Haryana Vet. (June, 2021) **60(1),** 81-85

Research Article

ROLE OF BIOCLIMATOGRAPHS IN FORECASTING STRONGYLE INFECTIONS IN GOATS OF MAHAKOUSHAL REGION, MADHYA PRADESH, INDIA

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Received: 17.09.2020; Accepted: 17.02.2021

ABSTRACT

The present study was designed to observe the role of bioclimatographs in forecasting the translation of nematode parasites in goats of Mahakoushal region, Madhya Pradesh. The bioclimatographs were useful for predicting the particular periods that are suitable for translation of exogenous stages of nematode parasite in environment with resultant peak of infection found in host. The average RH (relative humidity) was plotted against average maximum and minimum temperatures of each and the resultant points were joined by a closed curve. The limits of climatic condition most suitable for survival, development and dissemination of pre infective stages of gastrointestinal nematodes, indicated by lines, were superimposed on these graphs. The biology of parasite and integration of climate in the form of bioclimatographs, strengthen the idea for combating the menace caused by gastrointestinal nematodes in goats.

Keywords: Bioclimatograph, Goat, Madhya Pradesh, Nematode, Strongyle

How to cite: Singh, A.K. and Das, G. (2021). Role of bioclimatographs in forecasting strongyle infections in goats of Mahakoushal region, Madhya Pradesh, India. *Haryana Vet.* **60(1)**: 81-85.

Goats represent about 27.79 per cent of the total livestock population in the country (Livestock census, 2019). Various helminthic diseases are responsible for causing heavy losses due to reduced production, morbidity and mortality in goats. Conventional parasite control practices such as mass deworming of flock in presence of any kind of disease, without consideration of prevalent species, improper dose rate of drug, wrong choice of drug, frequent use of anthelmintic treatments in health camps have aggravated the problem of anthelmintic resistance, not only in India but throughout the world (Lloyd *et al.*, 2000; Swarnkar *et al.*, 2003). Under such conditions, environment plays a major role for survival, development and disseminating the free living stage of strongyles throughout year. The knowledge of climatic conditions and its impact on life cycle of parasite is crucial for designing the management programme, minimal use of anthelmintic and avoid the development of resistance as much as possible. Bioclimatographs give the valuable information in predicting the general pattern of parasitism to be found in particular locality. The present study was designed to observe the role of bioclimatographs in forecasting the propagation of different nematode parasites (Swarnkar and Singh, 2011) found in host and environment for reducing anthelmintic use for worm control strategies.

MATERIALS AND METHODS

Madhya Pradesh is called heart of India and it is situated between 17 to 25 °N latitude and 72 to 85 °E longitudes. Jabalpur Tehsil of Madhya Pradesh, where the present study was undertaken, is situated at 23.17 °N latitude and 79.57 °E longitude at 410.87 MSL (meters above sea level). The suitable temperature for the development of exogenous stages is 18 to 37 °C for *H. contortus*, 18-39 °C for *Oesophagostomum* and 6 to 20 °C for *Trichostrongylus* spp. (Levine, 1963).

Preparation of bioclimatograph: To prepare bioclimatograph, meteorological data *viz.* maximum (max.) and minimum (min.) temperature, total rainfall and average relative humidity were essential. The following metrological data was collected from the Regional Meteorological Department, Government of India (GOI), Nagpur. The epidemiology of parasites in goats, on pasture and their complex inter-relationship with climate was established by preparing bioclimatograph for Madhya Pradesh. This will help in future prediction and to visualize the effect of temperature, rainfall and relative humidity with favourable conditions for development and survival of *Haemonchus contortus* and *Oesophagostomum*, in which total monthly rainfall was plotted against the maximum and minimum temperature of each month. For *Haemonchus contortus* and *Oesophagostomum*, further average RH (relative humidity) was plotted against average maximum and minimum temperature of each month and the resultant points were joined by a closed curve. The limits of climatic condition most suitable for survival, development and dissemination of pre infective stages of gastrointestinal nematodes, indicated by lines, were superimposed on these graphs.

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The limits of suitable climatic condition based on available literature (Levine, 1963) were taken as total monthly rainfall (TRF) to the tune of 50 mm or more with average monthly maximum temperature (T_{max}) and minimum temperature (T_{min}) ranging from 18 °C to 37 °C for *H. contortus* and *Oesophagostomum* spp. Same rainfall with temperature ranging from 6 °C to 20 °C for *Trichostrongylus* spp. is used. The RH was considered >50% for optimum development of parasites. The bioclimatograph for Madhya Pradesh are depleted. The resultant bioclimatograph were compared with the real time incidence and intensity of the GI nematodes.

RESULTS AND DISCUSSION

The Meteorological data pertaining to average maximum temperature (T_{max}), minimum temperature (T_{min}), total monthly rainfall (TRF) and average relative humidity (RH) were obtained from the Regional Meteorological Centre, Government of India, Nagpur for the period April 2011 to March 2012.

The average monthly T_{max} ranges from 23.6 °C (January) to 39.4 °C (May) and average monthly T_{min} range from 11.7 °C (January) to 23.8 °C (May) in Chhindwara district. Total monthly rainfall (TRF) was high during the rainy season in the month of June to September with the highest TRF in the month of July (396.6 mm). The average humidity was highest in the month of September (87.63) and lowest in May (30.85).

In Balaghat district, the average monthly T_{max} ranged from 23 °C (January) to 40.1 °C (May). The average monthly T_{min} ranged from 9.3 °C (January) to 23.8 °C (June). Total monthly rainfall (TRF) was high during the rainy season in the month of June to September with the highest TRF in the month of August (403.3 mm). The average humidity was highest in the month of August (88.9) and lowest in May (31.95).

In Narsinghpur district, the average monthly T_{max} range from 20 °C (January) to 41.64 °C (May) and the average monthly T_{min} range from 8.6 °C (January) to 24.4 °C (May). The highest TRF was recorded in the month of July (389 mm). The average humidity was highest in the month of September (79.38) and lowest in May (43.06).

The epidemiology of parasites in goats, on pasture and their complex interrelationship with climate was established by preparing bioclimatograph. The resultant bioclimatographs were compared with the real time incidence and intensity of the GI nematodes (Fig. 1-9).

As per bioclimatograph, suitable months for survival and development of *Haemonchus* larvae were April, June to September and January in Balaghat district and June to September and January in Narsinghpur and Chhindwara districts on the basis of average monthly T_{max} and total monthly rainfall. In the present study, higher incidence and intensity of Strongyle infection was recorded in the month of July to October in the entire three districts (Table 1).

According to bioclimatograph, suitable period for survival and development of *Trichostrongylus* larvae in the environmental was Jan- Feb, Oct- Feb and Nov- Feb in Balaghat, Narsinghpur and Chhindwara district, respectively. The higher incidence of *Trichostongylus* in animal was recorded in the month of Nov- Feb, in all three districts (Table 2).

Favourable months for *Oesophagostomum* larvae was April-June and Jan in Balaghat district, whereas June-Sept and Jan in Narsighpur and Chhindwara district. Higher incidence was recorded in the month of July to Oct in all three districts (Table 3).

Table 1

Comparative prediction and testing of different bioclimatograph for *Haemonchus* spp. in goat

District	Parameters of bioclimatograph	Favourable months as per bioclimatograph	Months of high prevalence	Months of high intensity
Balaghat	T_{max} v/s TRF	Apr, June - Sept, Jan	July-Oct	July - Oct
	T_{min} v/s TRF	Apr, June - Sept		
	T_{max} v/s RH	June - Feb		
	T_{min} v/s RH	June - Dec		
Narsinghpur	T_{max} v/s TRF	June - Sept, Jan	July-Oct	July - Oct
	T_{min} v/s TRF	June - Sept		
	T_{max} v/s RH	June - Feb		
	T_{min} v/s RH	June - Aug		
Chhindwara	T_{max} v/s TRF	June - Sept, Jan	July-Oct	July - Oct
	T_{min} v/s TRF	June - Sept		
	T_{max} v/s RH	June - Feb		
	T_{min} v/s RH	June - Oct		

Table 2

Comparative prediction and testing of different bioclimatograph for *Trichostrongylus* spp. in goat

District	Parameters of bioclimatograph	Favourable months as per bioclimatograph	Months of high prevalence
Balaghat	T_{max} v/s TRF	Nil	Nov-Feb
	T_{min} v/s TRF	Jan	
	T_{max} v/s RH	Jan	
	T_{min} v/s RH	Jan-Feb	
Narsinghpur	T_{max} v/s TRF	Jan	Nov-Feb
	T_{min} v/s TRF	Aug-Sept, Jan	
	T_{max} v/s RH	Jan	
	T_{min} v/s RH	Oct-Feb	
Chhindwara	T_{max} v/s TRF	Nil	Nov-Feb
	T_{min} v/s TRF	Jan	
	T_{max} v/s RH	Nil	
	T_{min} v/s RH	Nov-Feb	

Table 3

Comparative prediction and testing of different bioclimatograph for *Oesophagostomum* spp. in goat

District	Parameters of bioclimatograph	Favourable months as per bioclimatograph	Months of high prevalence
Balaghat	T_{max} v/s TRF	Apr, June - Sept, Jan	July -Oct
	T_{min} v/s TRF	Apr, June - Sept	
	T_{max} v/s RH	June - Feb	
	T_{min} v/s RH	June - Dec	
Narsinghpur	T_{max} v/s TRF	June - Sept, Jan	July -Oct
	T_{min} v/s TRF	June - Sept	
	T_{max} v/s RH	June - Feb	
	T_{min} v/s RH	June - Aug	
Chhindwara	T_{max} v/s TRF	June - Sept, Jan	July -Oct
	T_{min} v/s TRF	June - Sept	
	T_{max} v/s RH	June - Feb	
	T_{min} v/s RH	June - Oct	

Bioclimatographs explain the distribution and time of larval nematodes on pasture and utilize climatic factor to observe important features of epidemiology of helminthic parasites. Earlier similar study was done in sheep (Swarnkar and Singh, 2011). As such, there are no reports for goats from India particularly from studied area or state. The prediction of favourable period for translation of *H. contortus*, bioclimatographs were prepared based on the data of climate and is depicted in Fig. 1 to 3. Bioclimatograph is prepared based on data of period from April 2011 to March 2012, the said period in which climatic conditions were suitable for survival, development and dissemination of exogenous stages of *H. contortus*, from April, June to September and January in Balaghat district, June to September and January in Narsinghpur and Chhindwara district. The bioclimatograph prepared was partially in agreement with real-time observations made for incidence and intensity of *H. contortus* in goat as well as translation and availability of exogenous stages on pasture in all three districts of M.P. However, there were minor variations between predicted and observed responses when compared with real time incidence (Swarnkar and Singh, 2011). Earlier, climatographs were used to observe the effect of temperature and precipitation on survival and development of nematode parasites (Gordon, 1948) where total graph was plotted against the maximum temperature and resultant points were joined by a closed curve. The superimposed lines indicating the limits of climatic conditions and most favourable for free living stages of nematodes and it may be compared with the resultant bioclimatographs with the known incidence of parasites in different places. In the life cycle of Strongylid larvae, exogenous phase involves development of infective larvae under favourable climatic conditions and hypobiosis of

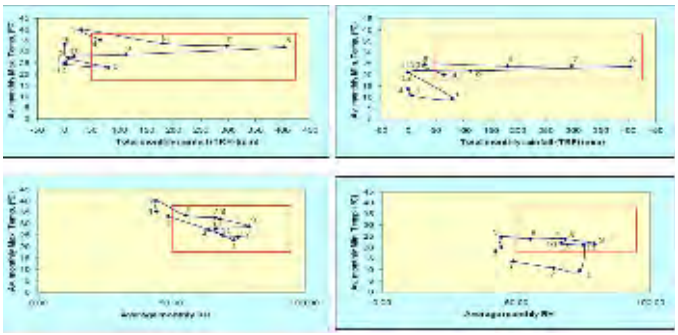

Fig. 1. Bioclimatograph in relation to the epidemiology of *Haemonchus* sp. in Balaghat district of M.P.

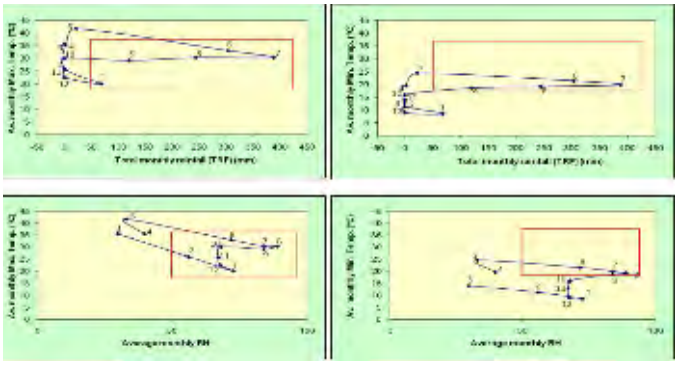

Fig. 2. Bioclimatograph in relation to the epidemiology of *Haemonchus* sp. in Narsinghpur district of M.P.

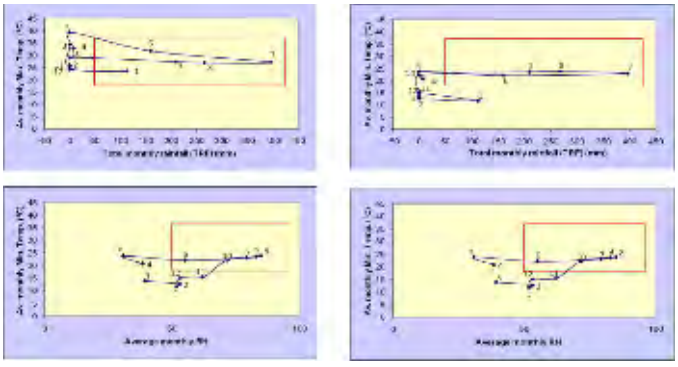

Fig. 3. Bioclimatograph in relation to the epidemiology of *Haemonchus* sp. in Chhindwara district of M.P.

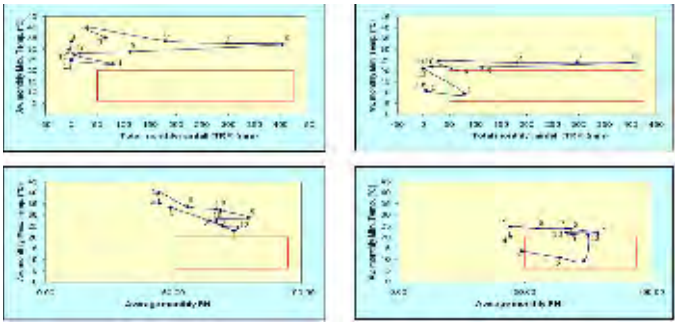

Fig. 4. Bioclimatograph in relation to the epidemiology of *Trichostronglylus* sp. in Balaghat district of M.P.

infective larvae under unfavourable climatic conditions. Temperature and moisture influence the free living stages of strongyle worms (O'Conner *et al.*, 2006), low temperatures inhibit the development, where availability of moisture and temperature becomes more important (Berbigier *et al.*, 1990). The summer season is critical for

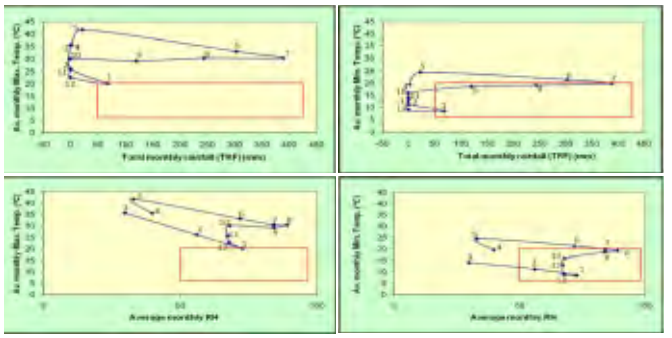

Fig. 5. Bioclimatograph in relation to the epidemiology of *Trichostronglylus* sp. in Narsinghpur district of M.P.

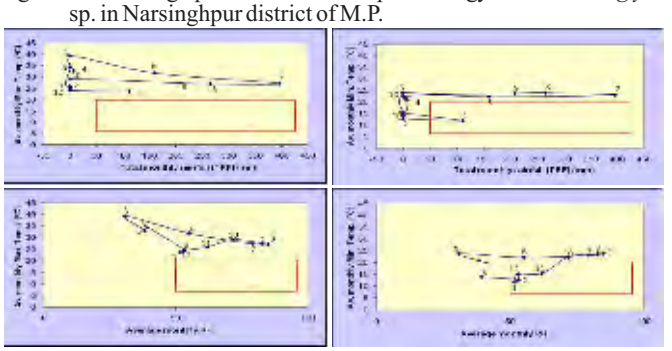

Fig. 6. Bioclimatograph in relation to the epidemiology of *Trichostronglylus* sp. in Chhindwara district of M.P.

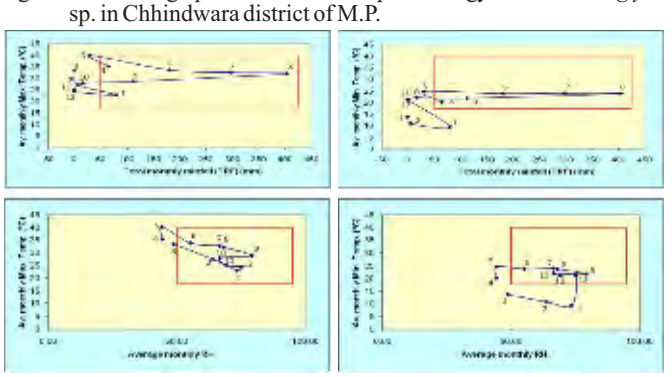

Fig. 7. Bioclimatograph in relation to the epidemiology of *Oesophagostomum* sp. in Balaghat district of M.P.

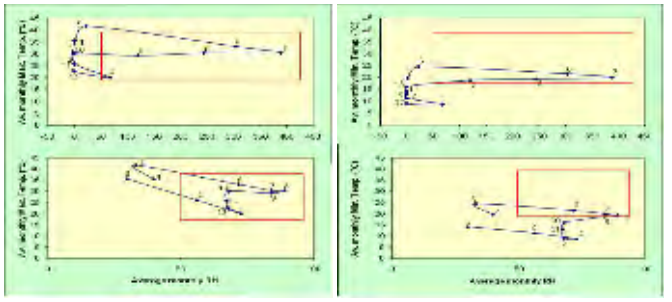

Fig. 8. Bioclimatograph in relation to the epidemiology of *Oesophagostomum* sp. in Narsinghpur district of M.P.

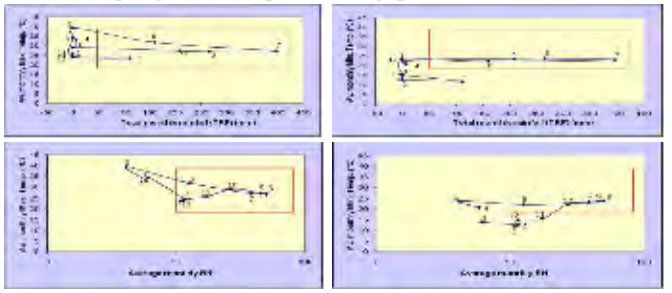

Fig. 9. Bioclimatograph in relation to the epidemiology of *Oesophagostomum* sp. in Chhindwara district of M.P.

larval translation (Nielsen *et al.*, 2007). *Haemonchus* was predominant parasite among all three worms. It causes anaemia, emaciation, weakness and ultimately death in severe conditions. Others are not much harmful as compared to *Haemonchus*. The larvae of *Haemonchus* are more resistant and require high temperature and adequate rainfall for optimum survival, cool moist climate for intermediate survival and no survival or minimum took place either in warm, dry season or in cool, dry weather (O'Conner *et al.*, 2008). Once worm reaches its infective stage, the impact of temperature and moisture on survival are less important, resulting survival times under conditions are lethal to pre infective stages (O'Conner *et al.*, 2008). The developmental process of free living is expressed as the time taken for freshly laid eggs to turn into infective larval stage. The grazing pattern and success rate of development is used to predict the timing and extent of pasture infectivity; hence it provides key factor for grazing as well as deworming strategies. Some limitations are found in the bioclimatographs because it is based on average conditions of weather over a period of years and since the weather may vary from year to year. Borthakur and Das (2005) prepared bioclimatograph of Guwahati for *Haemonchus* spp. to forecast haemonchosis in large ruminants (cattle) and reported that for making an acurate bioclimatograph, a detail study of vegetation, drainage, soil type, irrigation etc. are also needed of environmental temperature and precipitation for a period of at least 3-5 years (Soulsby, 1982). Thus biology of parasite and integration of climate in the form of bioclimatographs, strengthen the idea for combating the menace caused by gastrointestinal parasites in goats.

CONCLUSIONS

The preparation of bioclimatographs in forecasting of strongyle infection is helpful for predicting/ forecasting model for helminths infection in Madhya Pradesh. The limits of suitable climatic condition were total monthly rainfall (TRF) to the tune of 50 mm or more with average monthly maximum temperature (T_{max}) ranging from 18 to 37 °C for *H. contortus* and 18-39 °C for *Oesophagostomum*. Whereas, the RH to the tune of >50% with average monthly minimum temperature (T_{min}) ranging from 6 to 20 °C for *Trichostrongylus* sp.

ACKNOWLEDGEMENT

The authors are highly thankful to the Dean, College of Veterinary Science and Animal Husbandry (NDVSU), Jabalpur and "All India Network Programme on Gastrointestinal Parasitism" (ICAR) for providing the necessary facilities required for conducting research work.

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