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Population Dynamics of some nematode parasites of *Periplaneta americana* of Meerut region

12

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.Abstract

Patterns in the population dynamics of nematodes are determined by the intrinsic characteristics that regulate rates of births and deaths of individuals and modified by conditions of the environment in which the population functions. The weather parameters such as rainfall, relative humidity and temperature have influence on the persistence of entomopathogenic nematodes. Some species can survive temperatures constantly below freezing point while other live in the water of hot springs and still others can withstand complete dryness on the surface of rocks during hot summers reviving again with the onset of the raining season. Soil, the natural habitat for entomopathogenic nematodes varies greatly in chemical composition and physical structure. It is a dynamic system in continual state of flux combined within its physical, biological and chemical complexity. Nematode population dynamics are density dependent and are influenced by host growth, the reproductive potential of the species and by various environmental factors. Consequently, modelling nematode population dynamics is an equally impressive science. This study aims to investigate frequency, abundance, and seasonal distribution of nematode parasites of Periplaneta americana to determine population peaks and includes the application of statistical methods for analysis of data. Seasonal variation in environmental factors such as temperature and humidity has been correlated with occurrence of parasites and analyzed statistically.

Keywords- *Nematode parasites, Incidence%, Index of infestation, Dominant%.*

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Few workers have studied the significance of the life history and ecological factors to differing levels of parasitism in the insect-nematode system. Nadakal and Nayar (1968) studied the rate of infection of nematodes in insects in relation to different factors. Lee (1960) and Gordoa (1970) studied their morphology and physiology. Peregrine (1974 and 1974) investigated host dietary factors in relation to the co-existence of Thelastomatid nematodes in *Periplaneta americana.* Hominick and Davey (1972, 1972, 1973, and 1975) investigated host factors such as age, nutrition, space, and niches. Statistical survey and ecological studies of cockroaches and their nematode parasites have been carried out by Hominick and Davey (1972), Kharul Anuar and Rodzoh (1978) and Mc callister (1988). Mathur and Khera (1989) studied the influence of host stage and sex on the size and composition of nematode parasites in *P. americana.* Studies on population dynamics on nematodes have been concluded by some workers. Dobson (1989) studied the population ecology of parasitic helminthes in animal population. Jairajpuri (1986) studied the richness of species and the variety of their form and habitat suggest that they are comparatively recent in origin and a dynamically develop group of animals. The weather parameters such as temperature, rainfall, humidity and relative humidity have influence on the persistence of entomopathogenic nematodes. Until the mid 1970s it was believed that temperature and moisture were dominant meteorological factors determining diseases outbreaks. Curiously, this area of Parasitology has been relatively neglected for the last ten to fifteen years (Dobson and Carper 1992). There are very few reports on population dynamics of insect parasitic nematodes in general and *P.americana* in particular. The studies related to the population dynamics and seasonal occurrence of nematodes is confined mostly to plant parasitic and other groups. Thus, with a view to have an idea on the occurrence of insect parasitic nematodes in relation to prevailing environmental conditions the present study has been carried out.

Materials and Methods

During course of morphological and taxonomical investigations of insect parasitic nematodes of economically important insect *Periplaneta americana* L., periodical observations were made to evaluate population dynamics and seasonal occurrence of the parasitic nematodes. Parasites were collected by a thorough examination of the insects alimentary canal and the whole body observed made under Stereoscopic binocular microscope/ Motic microscope/ Bioplan microscope for the

presence of parasites. The adult nematode parasites were counted as a whole as well as genus wise, collected and preserved by the method of Soota (1980). A thorough record of the data comprising the number of host specimens examined, number of host specimens infected and the number of parasites found was maintained for three different annual cycle *i.e.*, from December 2006 to November 2009. The data of temperature and humidity were obtained from daily newspapers as well as from the laboratory and field. To study the aspects of population dynamics the data gathered during the infestation were analyzed for several parameters like Incidence percentage, Intensity, Density, Index of investigation and Dominant percentage with the help of following formulae as given by Tenora and Zejda (1974).

$$\text{Incidence \%} = \frac{\text{No. of host infected}}{\text{No. of host examined}} \times 100$$

$$\text{Intensity} = \frac{\text{Worm burden of a particular species}}{\text{No. of host infected with it}}$$

$$\frac{\text{Worm burden of a particular species}}{\text{Total no. of host examined}}$$

Index of Infestation $= Z = (A \times B)/C^2$

This observation was recorded month wise and season wise

Where A=Number of parasites
B= Number of host found infected with it and
C= Number of host examined.

$$\text{Dominant \%} = \frac{\text{Worm burden monthly}}{\text{Worm burden annually}} \times 100$$

Statistical analysis was carried out with the help of computer aided software to study the correlation between seasonal variations in nematode populations and environmental factors like temperature (maximum and minimum) and relative humidity (maximum and minimum) for determining the relationship between prevailing environmental factors and population density of insect parasitic nematodes. Entire data collected from different seasons of the years were anclysed and reprresented graphically.

Results

During the present study, the evaluation of population dynamics and seasonal occurrence of insect parasitic nematodes in the host, *P. americana* was observed. The parasites were *Hammerschmidtiella indicus* Singh and Malti, 2003, male and female, *Leidynema appendiculata* (Leidy, 1850) Chitwood, 1932, male and female, *Schwenkiella icemi* (Schwenk, 1926) Basir, 1956, male and female, *Thelastoma alii* Farooqui, 1970, male and female. . Since host, *P. americana* it was easily available and found all throughout the year., regular data on the rate of information and population dynamics of the nematode parasites infecting *P. americana.* was easily mentioned month wise and season wise. The data of population of nematode parasites of *P. americana* was recorded

from December, 2006 to November, 2009. The annual records of nematode parasites from December, 2006 to November, 2007 (Table 1); December 2007 to November, 2008 (Table 2) and December, 2008 to December, 2009 (Table 3).

In all, five parameter were selected to calculate the rate of infection of nematodes and simultaneously statistical analysis were also made. The results were showed through graphs. Parameters taken:

1) ***Incidence %***: From December, 2006 to November, 2009 highest incidence percentage is 100% recorded in March 2007, March 2008, July 2008, February 2009, July 2009 and August 2009 and lowest is 22.22% recorded in September 2008. (Fig. 1).

2) ***Index of infestation:*** Maximum index of infestation is 10.45 in August 2009 and minimum is 0.18 in January 2009. (Fig. 2).

3) ***Density:*** Highest density is recorded in August 2007 *i.e.*, 10.71 and lowest is in January 2009 *i.e.*, 0.67. (Fig. 3).

4) ***Intensity:*** Maximum intensity is calculated 12.50 in August 2007 and lowest is 2.40 in October 2008. (Fig. 4).

5) ***Dominant %***: Highest dominant % is 21.43 in August 2007 and lowest is 1.42 in January 2007. (Fig. 5).

It was observed that in month of August 2007 and 2009 had highest values of all parameters and in January 2009 have lowest two parameters *i.e.*, index of infestation and density and October 2008 has lowest intensity, September 2008 has lowest incidence percentage and January 2007 had lowest Dominant percentage. I have taken four kinds of season in a year winter, summer, monsoon and post-monsoon and five parameters were calculated.

1) ***Incidence %***: All the three year data exhibited highest incidence between 80-100% in monsoon months. Whereas in winter, summer and post monsoon it ranges between 58-70% (Fig. 6).

2) ***Index of infestation:*** Overall index of infestation was found low in year 2007-2008 *i.e.*, 0.89 and highest index of infestation was also noticed in summer months of year 2007-2008 which is 9.00. For other seasons of the year it ranged between 1-7.21. (Fig. 7).

3) ***Density:*** Highest density is 8.61 in monsoon season and lowest is 1.67 in post-monsoon season. (Fig. 8).

4) ***Intensity:*** Highest calculated intensity in season of monsoon of year December 2006 to November 2007 *i.e.*, 10.33 and lowest is in season of post monsoon of year December 2007 to November 2008 *i.e.*, 3.13 (Fig. 9).

5) ***Dominant %***: Maximum dominant % of nematodes parasites is 50.00 in monsoon season of year December 2007 to November 2008 and

minimum of year December 2007 to November 2008 *i.e.,* 10.55. (Fig. 10).

It was observed that in monsoon season, worm burden is high and in winter season worm burden is low. Monsoon season had highest incidence % (93.55 %, Table 6); density (8.61, Table 4); intensity (10.33, Table 4) and dominant % (50.00, Table 5), summer had highest index of infestation (9.00, Table Table 5). Investigator has maintained (two climatological parameters *i.e.,* temperature and humidity) for correlation in respect of rate of infection of nematode parasites of *P. americana.* It shows the average Maximum and Minimum temperature and humidity month wise from December 2006 to November 2009(fig. 11,12). Correlation of maximum and minimum humidity in relation to incidence % and index of infestation as described in Table 7. It was observed that found that from December 2006 to November 2009 correlation is negative for incidence % v/s maximum. Humidity (*i.e.,* -0.13%, -0.26 and -0.12) respectively and it also negative in case of incidence % v/s minimum. Humidity in December 2006 to November 2007 (*i.e.,* -0.22) and positive from December 2007 to November 2009 (*i.e.,* 0.02 and 0.21) respectively. Index of infestation v/s maximum humidity in year December, 2006 to November, 2007 is negative (*i.e.,* -0.02) and it is positive from December 2007 to November 2009 (*i.e.,* 0.14 & 0.02) respectively. Index of infestation v/s minimum humidity is negative in year December, 2006 to November, 2007 (*i.e.,* -0.09) and positive from December, 2007 to November, 2009 (*i.e.,* 0.09 & 0.025) respectively. In Table 8 temperature is taken as second climatological parameter to find out the correlation of nematode parasites infecting *P. americana,* In this table all the values are positive. Highest incidence % v/s maximum temperature is 0.33 continuously for two years from December 2007 to November 2009 and lowest is 0.09 in December 2006 to November 2007. Correlation between the incidence % v/s minimum temperatures is highest in year December 2006 to November 2007 is 0.42 and lowest in year December 2007 to November 2008 is 0.24. While correlation between the index of infestation v/s maximum temperature is 0.502 in year December 2007 to November 2008 and lowest is 0.08 in year December 2006 to November 2007.

Index of infestation v/s minimum temperature is maximum in year December, 2008 to November 2009 *i.e.,* 0.43 and minimum in year December 2007 to November 2008 *i.e.,* 0.05.

Discussion

Nematode population dynamics and density dependent and are influenced by host growth, the reproductive

potential of the species and by various environmental factors. Consequently modelling nematode population dynamics is an equally impressive science (Trudgill and Phillips, 1997). Parasites species diversity is a direct function of host density and the relative abundance of each parasites species is determined more by the parasite's life history attributes that determine its transmission success than by interactions with other parasite species (Dobson, 1986 and 1989). The changes in host density due to changes in meteorological conditions will be crucial in determining the diversity of the community of parasite supported by the hosts.

Increase in the density of some hosts will allow them to support a more diverse parasite fauna, while decrease in the density of other hosts will reduce the diversity of their parasites community. Prasad *et.al.*, (2001) found the extremes of the weather parameters like rainfall, relative humidity and soil temperature are the major limiting factors affecting their persistence. Inter and intraspecific competition usually occurs among of parasites. According to Welch (1963) intraspecific competition generally results in a decrease in parasite size with an increase in parasite number, as in allantonematoides. The same situation was obtained by Mathur and Khera (1989) with respect to Thelastomatides in *P.americana.*

Findings of present study are in confirmation with earlier workers. Humidity of the monsoon months are favourable for infection. It might be breeding season of the parasite. However, it could also be due to high temperature of summer which might have suppressed the immune system of the host during summer and they might have got infection.

Table-1 Annual records of nematode parasites of *P. americana* (month-wise) From December 2006 to November 2007.

Months	No. of hosts examined	No. of hosts infected	Total no. of parasites	Incidence%	Index of Infestation	Density	Intensity	Dominant%
Dec. 2006	12	04	18	33.33	0.50	1.50	4.50	2.57
Jan. 2007	07	03	10	42.85	0.61	1.43	3.33	1.42
Feb. 2007	08	04	32	50.00	2.00	4.00	8.00	4.57
Mar. 2007	07	07	45	100.00	6.43	6.43	6.43	6.43
Apr. 2007	08	07	50	87.50	5.47	6.25	7.14	7.14
May. 2007	10	06	27	60.00	1.62	2.70	4.50	3.86
Jun. 2007	08	04	30	50.00	1.86	3.75	7.50	4.29
Jul. 2007	08	06	50	75.00	4.69	6.25	8.33	7.14
Aug. 2007	14	12	150	85.71	9.18	10.71	12.50	21.43
Sep. 2007	14	12	110	85.71	6.73	7.86	9.17	15.71
Oct. 2007	09	08	80	88.89	7.90	8.89	10.00	11.43
Nov. 2007	15	11	98	73.33	4.79	6.53	8.91	14.00

Table -2 Annual records of nematode parasites of *P. americana* (month-wise) from December 2007 to November 2008.

Months	No. of hosts examined	No. of hosts infected	Total no. of parasites	Incidence%	Index of Infestation	Density	Intensity	Dominant %
Dec. 2007	10	06	20	60.00	1.20	2.00	3.33	4.22
Jan. 2008	09	03	10	33.33	0.37	1.11	3.33	2.11
Feb. 2008	07	04	14	57.14	1.14	2.00	3.50	2.95
Mar. 2008	06	06	42	100.00	7.00	7.00	7.00	8.86
Apr. 2008	08	06	52	75.00	4.88	6.50	8.67	10.97
May. 2008	10	06	27	60.00	1.62	2.70	4.50	5.69
Jun. 2008	17	08	42	47.05	1.16	2.47	5.25	8.86
Jul. 2008	12	12	82	100.00	6.83	6.83	6.83	17.29
Aug. 2008	14	11	100	78.57	5.61	7.14	9.09	21.09
Sep. 2008	10	08	55	22.22	4.40	5.50	6.88	11.60
Oct. 2008	11	05	12	45.45	0.49	1.09	2.40	2.53
Nov. 2008	09	05	18	55.55	1.11	2.00	3.60	3.79

Table -3 Annual records of nematode parasites of *P. americana* (month-wise) from December 2008 to November 2009.

Months	No. of hosts examined	No. of hosts infected	Total no. of parasites	Incidence %	Index of Infestation	Density	Intensity	Dominant %
Dec. 2008	12	04	18	33.33	0.50	1.50	4.50	2.83
Jan. 2009	15	04	10	26.67	0.18	0.67	2.50	1.57
Feb. 2009	07	07	40	100.00	5.17	5.71	5.71	6.28
Mar. 2009	12	10	42	83.33	2.92	3.50	4.20	6.59
Apr. 2009	13	10	45	76.92	2.66	3.46	4.50	7.06
May. 2009	08	05	28	62.50	2.19	3.50	5.60	4.39
Jun. 2009	09	04	30	44.44	1.48	3.33	7.50	4.71
Jul. 2009	10	10	64	100.00	6.40	6.40	6.40	10.05
Aug. 2009	11	11	115	100.00	10.45	10.45	10.45	18.05
Sep. 2009	10	08	60	80.00	4.80	6.00	7.50	9.42
Oct. 2009	15	12	105	80.00	5.60	7.00	8.75	16.48
Nov. 2009	20	14	80	70.00	2.80	4.00	5.71	12.56

Table -4 Population dynamics of nematodes parasites of *P. americana* (season-wise) from December 2006 to November 2007

Seasons	No. of hosts examined	No. of hosts infected	Total no. of parasites	Incidence %	Index of infestation	Density	Intensity	Dominant%
Winter	22	14	87	63.60	2.52	3.95	6.21	12.43
Summer	26	17	107	65.38	2.69	4.12	6.29	15.29
Monsoon	36	30	310	83.33	7.17	8.61	10.33	44.29
Post-monsoon	36	23	196	63.88	3.48	5.44	8.52	28.00

Table -5 Population dynamics of nematodes parasites of *P. americana* (season-wise)from December 2007 to November 2008.

Seasons	No. of hosts examined	No. of hosts infected	Total no. of parasites	Incidence %	Index of infestation	Density	Intensity	Dominant %
Winter	22	13	66	59.09	1.77	3.00	5.08	13.93
Summer	35	20	121	57.14	9.00	3.46	6.05	25.53
Monsoon	36	31	237	86.11	5.67	6.58	7.65	50.00
Post-monsoon	30	16	50	53.33	0.89	1.67	3.13	10.55

Table -6 Population dynamics of nematodes parasites of *P.americana* (season-wise) from December 2008 to November 2009.

Seasons	No. of hosts examined	No. of hosts infected	Total no. of parasites	Incidence %	Index of infestation	Density	Intensity	Dominant %
Winter	34	21	92	61.76	1.67	2.71	4.38	14.44
Summer	30	19	103	63.33	2.17	3.43	5.42	16.17
Monsoon	31	29	239	93.55	7.21	7.70	8.24	37.52
Post-monsoon	47	30	203	63.83	2.76	4.32	6.77	31.87

Table -7 Correlation between Humidity and Incidence% and Index of Infestation of nematode parasites infecting *P.americana* from December 06 to November 09.

Period	Incidence% v/s Maximum humidity	Incidence% v/s Min. Humidity	Index of Infestation V/s Max. Humidity	Index of Infestation v/s Min. Humidity
Dec. 06 to Nov. 07	-0.13	-0.22	-0.02	-0.09
Dec. 07 to Nov. 08	-0.26	0.02	0.14	0.09
Dec. 08 to Nov. 09	-0.12	0.21	0.02	0.25

Table -8 Correlation between Temperature and Incidence% and Index of Infestation Of nematode parasites infecting *P.americana* from December 06 to November 09.

Period	Incidence% v/s Max. Temp.	Incidence% v/s Min. Temp.	Index of Infestation V/s Max. Temp.	Index of Infestation V/s Min. Temp.
Dec. 06 to Nov. 07	0.09	0.42	0.08	0.42
Dec. 07 to Nov. 08	0.33	0.24	0.502	0.051
Dec. 08 to Nov. 09	0.33	0.37	0.27	0.43

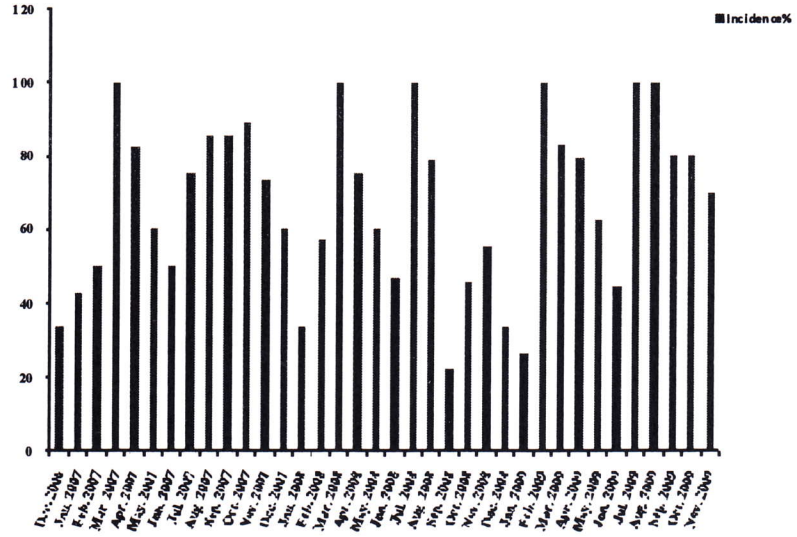

Fig.1 Graph shows the incidence% parasites of *P. Americana* from December 06 to November09

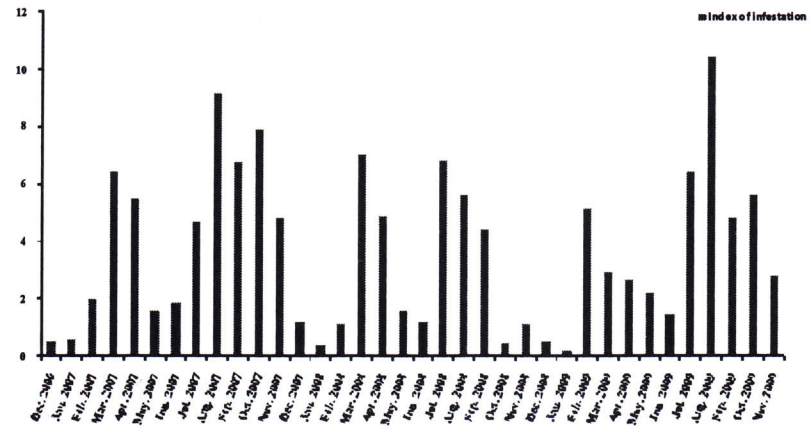

Fig.2 Graph shows the Index of Infestation of Parasites of *P. americana* from December 06 to November09.

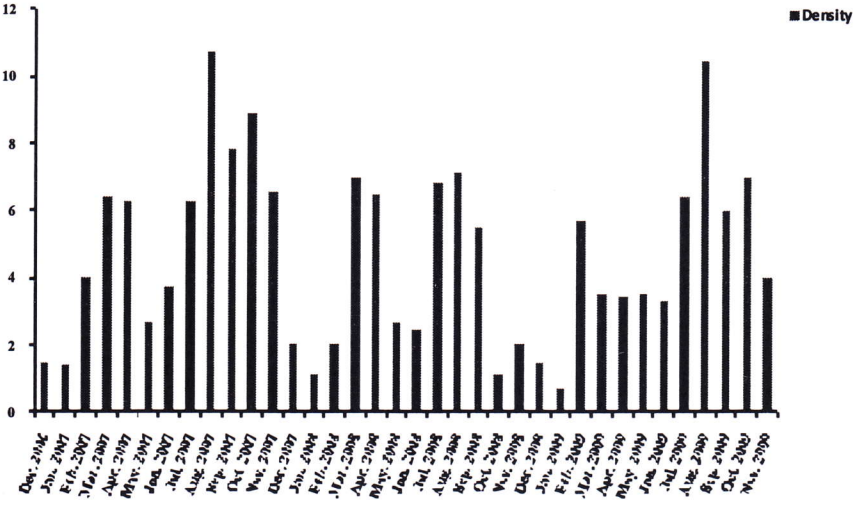

Fig. 3 Graph shows the density of parasites of *P. americana* from December 06 to November 09.

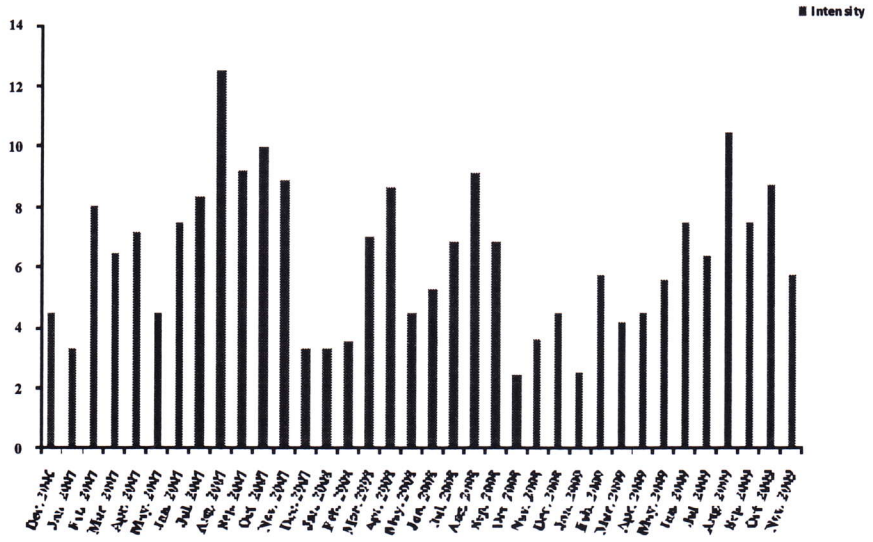

Fig. 4 Graph shows the Intensity of *P. americana* from December 06 to November 09.

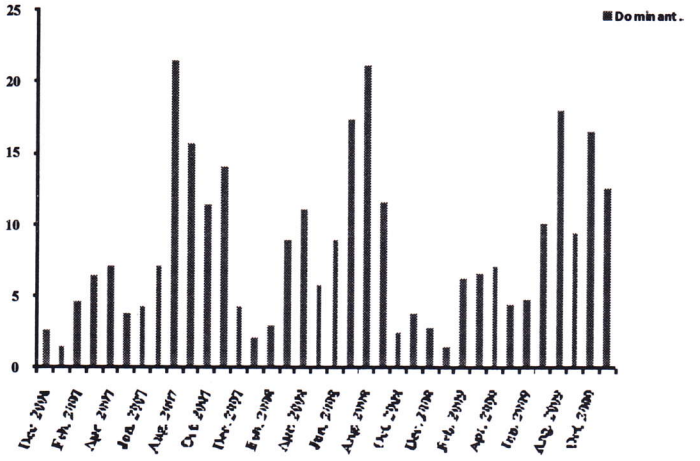

Fig. 5 Graph shows the Dominant% of parasites of *P. americana* from December 06 to November 09.

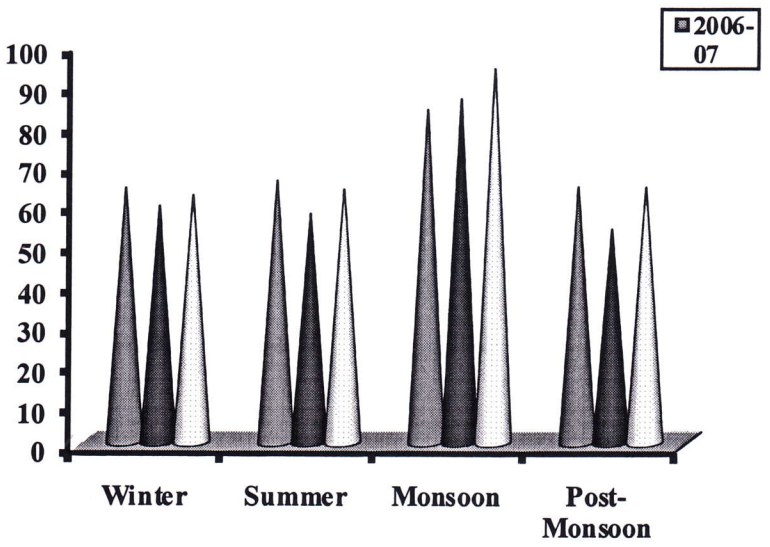

Fig. 6 Season wise Incidence% of nematodes of *P. americana* from December 06 to November 09.

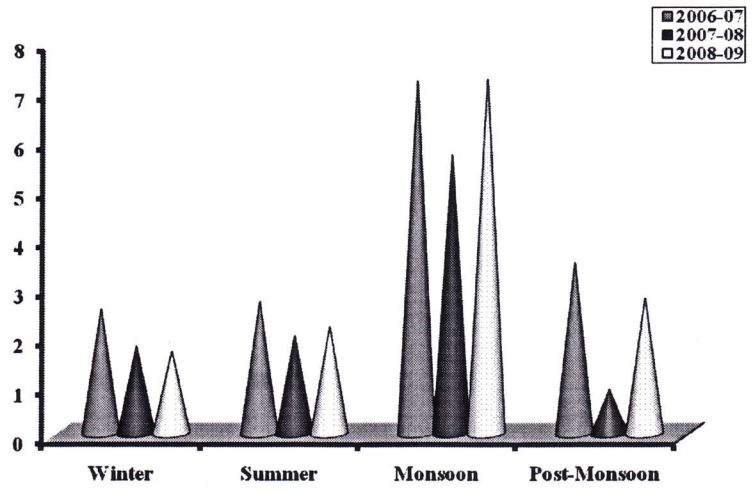

Fig. 7 Season wise Index of Infestation of nematodes of *P. americana* from December 06 to November 09.

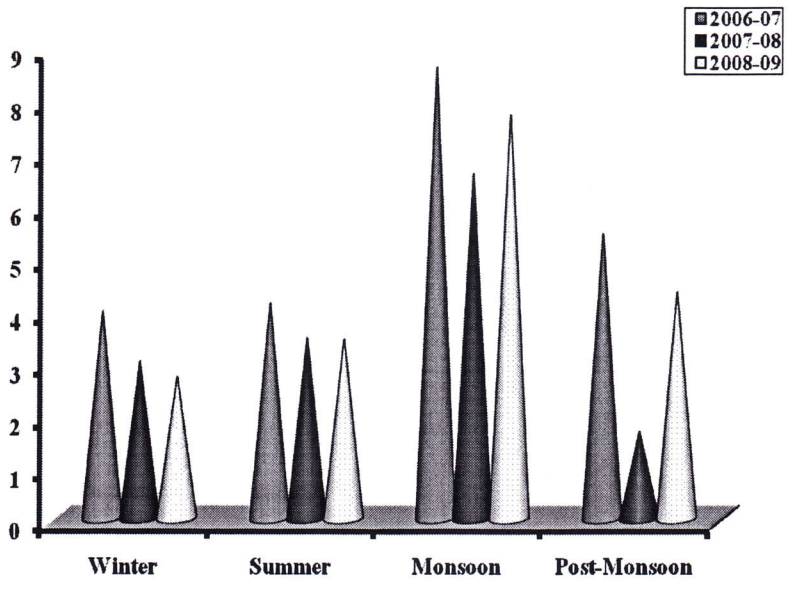

Fig. 8 Season wise Density of nematodes of *P. americana* from December 06 to November 09.

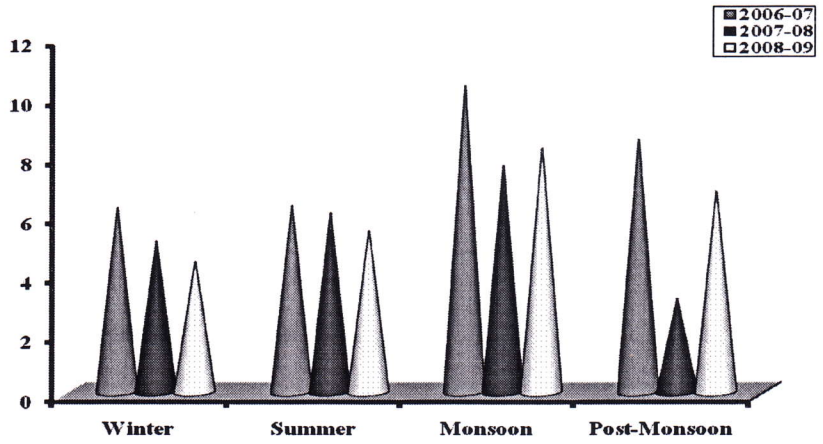

Fig. 9 Season wise Intensity of nematodes of *P. americana* from December 06 to November 09.

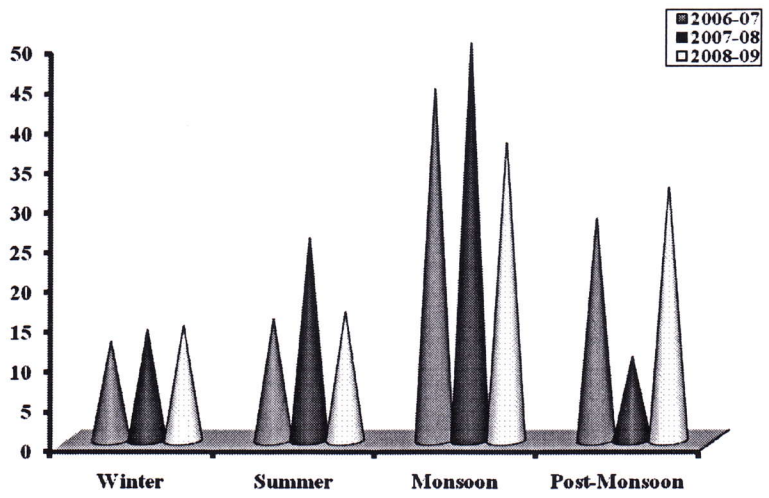

Fig. 10 Season wise Dominant % of nematodes of *P. americana* from December 06 to November 09.

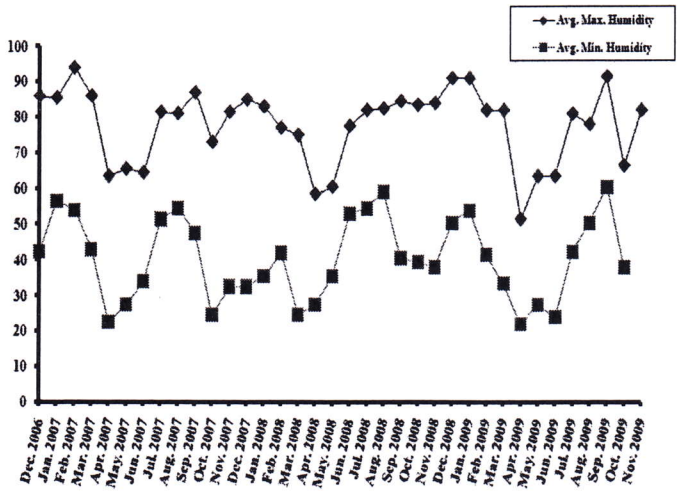

Fig. 11 Graph shows the average maximum and minimum Humidity from December 06 to November 09.

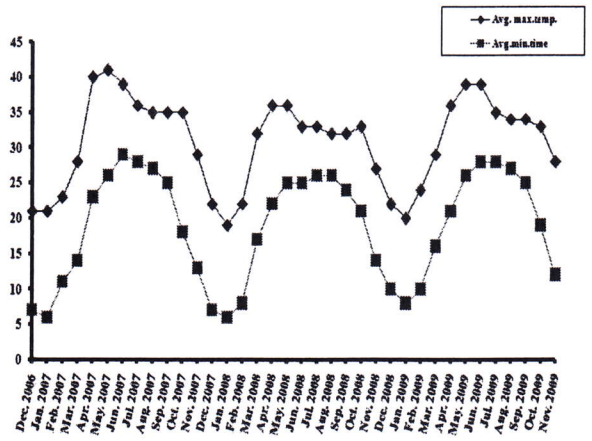

Fig. 12 Graph shows the average maximum and minimum Temperature from December 06 to November 09.

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References

Anderson, R.M. and May, R.M. 1979. Population biology of infectious diseases: Part I. **Nature., 280:361.**

Basir, M.A. 1956. Oxyuroid parasites of Arthropods. A monographic study. 1. Thelastomatidae 2. Oxyuroidae. **Zoologica., 38: 1-79.**

Chitwood, B.G. 1932. A synopsis of nematodes parasitic in insects of the family Blattidae. **Z. Parasitenk., 5: 14 - 50.**

Dobson, A. and Carper, R. 1992. Global warming and potential changes in host-parasite and disease-vector relationships. In Global Warming and Biodiversity, ed. R.L. Peters and T.E. Louejoy. New Heaven, CT: Yale University Press.

Dobson, A. P. 1986. The population dynamics of competition between Parasites. **Parasitology., 91:317.**

Dobson, A.P. 1989. The population biology of parasitic helminthes in animal populations. In: Levin, S.A., Hallam, T. G. and Gross, L. J. (Eds), Applied mathematical ecology. Springer-verlag., 145-175.

Esch G.W.; Gibbons J.W. and Bourque, J.E. 1975. An analysis of the relationship between stress and parasitism. **Am .Midl. Nat., 93:339.**

Farooqui, M.N. 1970. Some known and new genera and species of the family Thelastomatidae Travassos, 1929. **Rivista. Parasitol., 31: 195-214.**

Ferris, H. 2002. Nematode population dynamics and economic thresholds. (http://pplnemweb.ucdavis.edu/)

Gordoa, R. 1970. A neuroendemic relationship between nematode Hammerschimidtiella diesingi and its insect host, *Blatta orientalis* **Parasitology., 61:101.**

Hominick ,W.M. and Davey, K.G. 1972. The influence of host stage and sex upon the size composition of the population of two species of Thelastomatids parasitic in the hindgut of *Periplaneta americana.* **Canadian J. of Zool., 50:947-954.**

Hominick, W.M. and Davey, K.G. 1972. Reduced nutrition as the factor controlling the populations of the pinworms following endocrine gland removal in *Periplaneta americana.* **Canadian J. of Zool., 50:1421-1432.**

Hominick, W.M. and Davey, K.G. 1973. Food and spatial distribution of adult female pinworms parasitic in the hindgut of *Periplaneta americana.* L. **J. of Parasitology., 36:759-771.**

Hominick, W.M. and Davey, K.G. 1975. The effect of nutritional level of the host on space and food available to pinworms in the colon of *Periplaneta americana* L.

Comp. Biochem. Physiol., 51A:83-88

Jairajpuri, M.S.1986. Morphology of Nematodes. Plant Parasitic Nematodes of India Problems and Progress. Allied Publishers Pvt. Ltd. New Delhi.,10-57.

Lee, D. L.1960. The distribution of glycogen and fat in Thelastoma bulhoesi (Megalhaes, 1900), a nematode parasitic in cockroaches. **Parasitology., 50:241.**

Leidy, J. 1850. Description of some nematoid Entozoa infesting insects. **Proceedings of the Academy of Natural Sciences, Philadelphia., 5: 100 - 102.**

Mathur, N. and Khera, S. 1989. The influence of host stage and sex upon the size and composition of the nematodes parasitic in *Periplaneta americana*. **Res. Bul. (Sci .) Punjab University., 40:275-280.**

May, R.M. and Anderson, R.M. 1979. The population biology of infectious diseases: Part 11. **Nature., 280:455.**

Nadakal and Nayar 1968. Neural and hormonal influence on the fecundity and egg laying of certain oxyurid nematodes on habiting the hindgut of the cockroach *Periplaneta americana* L. **Indian J. Expt. Biol., 6:29-32.**

Peregrine, P.C. 1974. Host dietary changes and the hindgut fauna of cockroach. **Int. J. Parasitol., 4:645-656.**

Peregrine, P.C. 1974. The effects of host diet on Thelastoma attenuatum (Nematoda: Thelastomatidea) populations in cockroaches. **J. Helm., 48:47-57.**

Prasad, G.S.; Singh, P.K. and Ranganath, R. 2001. Population fluctuation of Entomopathogenic nematode, *Heterorhabtiditis Sp.* in South Andaman as influenced by weather parameters.

Renapurkar, D. M., Gossavi, A. V. and Arekar, A. S. 1993. Infection patterns in multiple species of nematodes parasitic in *Periplaneta americana* L. **Indian J. Helminth., 45:54-63.**

Schwenk, J.M. 1926. Fauna parasitologia des blattoides do Brasil. **Sciencia Medica,.Anno., 1V, 9:3-16.**

Singh H.S. and Malti. 2003. On a known and some unknown species of nematode parasites of *Gryllotalpa africana*. **J. Exp. India., 6: 329-330.**

Soota, T. D. 1980. Collection and preservation of nematode parasites of animals **Proc. Workshop Tech. Parasitol. Zoological Survey of India, Calcutta., 39-40.**

Tenora, F. and Zejda, J. 1974. The helminth synusy of *Clithrionomys glareolus* in low land forest and its changes. **Acta. Sci. Nat. Suno., 8:1-148.**

Trudgill D.L. and Phillips M.S. 1997. Nematode population dynamics, thresholds levels and estimation of crop losses. http://www.fao.org./docrep/v9978e/top.gif.

Welch H. E. 1963. Nematode infections In: E.A . steinhaus (Eds.), Insect Pathology. Academic Press, New York., 363-392.