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TO STUDY THE NATURAL ENEMIES OCCURRING UNDER RICE-ECOSYSTEM OF DISTRICTS OF NAINITAL

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ABSTRACT

Insects continue to cause significant crop losses for rice producers in Asia, even with the use of insecticides and other management measures. Because of their low cost, ease of availability, and immediate suppression of the pest population, farmers in Nanital typically prefer synthetic organic insecticides that require a high rate of application. However, the careless application of these artificial insecticides to eradicate pests disrupted the natural ecosystem, resulting in a rebound of pests, contamination of the environment, and unfavorable impacts on organisms that are not the target of the pests, including their natural adversaries. Therefore, it's time to adopt an eco-friendly strategy for a safe and healthy environment. However, in recent years, there has been an increasing focus on using botanicals to manage insect pests. Because they are harmless for the environment and excellent at managing pests, these botanical pesticides are among the promising insecticides that have gained favor recently.

KEYWORD: Pests, Natural, Suppression, Pesticides, Eco-Friendly

1. INTRODUCTION

A staple food for over half of the world's population, rice (Oryza sativa Linn.) is one of the world's cereal crops. For around 3 billion people, it is a basic food, and as the population grows, so does the need for it (Carriger and Vallee, 2007). According to Tsunoda and Takahashi (1984), this annual grass is extensively grown from 50°N to 40°S latitude and in regions ranging from sea level to elevations of over 2,500 meters. In India, rice is grown in latitudes ranging from 8oN to 35oN, and it thrives in a wide range of rainfall, altitude, and climate conditions. According to Prakash et al. (2007), it is produced at sea level in river deltas, such as in a portion of Kerela state; as a deep-water crop in West Bengal, Assam, and Bihar; and at high elevations, up to 1500 meters or higher in Kashmir; and on the Himalayan foothills. India produces 98.95 million tons of rice annually on an area of 43 million hectares (Anonymous, 2024). To sustain the current level of self-

sufficiency, it is projected that India will need to produce at least 170 to 180 million tons of rice by 2020, with an average productivity of 4.03 tons per hectare (Mishra et al., 2006). Rain-fed rice is the primary crop grown by farmers in Nanital during the Kharif season. It is the people's basic food and is grown on 168.40 thousand hectares, yielding 396.96 thousand tons and an average of 2357.20 kg/ha in 2008-2009 (Anonymous, 2010a). Even though the state's average output per hectare is greater than the national average, Nanital's Kharif rice production is still quite poor when compared to other significant rice-growing states.

It is mostly a crop grown in warm, humid climates with multiple, serious insect pest issues. During every stage of crop growth, the crop is plagued by a variety of insect pest species, resulting in significant output losses. Though most of them cause relatively little harm, more than 800 bug species harm rice in one way or another. About 20 insect pest species are significant and frequently found in tropical Asia alone (Grist and Lever, 1969). However, a number of species that were before regarded as minor pests have recently turned into major ones (Dale, 1994).

The stem borer, rice bugs, leaf folder, leaf and plant hoppers, gall midge, and rice hispa are the main rice insect pests that inflict significant financial losses in Asia. While the gall midge, brown plant hopper, yellow stem borer, and brown plant hopper are the insects that inflict the most damage in South Asia, the stem borer, brown plant hopper, gall midge, and leaf hopper are among the most significant insects in South East Asia and China (Herdt and Riely, 1987).

The agriculture economy in Nanital is largely focused on rice cultivation. The Kharif season is when the crop is grown in the state. The Kharif season is warm, humid, and has evenly distributed rainfall, which makes it ideal for the growth of many insects and results in significant crop losses. According to Pasalu et al. (2005), major insect pests found in the rice ecosystem of Nanital include the gall midge (Orseolia oryzae Wood Mason), leaf folder (Cnaphalocrocis medinalis Guenee), yellow stem borer (Scirpophaga incertulas Walker), ear head bug (Leptocorisa oratorius Fabricus), and cutworm (Mythimna seperata Walker). However, these days, other important factors that contribute to lower yields include rice skipper, case worm, yellow hairy caterpillars, semi-loppers, green leaf hopper, and whorl maggot.

2. REVIEW OF LITERATURE

Zhang et al. (2023) documented roughly 114 species of arthropods (58 species of spiders, 16 species of predatory insects, 25 species of phytophagous insects, and 16 species of neutral/other insects) while observing the variety and community structure of arthropods in China's Guangdong region. In their study of numerous research publications, Ul Ane and Hussain (2016) detailed the variety of insect pests and natural enemies found in the world's principal rice-growing regions. With 624 pest species and 1303 natural enemies, China was found to have the most biodiversity in rice fields among the major nations under study.

Siregar and Lubis (2017) used a variety of sampling techniques, including sweeping nets, pit fall traps, yellow sticky traps, and core samplers, to ascertain the insect diversity. Almost 37 species from eight insect groups were identified. The yellow sticky trap was the most successful of the four insect sample instruments since it gathered a greater number of bug species. Borkakati et al. (2018) documented the natural enemies of the rice environment in upper Assam. They identified 35 insect species that belong to the orders hymenoptera, coleoptera, odonata, dermaptera, diptera, and orthoptera, as well as 16 spider species.

The insect diversity in the rice fields of Tamil Nadu's Theni district was evaluated by Fathima et al. (2020). There were 587 reported insects in all, representing 26 species and nine orders (hemiptera, hymenoptera, lepidoptera, mantodea, odonata, orthoptera, thysanoptera, diptera, and coleoptera). In a same vein, Sheela and Rose (2021) found a lot of insects during their field survey in the Theni district's paddy fields. In all, 4501 insects from nine orders, five families, and fourteen species were identified.

3. OBJECTIVES OF THE STUDY

1. To survey the natural enemies occurring under rice-ecosystem of districts of Nanital.
2. To study the efficacy of certain biopesticides against major insect pests of rice (yellow stem borer, leaf folder, gall midge and case worm)

4. RESEARCH METHODOLOGY

In order to determine the impact of seven (seven) commercial biopesticides—Pestoneem (Azadirachtin 1500ppm @ 1500 ml/ha), Shakti (Azadirachtin 300ppm @ 2500 ml/ha), Margosom (Azadirachtin 300ppm @ 2500 ml/ha), Multineem (Azadirachtin 1500ppm @ 2500 ml/ha), Achook (Azadirachtin 1500ppm @ 1500 ml/ha), Maple ternim (E-M Formulation 2000ml/ha), Uro-insecticide (Cow- urine + Vitex trifolia @ 7500 ml/ha), and one standard check insecticide, Thiamethoxam (25 WG @ 200g/ha)—as well as well as an

untreated control (water spray) on the predatory populations of spiders and coccinellid beetles found in the experimental field.

With three replications and three sprays spaced 15 days apart, the experimental field was set up using Randomized Block Design (RBD). A one-month-old seedling of the paddy variety was moved into a 5 x 4-m2 plot with 15 x 20 cm between each other. For the trial, every agronomic procedure was adhered to.

Ten randomly chosen hills in each plot were observed for spider and coccinellid beetle populations one day prior to each spray and three, seven, ten, and fifteen days following each spray.

STUDY AREA:

Four locales in the valley districts of Nanital, Uttarakhand, were the sites of the current study. A distance of roughly 20 to 40 kilometers separates each locality from the others. Below is a quick explanation of the study locations.

LOCATION AND BOUNDARY:

One of the border states in the northeastern region of the country is Nanital. Its overall area is 22327 square kilometers. over 80% of the state of Nanital is topologically made up of mountain and hill ranges, with a tectonic valley in the middle.

It was once an ancient lake that filled up and was raised to its current location, with the remaining portion of the lake still occupying the southern part of the valley. Despite making up only 8% of the state, 70% of the population lives in the Nanital Valley, which has an average elevation of 790 meters above mean sea level (Anonymous, 2015).

5. RESULT AND DATA INTERPRETATION

Table 5.1. Showing the Shannon- Wiener diversity index (H'), Dominance Index (Berger-Parker dominance index) and Evenness (E) of total natural enemies communities in paddy ecosystem of four study sites during *Kharif* season (July- November)

	DIVERSITY INDEX (H')	BERGER PARKER	EVENNESS (E)

MONTH					DOMINANCE (D)							
	SITE 1	SITE 2	SITE 3	SITE 4	SITE 1	SITE 2	SITE 3	SITE 4	SITE 1	SITE 2	SITE 3	SITE 4
JULY 2023	2.73	2.27	2.70	3.07	0.01	0.06	0.02	0.00	0.67	0.61	0.58	0.73
AUGUST 2023	3.10	3.06	3.08	3.07	0.08	0.01	0.01	0.07	0.64	0.61	0.60	0.67
SEPTEMBER 2023	3.02	3.00	3.10	3.00	0.00	0.00	0.00	0.08	0.56	0.63	0.64	0.68
OCTOBER 2023	2.76	2.81	2.88	3.00	0.04	0.02	0.01	0.00	0.57	0.66	0.65	0.63
NOVEMBER 2023	2.45	2.54	2.60	2.54	0.15	0.04	0.05	0.06	0.48	0.72	0.57	0.64
JULY 2024	2.48	2.40	2.43	2.70	0.02	0.03	0.04	0.01	0.72	0.77	0.64	0.76
AUGUST 2024	3.04	2.87	3.05	3.06	0.00	0.00	0.08	0.00	0.60	0.65	0.68	0.71
SEPTEMBER 2024	3.06	3.05	3.00	3.05	0.04	0.01	0.00	0.07	0.50	0.62	0.67	0.65
OCTOBER 2024	3.03	2.84	2.73	3.04	0.00	0.03	0.00	0.08	0.57	0.57	0.58	0.67
NOVEMBER 2024	2.73	2.67	2.50	2.77	0.01	0.04	0.06	0.00	0.71	0.63	0.54	0.74

Note: Site 1 = Kiyamgei; Site 2 = Mayang Imphal; Site 3 = Kakching & Site 4 = Bishnupur.

Table provides an interpretation of the Shannon-Weiner index of the total natural enemy fauna of the four study sites. This index ranged from 2.545 to 3.10 in Site 1, with the lowest diversity (2.45) occurring in November 2023 and the highest diversity (3.10) occurring during the first season in August 2023. In the next season, it peaked in September 2024 at 3.07 and fell to its lowest in July 2024 at 2.48.

However, September 2023 and September 2024 had the highest diversity in Site 2, with values of 3.00 for the first yearly cycle and 3.05 for the second. The months of July 2023 (2.27) and 2024 (2.40) in the first and second annual cycles, respectively, likewise saw the lowest index.

For Site 3, the diversity index peaked in September 2023 (3.10) and September 2024 (3.00), the same month for both seasons. Nonetheless, the first season's index was lowest in November 2023 (2.60), and the second season's was lowest in July 2024 (2.43).

For the first and second seasons, respectively, August 2023 (3.07) and August 2024 (3.06) had the highest diversity index (H') of natural enemies in Site 4. However, the months of November 2023 (2.54) and July 2024 (2.70) had the lowest indexes for the first and second seasons, respectively.

Spider

Table provided a description of the spider communities' Shannon-Weiner diversity index. Spider diversity index values in Site 1 varied from 1.38 to 1.87. August 2023 and October 2024 had the highest diversity (1.87 and 1.82, respectively) in the first and second seasons. November 2023 and July 2024 had the lowest diversity values (1.38) and 1.62, respectively, for the first and second Kharif seasons.

Table 5.2. Showing the Shannon- Wiener diversity index (H'), Dominance Index (Berger-Parker dominance index) and Evenness (E) of spider communities in paddy ecosystem of four study sites during *Kharif* season (July- November).

MONTH	DIVERSITY INDEX (H')				BERGER PARKER DOMINANCE (D)				EVENNESS (E)			
	SITE 1	SITE 2	SITE 3	SITE 4	SITE 1	SITE 2	SITE 3	SITE 4	SITE 1	SITE 2	SITE 3	SITE 4
JULY 2023	1.58	1.50	1.67	2.04	0.14	0.218	0.22	0.10	0.80	0.72	0.63	0.61
AUGUST 2023	1.87	1.85	1.82	2.06	0.12	0.14	0.15	0.10	0.70	0.81	0.66	0.76
SEPTEMBER 2023	1.80	1.80	2.05	2.02	0.13	0.15	0.13	0.12	0.56	0.56	0.86	0.65
OCTOBER 2023	1.55	1.60	1.67	1.88	0.20	0.16	0.18	0.12	0.55	0.67	0.63	0.70
NOVEMBER 2023	1.38	1.42	1.41	1.55	0.34	0.17	0.23	0.22	0.52	0.60	0.54	0.64
JULY 2024	1.62	1.60	1.43	1.66	0.14	0.16	0.22	0.20	0.83	0.57	0.67	0.73
AUGUST 2024	1.80	1.81	1.77	2.07	0.13	0.15	0.13	0.18	0.63	0.65	0.71	0.70

SEPTEMBER 2024	1.81	2.01	1.72	2.02	0.23	0.14	0.20	0.11	0.42	0.81	0.67	0.73
OCTOBER 2024	1.98	1.70	1.44	2.03	0.15	0.20	0.20	0.10	0.52	0.50	0.57	0.74
NOVEMBER 2024	1.65	1.37	1.41	1.86	0.14	0.22	0.25	0.11	0.62	0.762	0.54	0.70

Note: Site 1 = Kiyamgei; Site 2 = Mayang Imphal; Site 3 = Kakching & Site 4 = Bishnupur

The spider diversity index value at Site 2 ranges from 1.42 to 1.85 for the first season; the highest value of 1.85 was recorded in August 2023 and the lowest value of 1.42 was recorded in November 2024. September 2024 was the top (2.02) for the following season, while November 2024 was the lowest (1.37).

during Site 3, the diversity index value was higher in September 2023 (2.05) and August 2024 (1.77), respectively, during the first and second seasons. But for both Kharif seasons, November 2023 and 2024 had the lowest index (1.41) with the same value.

August 2023 for the first season and October 2024 for the second season had the highest index (2.06) for Site 4. The months with the lowest index were November 2023 (1.55 for the first season) and July 2024 (1.66 for the second).

Odonata

For Odonate in Site 1, the measured Shannon-Weiner diversity index (Table 4.5) varied between 1.51 and 2.04. For the first and second seasons, respectively, the highest value was noted in September 2023 (2.04) and September 2024 (2.02). In the same way, July 2023 and July 2024 had the lowest indexes, 1.56 and 1.51, respectively.

Table 5.3. Showing the Shannon- Wiener diversity index (H'), Dominance Index (Berger-Parker dominance index) and Evenness (E) of Odonata communities in paddy ecosystem of four study sites (during *Kharif* season July- November)

	DIVERSITY INDEX (H')	BERGER PARKER DOMINANCE (D)	EVENNESS (E)

MONTH	SITE 1	SITE 2	SITE 3	SITE 4	SITE 1	SITE 2	SITE 3	SITE 4	SITE 1	SITE 2	SITE 3	SITE 4
JULY 2023	1.56	1.20	1.51	1.40	0.21	0.30	0.20	0.21	0.65	0.63	0.61	0.78
AUGUST 2023	2.03	2.00	1.64	1.73	0.13	0.14	0.20	0.13	0.75	0.70	0.70	0.80
SEPTEMBER 2023	2.04	2.00	2.03	1.80	0.08	0.11	0.12	0.14	0.76	0.80	0.74	0.73
OCTOBER 2023	1.88	1.88	1.86	1.83	0.11	0.08	0.14	0.12	0.80	0.80	0.61	0.76
NOVEMBER 2023	1.84	1.80	1.62	1.57	0.18	0.10	0.17	0.16	0.67	0.86	0.70	0.78
JULY 2024	1.51	1.53	1.56	1.66	0.22	0.20	0.20	0.13	0.74	0.75	0.65	0.87
AUGUST 2024	2.00	2.06	1.85	1.84	0.10	0.11	0.15	0.10	0.72	0.75	0.68	0.76
SEPTEMBER 2024	2.02	2.05	2.04	1.86	0.08	0.15	0.13	0.15	0.74	0.76	0.74	0.70
OCTOBER 2024	2.01	2.04	1.84	1.88	0.15	0.08	0.16	0.10	0.872	0.75	0.67	0.70
NOVEMBER 2024	2.00	2.03	1.74	1.55	0.07	0.10	0.16	0.22	0.82	0.74	0.60	0.76

In contrast, the first Kharif season in Site 2 saw the least diversity in July 2023 (1.20), while the highest diversity was seen in August and September 2023 (both with the same index value of 2.00). August 2024 had the highest diversity throughout the second season (2.06), while July 2024 had the lowest diversity (1.53).

For Site 3, the first and second yearly cycles, respectively, saw the highest levels of diversity in September 2023 (2.03) and September 2024 (2.04). Similarly, July 2023 (1.51) for the first Kharif season and July 2024 (1.56) for the second Kharif season had the least diversity.
For Site 4, the first and second Kharif seasons, respectively, saw the highest levels of diversity in October 2023 (1.83), and October 2024 (1.88). However, the first Kharif season in July 2023 (1.40) and the subsequent Kharif season in November 2024 (1.55), respectively, had the least diversity.

6. CONCLUSION

The ecosystem of a paddy field has the special qualities of a semi-natural wetland, which supports the diversity of plants and animals while also offering food for people. Many beneficial insects, which are the natural biocontrol agents that are essential to pest management, are favored by conservation and knowledge of insect variety, which influences the prudent use of insecticides. Natural enemy surveys carried out in four rice-growing locations have unequivocally demonstrated that this artificial ecosystem supports a high level of biodiversity and is among the most sustainable agricultural practices. The orders Araneae (16 species) and Hymenoptera (15 species) have the most species among the insect orders that were reported, followed by Odonata (10 species). The Tetragnathidae family of the order Araneae had the greatest number of species, with six (6), whereas the Libellulidae family of the order Odonata had the greatest number of species, with six (6). Three species were found in the Coccinellidae family of Coleoptera. In the instance of Hymenoptera, eight species from the Ichneumonidae family were identified. Because of their species diversity and richness, the aforementioned families accounted for a significant portion of the species. For the first time, two predatory spider species were identified from Nanital: Neoscona elliptica Tikader and Bal, and Tylorida straita Thorell.

Comparing the current analysis to that of other researchers, fewer groupings of natural adversaries were discovered. The kind of habitat, the quantity of samples collected, the sampling period, and variations in the climate could all be contributing factors. The most common spider families in rice fields were the Lycosidae, Tetragnathidae, and Oxyopidae families. Given the abundance of prey in the agro-ecosystem and the fact that rice plants provide excellent web-building sites, these families may be rather prevalent in rice. The two most common parasitoids found during the study period were Apanteles sp. and Cotesia rufricus. These might result from a particular host and favorable circumstances for the parasitoid. The majority of the fifteen parasite species that were gathered were able to infect the leaf folder alone, making it a significant nuisance in Nanital's rice-growing regions. From July to October, every parasitoid was active on paddy.

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