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Article

Seasonal incidence of *Raoiella indica* Hirst (Acari: Tenuipalpidae) on different varieties of date palm in Kachchh region of Western India

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ABSTRCT
The data on abundance showed that the incidence of *Raoiella indica* and *Stethorus keralicus* was highest on Barhee and lowest on Anand TC variety, while moderate incidence was observed on KCCL-169. The incidence was observed throughout the year 2020–21 and 2021–22. The highest population was recorded in June and it was lowest during December. Among the four directions, maximum population was recorded from south and lowest from east throughout the year. Correlation studies revealed that *S. keralicus*, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, wind speed and evaporation showed highly significant positive correlation with incidence of *R. indica*, while, rainfall and rainy days showed non-significant positive correlation. However, bright sunshine hour exhibited non-significant negative correlation with incidence of *R. indica*. These results clearly showed that natural enemies are density-dependent and have a close association with *R. indica* population.

KEYWORDS: Date palm, India, mite, seasonal incidence, weather parameters.

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INTRODUCTION

The date palm, *Phoenix dactylifera* L. (Arecales: Arecaceae) is an important horticultural crop which thrives well in the world's hot arid regions (Chao and Krueger 2007). It is one of the oldest trees known to mankind grown in more than 40 countries with its maximum productivity reported from the Middle East *viz*., Egypt, Iran, Saudi Arabia, Pakistan, Iraq, Algeria, the United Arab Emirates, Sudan, Oman, and Morocco. Date Palm is also found in Australia, Mexico, Namibia, Peru, South Africa, Spain, and USA (Johnson 2010) and it is believed to have originated in Mesopotamia (Iraq), where it was grown more than 6000 years ago (Johnson *et al*. 2013). Date palm has played an important role in the economics of date-producing countries, and its global production rose from 1.8 million tons in 1962 to about 9.45 million metric tons in 2020 (Anonymous 2022). Date palm is one of the important arid horticulture trees of Western India where its commercial cultivation occurs on the coastal belt of Western Gujarat, more specifically in the Kachchh district of Gujarat, where there

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are about 2.0 million palms mainly of seedling origin. In Kachchh, it is popularly referred to as "*Kalpavriksha of Kachchh*" as it is an important fruit tree of the State's arid and semi-arid regions due to its high tolerance to especially abiotic environmental stresses. This region enjoys the monopoly of having commercial cultivation of date palm, spreads over 19980 ha with a fresh date production of 185346 tones during 2018–19 (Anonymous 2021).

A total of 132 insect species and mite pests are reported to cause damage to date palm all over the world. These species are distributed among eight orders of insects and 30 families, in addition to one order of mites composed of nine families. Although the number of date palm pest species appears to be large, a few species of mites are considered major economically-important pests (El-Shafie *et al*. 2017). Factors such as date palm monoculture, global warming, unregulated insecticide application and global movement of date palm planting materials have affected the mites and their natural enemies (Wakil *et al*. 2015). Mite infestation and damage to date palms were first recorded in Israel in the southern valley during late 1970s (Gerson *et al*. 1983); 15 species of phytophagous mites have been reported from various date palm growing areas of the world (El-Shafie 2012).

In the coastal belt of Kachchh, red palm weevil (*Rhynchophorus ferrugineus* Oliver, Coleoptera: Curculionidae), rhinoceros beetle (*Oryctes rhinoceros* L., Coleoptera: Scarabaeidae) and date palm white scale (*Parlatoria blanchardii* (Targgioni Tozzetii), Hemiptera: Diaspididae) are the major pests to cause economic damage to date palm (Muralidharan *et al*. 1993, 2000). Recently, incidence of red palm mite, *Raoiella indica* Hirst has been reported in date palm groves of Kachchh in Gujarat, India. The red palm mite, *R. indica* has also been found infesting palms in many countries in Asia and Africa, such as Sri Lanka, Pakistan, Egypt, Iran, Sudan, and the Philippines. Although coconut is its main host, *R. indica* also has been found on many hosts, including banana, date palm and plantain (Rodrigues and Irish 2011). This mite feeds through the stomata of the host plant causing scattered yellow spots or strong yellowish coloration on the entire leaflet (Ochoa *et al.* 2011). Through this specialized feeding habit, *R. indica* interferes with the photosynthesis and respiration processes of its host plants. Mite infested palms displayed stunted growth and withering of leaves.

The geographical distribution and seasonal incidence of *R. indica* is somewhat unknown in date palm groves in Kachchh region, India. Therefore, a field trial was done to determine the current status and distribution of *R. indica* in date palm-growing areas in Kachchh, Gujarat. This study was also necessary to provide information about the impact of weather parameters on incidence of mite population, including its natural enemies.

METHODS

Seasonal incidence study was conducted at Date Palm Research Station, S. D. Agricultural University, Mundra- Kachchh, Gujarat (India). The climate of this region is sub-tropical monsoon type and falls under arid and semi-arid regions. The region receives its yearly rainfall from June to September, during the south-west monsoon season. The distribution of yearly rainfall, which ranged from 250 to 350 mm, is erratic and unequal. Temperatures in the winter and summer ranged from −7 to 48 °C, with an average humidity of 60%, which rises to 80% during the south-west monsoon and falls to 50% in November and December. Average wind speed of 4.65 m/s/year with a maximum wind speed of 10.61 m/s during June was recorded. The coastal belt of Kachchh district of Gujarat encompass a unique date palm based agrarian ecosystem with considerable area under cultivation and playing a key role in the economy of the region.

The study on seasonal incidence of *R. indica* and its predator, *Stethorus keralicus* Kapur on three cultivars *viz*., Barhee, KCCL-169 and Anand TC of date palm was carried out during 2020–21 and 2021–22. The experimental plot was kept free from insecticidal spray during both years. A monthly observation on the population of *R. indica* and *S. keralicus* was recorded from five randomly selected plants from each cultivar (Barhee/KCCL-169/Anand TC). Five leaves were observed randomly from each direction (north, south, east and west) from the five palms (Total 100 leaves from each variety)

for counting the mite population. Number of mites were observed per cm^2 area from the upper, middle and lower portion of the leaves with help of hand lens (10X). Predatory insect, *S. keralicus* was counted from the whole leaf area. The data on population of mites and their predators were correlated with the weather parameters *viz*., maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, rainfall, rainy days and bright sunshine hours. The pattern of distribution of date palm mite in the plant canopy *i.e*., north, south, east and west were also estimated.

RESULTS

The incidence of *R. indica* was observed on all three tested varieties/cultivars (Fig. 1). This mite feeds through the stomata of the host plant causing scattered yellow spots or strong yellowish coloration on the entire leaflet (Fig. 2). The data of two years (2020–21 and 2021–22) on incidence of *R. indica* on Barhee variety, ranged from 1.73 to 18.61 mites/cm^2 with an average of 9.63 ± 5.03 (Table 1). The occurrence of *R. indica* was persistent throughout the year. The highest mite population (18.61/cm^2) was observed in June, while the lowest (1.73/cm^2) in December. Throughout the study, the highest average mite population was found in the south (11.46 ± 5.30/cm^2) and the lowest in the east (8.05 ± 4.70/cm^2) direction (Fig. 3).

The data of two years (2020–21 and 2021–22) on incidence of *R. indica* on KCCL-169 variety, ranged from 1.41 to 17.26 mites/cm^2 with an average of 8.72 ± 4.83 (Table 1). The occurrence of *R. indica* was constant throughout the year. The highest mite population (17.26/cm^2) was noticed in June, while it was the lowest (1.41/cm^2) in December. The highest average population was recorded in the south (10.50 ± 5.13/cm^2) and the lowest in the east (7.24 ± 4.48/cm^2) direction throughout the experiment (Fig. 3).

The average *R. indica* incidence during a two-year period on the Anand TC variety varied from 1.14 to 14.74 mites per cm^2, with a mean of 7.15 ± 4.23. *R. indica* was present continuously throughout the year. The mite population peaked in June at 14.74/cm^2, whereas it dropped to 1.14/cm^2 in December. Throughout the years, the east had the lowest average mite population (5.80 ± 3.85/cm^2) while the south had the greatest average mite population (8.90 ± 4.74/cm^2) (Fig. 3). The overall data on average incidence of two years on three varieties/cultivars, presented in Table 1, ranged from 1.43 to 16.87 mites/cm^2 leaf area with an average of 8.50 ± 4.96. The occurrence of *R. indica* was constant throughout the year. The highest mite population (16.87/cm^2) was observed in June, while it was lowest (1.43/cm^2) in December.

The results presented in Table 2 revealed the presence of coccinellids, *Stethorus keralicus* on all three variety throughout the year except January. The data on average population abundance of two year on Barhee variety ranged from 0.07 to 0.61 with an average of 0.27 ± 0.19 adults/leaflet (Table 2). The occurrence of *S. keralicus* was constant throughout the year except January. The highest population of *S. keralicus* (0.61/leaflet) was observed in June, while the lowest *S. keralicus* population (0.07/leaflet) was observed in December.

The two-year data on population abundance of *S. keralicus* on KCCL 169 variety ranged from 0.03 to 0.44 adults/leaflet with an average of 0.21 ± 0.15. The occurrence of *S. keralicus* was almost uniform throughout the year except January. The highest population (0.44/leaflet) was observed in June, while it was lowest (0.03/leaflet) in December.

The population during the two years ranged from 0.01 to 0.36 adults/leaflet with an average of 0.14 ± 0.11 on Anand TC Variety. The occurrence of *S. keralicus* was constant throughout the year except January. The highest *S. keralicus* population (0.36/leaflet) was observed in June, while it was lowest (0.01/leaflet) in December.

The average data on population of two years on three varieties/cultivars, presented in Table 2, showed that it ranged from 0.04 to 0.47 adults/leaflet with an average of 0.21 ± 0.15. The occurrence

of *S. keralicus* was constant throughout the year except January. The highest population of 0.47/ leaflet was recorded in June, while it was lowest (0.04/leaflet) in December.

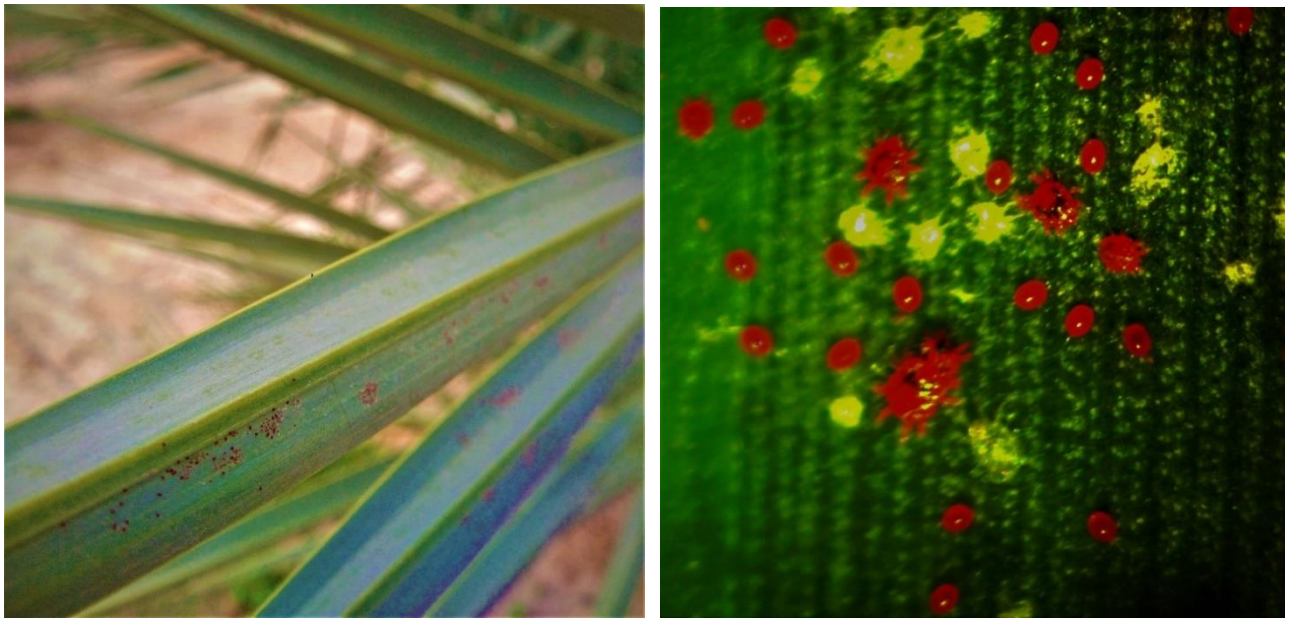

Figure 1. Incidence of *R. indica* on date palm.

Figure 2. Damage symptoms of *Raoliella indica* on date palm leaves.

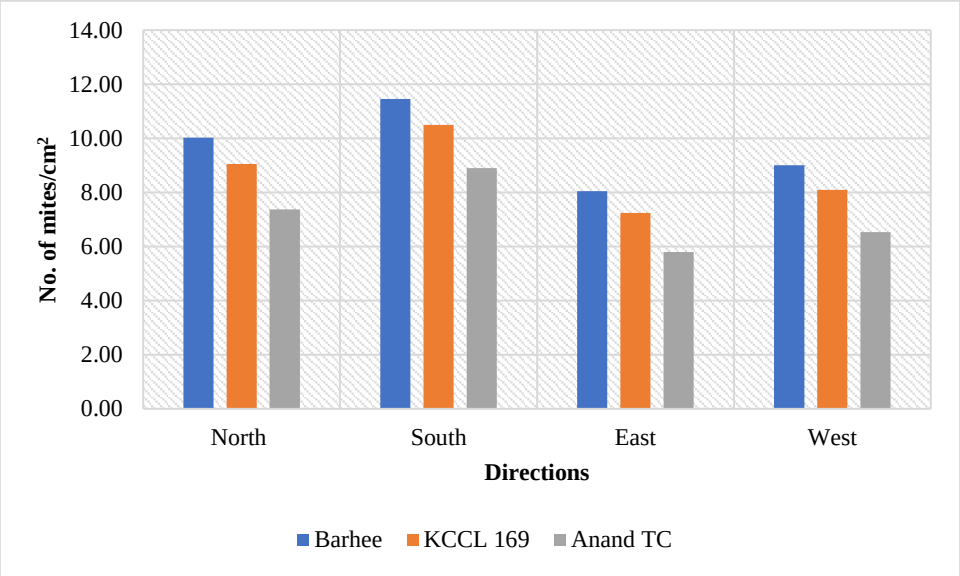

Figure 3. Pattern of distribution of red palm mite, *Raoiella indica* in different directions on three different varieties (pooled).

Table 1. Seasonal incidence of *Raoiella indica* on different varieties/cultivars of date palm.

Month	Number of mites per cm²									Overall Mean
	Barhee			KCCL-169			Anand TC			
	2020–21	2021–22	Average	2020–21	2021–22	Average	2020–21	2021–22	Average	
Jan.	03.96	04.86	04.41	03.19	04.00	03.60	01.96	02.71	02.33	3.45
Feb.	06.81	07.76	07.29	05.84	06.63	06.24	04.39	05.12	04.75	6.09
March	08.86	09.85	09.36	07.92	08.82	08.37	06.01	06.91	06.46	8.06
April	11.15	12.24	11.69	10.22	11.25	10.73	09.22	10.01	09.62	10.68
May	13.65	14.66	14.15	12.53	13.65	13.09	10.73	11.57	11.15	12.80
June	18.09	19.13	18.61	16.61	17.92	17.26	14.21	15.27	14.74	16.87
July	14.87	15.82	15.35	13.85	15.03	14.44	11.31	12.28	11.79	13.86
Aug.	12.01	13.11	12.56	11.09	12.08	11.59	08.91	09.72	09.31	11.15
Sep.	08.78	09.86	09.32	07.84	08.91	08.37	06.47	07.61	07.04	8.25
Oct.	06.31	07.38	06.84	05.45	06.33	05.89	04.22	05.04	04.63	5.79
Nov.	03.76	04.77	04.26	03.23	04.10	03.66	02.45	03.23	02.84	3.59
Dec.	01.35	02.11	01.73	01.17	01.66	01.41	00.94	01.34	01.14	1.43
Mean ± SD	9.13 ± 5.00	10.13 ± 5.06	9.63 ± 5.03	8.24 ± 4.73	9.20 ± 4.93	8.72 ± 4.83	6.73 ± 4.17	7.57 ± 4.29	7.15 ± 4.23	8.50 ± 4.96

The correlation studies (Table 3) revealed that *S. keralicus* ($r = 0.970^{**}$) showed highly significant positive correlation with population of *R. indica*. Weather parameters *viz*., maximum temperature ($r = 0.762^{**}$), minimum temperature ($r = 0.837^{**}$), maximum relative humidity ($r = 0.739^{**}$), minimum relative humidity ($r = 0.756^{**}$), evaporation ($r = 0.942^{**}$) and wind speed ($r = 0.922^{**}$) showed highly significant positive correlation with incidence of *R. indica*, while a non-significant positive correlation was observed between *R. indica* and weather parameters *viz*., rainfall (r = 0.380), rainy days (r = 0.380). However, bright sunshine hour (r = −0.238) exhibited a non-significant negative correlation with *R. indica*.

Table 2. Seasonal incidence of *Stethorus keralicus* on different varieties/cultivars of date palm.

Month	Number of mites per cm^2									
	Barhee			KCCL-169			Anand TC			Overall Mean
	2020–21	2021–22	Average	2020–21	2021–22	Average	2020–21	2021–22	Average	
Jan.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb.	0.08	0.13	0.11	0.05	0.10	0.07	0.02	0.05	0.03	0.07
March	0.17	0.23	0.20	0.12	0.20	0.16	0.07	0.13	0.10	0.15
April	0.28	0.37	0.32	0.22	0.30	0.26	0.13	0.20	0.17	0.25
May	0.42	0.48	0.45	0.33	0.38	0.36	0.22	0.25	0.23	0.35
June	0.55	0.67	0.61	0.42	0.47	0.44	0.33	0.38	0.36	0.47
July	0.45	0.52	0.48	0.38	0.40	0.39	0.25	0.32	0.28	0.39
Aug.	0.38	0.43	0.41	0.32	0.33	0.33	0.17	0.23	0.20	0.31
Sep.	0.30	0.32	0.31	0.22	0.25	0.23	0.12	0.18	0.15	0.23
Oct.	0.17	0.23	0.20	0.13	0.17	0.15	0.07	0.12	0.09	0.15
Nov.	0.10	0.17	0.13	0.05	0.10	0.07	0.02	0.05	0.03	0.08
Dec.	0.05	0.08	0.07	0.02	0.05	0.03	0.00	0.02	0.01	0.04
Mean ± SD	0.25 ± 0.18	0.30 ± 0.20	0.27 ± 0.19	0.19 ± 0.15	0.23 ± 0.15	0.21 ± 0.15	0.12 ± 0.11	0.16 ± 0.12	0.14 ± 0.11	0.21 ± 0.15

Table 3. Association between incidence of *Raoiella indica* with *Stethorus keralicus* and weather parameters.

Sr. No.	Biotic and abiotic factors	Correlation coefficient
1	Mean number of *S. keralicus*/leaflet	0.970**
2	Maximum Temperature (°C)	0.762**
3	Minimum Temperature (°C)	0.837**
4	Maximum Relative Humidity (%)	0.739**
5	Minimum Relative Humidity (%)	0.756**
6	Wind Speed (km/hr)	0.922**
7	Rainfall (mm)	0.380
8	Rainy days (days)	0.380
9	Bright sunshine hours (hr)	−0.238
10	Evaporation	0.942**

** significant at 1% level of significance.

DISCUSSION

Overall, data of abundance showed that the incidence of *R. indica* and *S. keralicus* was recorded highest on Barhee variety and lowest on Anand TC variety, while moderate incidence was observed on KCCL-169. The incidence was observed throughout the year 2020–21 and 2021–22. Highest population was recorded in June and lowest population was noticed during December. Among the four directions, highest average population was recorded from south and lowest from east throughout the year. Correlation studies revealed that population of *S. keralicus*, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, wind speed and evaporation showed highly significant positive correlation with incidence of *R. indica*; while, rainfall and rainy days showed non-significant positive correlation with *R. indica*. However, bright sunshine hour exhibited non-significant negative correlation with incidence of *R. indica*.

These results clearly showed that natural enemies are density-dependent and had a close

association with *R. indica* population. Similar findings were given by Nagesh Chandra (1980); Somchoudhry and Sarkar (1987) who reported an association of predatory coccinellids with peak population of *R. indica*.

Kumar and Hegde (2007) reported that the population of *R. indica* started in the month of February and continued up to July in Karnataka, India. They recorded a decline in population from July (31.5 mites/cm^2) which reached almost zero from August onwards. They reported that the increase of mite population during April to June may be because of higher temperature and relative humidity and also drier conditions prevailing in this region during these months. Vásquez *et al*. (2019) also reported that the *R. indica* population showed a negative association with rainfall in Venezuela.

Studies on seasonal incidence of *R. indica* and its natural enemies were carried out by Chavan *et al*. (2020) during May 2016 to April 2018. They revealed that the *R. indica* population was highest during first fortnight of March (39.42/cm^2), while the lowest mites of 1.69/cm^2 was recorded during first fortnight of November. The natural enemies population *viz*., *Stethorus keralicus* and *Scolothrips* spp. was highest during first fortnight of March coinciding with peak density of *R. indica*. Correlation studies revealed a significant positive association with maximum temperature ($r = 0.636^{**}$) while negative nonsignificant correlation with morning relative humidity ($r = -0.700^{**}$), evening relative humidity ($r = -0.468^{*}$) and rainfall ($r = -0.306$).

The decline in mite population with the onset of monsoon and an increase in relative humidity are in conformity with Nair and Daniel (1982). Thus, results of our study showed that high temperature, low relative humidity and rainfall greatly influenced the incidence of *R. indica*. Our results are in close conformity with Yadav Babu and Manjunatha (2007) who reported that there was a positive correlation observed with mite population and temperature, while relative humidity and rainfall had a negative relationship with mite population. Similarly, Hoy *et al*. (2010) reported that populations of *R. indica* in India are negatively affected by rainfall and high relative humidity while they are highest during hot, sunny, and dry conditions. Taylor *et al*. (2012), and Prabheena and Ramani (2014) found that *R. indica* densities were significantly higher during hotter and drier periods.

CONCLUSION

Incidence of *R. indica* and *S. keralicus* was recorded highest on Barhee variety and lowest on Anand TC variety, while moderate incidence was observed on KCCL-169. The incidence was observed throughout the year 2020–21 and 2021–22. Highest population was recorded in June and lowest population noticed during December. Among the four directions, highest average population was recorded from south and lowest from east throughout the year. Correlation studies revealed that population of *S. keralicus*, maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity, wind speed and evaporation showed highly significant positive correlation with incidence of *R. indica*.

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بروز فصلی *Raoiella indica* Hirst (Acari: Tenuipalpidae) در گونه‌های مختلف نخل خرما در منطقهٔ کچچه در غرب هند

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چکیده

داده‌های فراوانی نشان داد که بروز *Raoiella indica* و *Stethorus keralicus* در رقم Barhee بیشترین و در رقم Anand TC کمترین و در KCCL-169 متوسط بود. بروز در طول سال‌های ۲۰۲۰–۲۱ و ۲۰۲۱–۲۲ بررسی شد. بیشترین جمعیت در ماه ژوئن و کمترین آن در ماه دسامبر ثبت شد. در بین چهار جهت، بیشترین جمعیت از سمت جنوب و کمترین آن از سمت شرق در طول سال ثبت شد. مطالعات همبستگی نشان داد که *S. keralicus*، بیشینهٔ دما، کمینهٔ دما، بیشنهٔ رطوبت نسبی، کمینهٔ رطوبت نسبی، سرعت باد و تبخیر همبستگی مثبت و معناداری با بروز *R. indica* نشان دادند. در حالی که بارندگی و روزهای بارانی همبستگی مثبت غیرمعنی‌داری را نشان دادند. با این حال، ساعات آفتابی همبستگی منفی غیرمعنی‌داری با بروز *R. indica* نشان دادند. این نتایج به روشنی نشان می‌دهد که دشمنان طبیعی وابسته به تراکم هستند و ارتباط نزدیکی با جمعیت *R. indica* داشتند.

واژگان کلیدی: نخل خرما، هند، کنه، بروز فصلی، پارامترهای آب و هوا.

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