad District (Sillod)	Monsoon	4200±212.13	784.00	29.87	21.65	84.50	59.50
			Winter	3800± 443.84	170.2	30.65	13.42	77.25	35.25
			Summer	2200± 353.55	28.1	38.12	19.75	58.25	19.50
		Part of Jalna District (Jafrabad)	Monsoon	3720±73.48	784.00	29.87	21.65	84.50	59.50
			Winter	3100 ± 209.76	170.2	30.65	13.42	77.25	35.25
			Summer	880 ± 66.33	28.1	38.12	19.75	58.25	19.50
		Part of Buldana Konti	Monsoon	1740 ± 180.55	830.1	32.07	23.95	83.00	58.50
			Winter	1420 ± 222.26	62.00	31.32	14.05	75.50	31.00

		District		Summer	460 ± 163.09	4.9	39.0	22.95	40.75	16.00
			Chandol	Monsoon	2520 ± 753.92	830.1	32.07	23.95	83.00	58.50
				Winter	1260 ± 295.97	62.00	31.32	14.05	75.50	31.00
				Summer	440 ± 120.83	4.9	39.0	22.95	40.75	16.00

Source: **1]** Department of Agro meteorology - M.P.K.V., Rahuri **2]** Dr. P.D.K.V. Akola **3]** V.N.M.K.V., Parbhani **4]** Dr.B.S.K.K.V. Dapoli **5]** Web site Department of Agriculture and Horticulture, Government of Maharashtra

Table 2: Correlation between EPG in **Goat** and seasonal meteorological parameters in different agro climatic zones of Maharashtra

Agro climatic zone no.	Agro climatic zone of Maharashtra	Study area (collection center)		Season	EPG Mean ± SE	Total Rain Fall (mm)	Temperature (O^0 C)		Humidity (%)	
							Max.	Min.	Max.	Min.
2	Very high rainfall zone with non lateritic soil	Part of Mumbai Suburban (Goregaon)		Monsoon	6060 ± 17.35	3028.00	28.87	23.05	94.37	89.46
				Winter	2680 ± 1251.15	159.3	31.83	16.94	94.18	61.52
				Summer	1160 ± 420.23	00	33.01	18.85	92.41	69.73
		Part of Palghar District (Dadade)		Monsoon	5320 ± 1120.44	3028.00	28.87	23.05	94.37	89.46
				Winter	2080 ± 623.21	159.3	31.83	16.94	94.18	61.52
				Summer	660 ±143.52	00	33.01	18.85	92.41	69.73
3	Ghat Zone	Part of Satara District (Dahiwadi)		Monsoon	3420 ± 948.89	289.60	31.51	22.52	73.74	56.29
				Winter	2600 ± 731.43	49.4	30.13	14.35	66.64	38.11
				Summer	1340 ± 342.92	1.00	36.32	19.05	44.67	20.80
6	Scarcity zone	Part of Ahmadnagar District Rahuri)		Monsoon	3680 ± 869.71	289.60	31.51	22.52	73.74	56.29
				Winter	2560 ± 587.87	49.4	30.13	14.35	66.64	38.11
				Summer	680 ± 162.48	1.00	36.32	19.05	44.67	20.80
7	Assured rainfall zone	Part of Aurangabad District (Sillod)		Monsoon	4500 ± 100	784.00	29.87	21.65	84.50	59.50
				Winter	3400± 456.07	170.2	30.65	13.42	77.25	35.25
				Summer	1880± 139.28	28.1	38.12	19.75	58.25	19.50
		Part of Jalna District (Jafrabad)		Monsoon	4400± 1010.44	784.00	29.87	21.65	84.50	59.50
				Winter	3440± 566.21	170.2	30.65	13.42	77.25	35.25
				Summer	2900± 639.53	28.1	38.12	19.75	58.25	19.50
		Part of Buldana District	Konti	Monsoon	3460 ± 1521.38	830.1	32.07	23.95	83.00	58.50
				Winter	1860 ± 680.14	62.00	31.32	14.05	75.50	31.00
				Summer	780 ± 381.31	4.9	39.0	22.95	40.75	16.00
			Chandol	Monsoon	3560 ± 1789.58	830.1	32.07	23.95	83.00	58.50
				Winter	1980 ± 640.82	62.00	31.32	14.05	75.50	31.00
				Summer	600 ± 277.48	4.9	39.0	22.95	40.75	16.00

Source: **1]** Department of Agro meteorology - M.P.K.V., Rahuri **2]** Dr. P.D.K.V. Akola **3]** V.N.M.K.V., Parbhani **4]** Dr. B.S.K.K.V. Dapoli **5]** Web Site Department of Agriculture and Horticulture, Government of Maharashtra

Table 3: Overall region wise prevalence of G.I. parasites of in small ruminants of Maharashtra

Species	Name of Region	No. of Animals Examined	Found positive	Percentage	χ^2 1%
Goat	West. Maharashtra	161	141	87.57	20.09**
	Vidarbha	151	115	76.15	
	Marathwada	165	106	64.24	
	Konkan	190	136	71.57	
	Overall	667	498	74.66	
Sheep	West, Maharashtra	181	127	70.16	20.09**
	Vidarbha	152	86	56.57	
	Marathwada	186	124	66.66	
	Konkan	150	77	51.33	
	Overall	669	414	61.88	

**Indicate significant difference at 1% level.

Table 4: Overall species wise prevalence of G.I. parasites of Goat in Maharashtra

Sr. No.	Name of parasites	Total animals examined	Positive animals	Percentage	χ^2
1	*Strongyle* sp.	667	395	59.22	11.35**
2	*Strongyloides* sp	667	162	24.28	
3	*Trichuris* sp	667	162	24.28	
4	*Paramphistomum spp.* sp	667	43	6.44	
5	*Eimeria* sp	667	228	34.18	

**Indicate significant difference at 1% level.

Table 5: Overall species wise prevalence of G.I. parasites of Sheep in Maharashtra

Sr. No.	Name of parasites	Total animals examined	Positive animals	Percentage	χ^2
1	*Strongyle* sp.	669	338	50.52	16.81**
2	*Strongyloides* sp.	669	196	29.29	
3	*Trichuris* sp.	669	77	11.50	
4	*Paramphistomum spp.*	669	17	2.54	

5	*Eimeria* sp	669	138	20.62	

**Indicate significant difference at 1% level.

Table 6: Seasonal prevalence of G.I. Parasites in goats of Maharashtra

Sr. No.	Season	No. of Animals Examined	Found Positive	Percentage	X^2
1	Winter	201	132	65.67	16.81**
2	Summer	220	150	68.18	
3	Monsoon	246	216	87.80	
Overall		667	498	74.66	

**Indicate significant difference at 1% level.

Table 7: Seasonal prevalence of G.I. Parasites in sheep of Maharashtra

Sr. No.	Season	No. of Animals screen	Found Positive	Percentage	X^2
1	Winter	203	77	37.93	16.81
2	Summer	251	163	64.94	
3	Monsoon	215	174	80.93	
Overall		669	414	61.88	

**Indicate significant difference at 1% level.

Seasonal prevalence

The seasonal prevalence of GI parasites showed higher in monsoon season followed by winter season and least in summer season. In the present study lowest prevalence was observed from February to the end of summer season indicates clearly that the environmental data of the summer season was unfavorable for the survival and development of GI parasites.

The infection pattern in goat recorded highest in Western Maharashtra 87.57 percent and lower in Marathwada region 64.24. Indicating overall infection throughout the year was 74.66 percent. In sheep, also shown slight lower infection as compare to goat with highest in Western Maharashtra 70.16 percent and lowest in Konkan 51.33 percent indicating average 61.88 percent throughout the year. [Table -3] The pattern of infection of GI parasites found in summer season was due to accumulation of parasite infection from previous season [Sutar *et al.* 2011] [16] similar findings were recorded from Sutar *et al.* [2010] [15] in goats, in Ahmednagar, Palampalle *et al.* [2002] [12] in sheep and goat at Marathwada region and Kharjuia *et al.* [2013] [10] in Jammu province in Sheep and goats and Balasubramaniam *et al.* [2001] [1] of Tamil Nadu.

In the present study no significant difference was found in the infection pattern of sheep and goat. The reason might be that the faecal samples were collected from the sheep & goat of shepherds having mixed flock population. Grazing patterns, watering and managemental practices followed by these shepherds are most similar for both species of animals. The grazing pasture, types of housing and watering places were shared by these animals and that could be an important risk factor responsible for similar pattern of infections in sheep and goats. [Khajuria *et al.* 2013] [10], Significantly [P>0.05] higher GIP infections 7.85% and significantly [P>0.01] higher in goat 74.66 percent and 61.88 percent in sheep were observed. In rainy season as compared to summer in sheep 80.93 percent and 64.94 percent were found positive respectively. The least in winter season 37.93 percent in sheep and least in 65.67 percent in sheep and goat respectively.

However, the difference was non significant between winter and summer, higher the rainfall during rainy season provides favorable morality for salt in soil which is an important for ecdysis. It also helps for larval dispersion on grazing pasture and increases the chances of contact period between infective larva and host. Higher rainfall and temp causes stress to the host which decreases its immunity and predisposes it to the heavy infection Katoch *et al.* [1998] [7], Yadav *et al.* [2006] [18].

Correlation between EPG and seasonal meteorological parameters

The quantitative analysis of faecal samples of goat and sheep were performed in 3 different seasons of four agro climatic zones of Maharashtra. It revealed that highest EPG [7320± 338.23] in sheep and [6060±13.35] in goats during the monsoon season and lowest in summer season [440±120.83] and [600±277.48] respectively in sheep and goats. When compared collection centre wise, the lowest EPG of sheep [440±120.83] was found in Chandol of Buldana district and highest [7320±338.23] in Sillod of Aurangabad district. Two peaks of EPG count wave recorded in monsoon of Sillod and Goregaon (Mumbai sub urban area) in sheep and goat respectively. [Table No. 1,2 and7]

Highest EPG during rainy season could be attributed by many other factors. Majority of these shepherds graze on pasture land near water bodies and partially intensive rearing method. The adult animals showing highest percentage of infection might be due to lowering the innate immunity. This is noted as disadvantage by the infective stage of GI nematodes during this season. Katoch *et al.* [1999] [8], Jitendran, [1998] [6], Devina *et al.* [2007] [3], Singh *et al.* [2018] [13] [Table No. 1&2]

As the environmental temperature hike from March, the over winter larvae start moulting and became infective. In summer season [February – May] GI infections leads to low shedding of eggs of GI nematodes thereby decreasing the pasture infectivity leading to lowering the egg per gram [EPG] during summer season. The level of EPG in sheep [7320± 338.23 to 440±120.83] and in goat EPG [6060±17.35 to 600±277.48] and infection in sheep 37.93 percent and goat 65.67 percent during winter season could be due to the adverse climatic condition and hypobiotic nature of worms which helps in arrested development in environment and host. [Hutchinson *et al* 1972] [5]. In addition to long period in summer reduces grazing period and helps in decreasing the chance of contact between the parasite and host. Most of the ewes during the summer period are pregnant and hormonal impact results in reducing the EPG count and contribute to the less avaibility of GI infections in grazing pastures as reported earlier from various workers of country. In the present study there is drastic variation in EPG count along with intensity of GI parasites in agro climatic zones and collection centers might

be due to large geographical area within the particular region. [Table No. 1, 2 and 7].

Conclusion

In the present study, it is concluded that the small ruminants harboured GI parasitic worm burden in normal health condition without any visible clinical symptoms shown by infected animals. The overall GI parasites found 74.66 percent and 61.88% in goat and sheep respectively. Further the *Strongyle* spp. and *Strongyloide* spp. group of worm were predominantly observed all over the Maharashtra. The increase in rainfall and humidity in these different agro climatic zones are important factors for survivability GI nematode eggs which increase possibility of host infection. The present study data evident that from June to September sheep and goats were most vulnerable to GI parasitic infection correlation of season wise prevalence of GI parasites in small ruminants with meteorological parameters in different agro climatic zones of Maharashtra revealed that minimum temperature and required humidity are determinants of environment required for prevalence of infection of larvae in the sheep and goats. Thus the minimum temperature and humidity are the important determinants factors in deciding the prevalence of parasitic infection in small ruminants in different agro climatic zones of Maharashtra. The sheep and goat needs broad spectrum anthelmintics treatment at least thrice a year, once in June to July and second in October to November and last February to March that might minimize the GI parasitism and enhance the optimum productivity of small ruminants of Maharashtra state.

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