THE EFFECT OF CLIMATIC CHANGE ON THE FUNCTIONAL RESPONSE OF THE PREDATORY WOLF SPIDER, PARDOSA PSEUDOANNULATA (BOESENBERG AND STRAND)

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Abstract

Study on the effect of functional response of wolf spider, Pardosapseudoannulata (Boesenberg and Strand), in relation to different prey densities of 3rd and 4th instar Brown planthopper, Nilaparvatalugens (Stal.) nymphs was carried out in glass jar arena with '3' spiders under both ambient CO_2 and elevated CO_2 conditions. Wolf spiders were exposed to different prey densities of The feeding rate of the predator increased from 10.03.24 to 31.04.36 hoppers per predator under elevated CO_2 conditions, while the feeding rate of the predator increased from 10 to 50 hoppers per predator under ambient CO_2 conditions. This is in comparison to the feeding rate that was 10.03.24 to 33.04.39 under elevated CO_2 conditions. Because rising CO_2 undoubtedly caused a decrease in the quality of the rice plant, which in turn caused a decrease in the quality of the prey, the feeding rate of the spider was somewhat greater under elevated CO_2 conditions than it was under ambient CO_2 conditions. When compared to the CO_2 levels found in the ambient environment, higher CO_2 levels may have caused predators to devour a greater quantity of prey in order to make up for the lower nutritional content of the prey. On the basis of a research of predation, the number of prey that were attacked (Ha) and the density of prey per unit area during a certain amount of time (HT) were calculated.

Keywords: Wolf Spider, Pardosa Pseudoannulata, Co_2, Brown Planthopper, Prey

INTRODUCTION

Rice, which comes from the Oryza sativa L. plant, is considered to be one of the most significant grains in the world, especially in Asian nations, where it provides a staple food for more than half of the population. The production of rice is hampered by abiotic variables such as soil fertility, soil moisture, droughts and floods, and other environmental conditions; biotic factors, such as pests and illnesses, are responsible for yield loss in rice. It is so evident that in the future, rice production is expected to confront severe limits, which will lead to fluctuations in output and substantial economic losses (Khush, 2004). There are many different types of biotic stressors, but one of the most damaging is caused by insect pests. Between 20 and 33 distinct kinds of insect pests are economically relevant in various regions of the nation, and they cause major decreases in output. Rice planthoppers are among the pests that feed on the rice plant's sap, and they have grown economically significant in many parts of the globe (Magunmder et al., 2013). The brown plant hopper, also known as NilaparvatalugensStal. (Homoptera: Delphacidae), is the most destructive and dangerous of the two significant planthoppers. It is responsible for creating enormous financial losses. In addition to causing direct harm to the rice crop by its practise of sap sucking, the BPH is responsible for the transmission of viral illnesses of rice, including grassy stunt and rugged stunt (Reissig et al., 1986). For a great many years, insecticides were the primary tool for controlling pests in rice crops. However, the persistent and careless use of a diverse array of pesticides led to issues of resistance, comeback, secondary pest outbreaks, loss of biodiversity, and environmental contamination. Among the many possible strategies for IPM, biological control is generally regarded as the most essential one.

According to Vanden Bosch et al. (1982), there are a lot of advantages to controlling agricultural pests with the help of natural enemies that are parasitic or predatory. Spiders are the most common and widespread obligate carnivorous arthropods. They feed on a wide variety of prey and may be found in any form of cropping system. The wolf spider, also known as Pardosapseudoannulata, is a predator that feeds on a variety of different organisms and may be found in the rice environment across much of Asia. Plant hoppers, leaf hoppers, and other insects make up a significant portion of spiders' diets (Bardwell and Averill, 1997). The populations of natural enemies are also impacted by climate change. Integrated pest management is one of the most crucial aspects of managing pest populations effectively, and natural enemies are one of the most critical components of this approach (Walker and Jones, 2001). Stiling et al. (1999) made the observation that natural predators that fed on insects that were exposed to increased levels of CO_2 were indirectly impacted as a result of the food chain, also known as trophic cascade. Plants that are exposed to excessive CO_2 have a low C:N ratio, which causes them to be deficient in nutrients. As a result, herbivores need to graze on these plants for a longer amount of time in order to make up for the lack of nutrients. However, multiple research have shown that increased CO2 levels have no impact on natural predators. Under conditions of high CO2, the aphid population may rise, decrease, or not be impacted at all (Chen et al., 2005 and Gao et al., 2008).

Nearly half of the world's population relies on rice (Oryza sativa L.) as their primary source of nutrition, making it the single most important crop grown for human consumption. Rice is a member of the Gramineae family and comes from the genus Oryza. Rice, also known as Oryza sativa L., is a plant that is often cultivated in tropical and subtropical countries (Singh et al., 2012). Rice is the second most significant crop grown for human consumption in the world, supplying more than half of the world's population and contributing between 20 and 80 percent of the nutritional energy that people in Asia consume on a daily basis. More than one hundred different kinds of insects prey on the rice plant, and twenty of them may result in significant losses to the economy.

Under a variety of ecological situations, paddy crop experiences the greatest amount of damage as a result of an extensive number of insect and non-insect pests. Insects are responsible for around 30–40 percent of the annual output loss in rice due to the fact that they feed on practically all of the crop plants' aerial parts as well as the root system in the soil. In India, the principal insect pests that attack rice crops are the stem borer, gall midge, grass hopper, brown plant hopper, and leaf folder.

METHODS AND MATERIALS

Brown planthopper 3rd and 4th instar nymphs were needed to evaluate the feeding capability of wolf spider, under raised CO_2 condition. These nymphs were taken from an open top chamber (OTC) that was maintained at elevated CO_2 levels. In a manner similar, third and fourth instar BPH nymphs were gathered from OTC in conditions of ambient CO_2 concentration. The experiment on feeding potential in the glass jar arena was carried out in the laboratory at a temperature of 25.2 degrees Celsius and a relative humidity of 70.5 percent.

Collection of wolf spider population

Wolf spiders that had reached their sexual maturity were gathered from an untreated rice field by the "Entomology Division of the Indian Agriculture Research Institute in New Delhi.

Immediately, without any delay, the collected spiders were kept individually and starved (as the spiders are sexually cannibalistic), both in a glass jar arena (19x15 cm^2) under laboratory conditions and in a glass chamber (37x37 cm^2) at roomtemperature (25.2 degrees Celsius and 70.5 percent humidity) for three days (Xaaceph and Butt, 2014)." In a glass jar was where the experiment on the functional reaction of the spider was carried out. Additionally, throughout the course of three days, daily records were kept of the total number of persons devoured by each spider. Deformed BPH as well as dead BPH that had not been consumed by spiders were also documented in the study.

Feeding potential of spider in jar under laboratory condition:

Experiment on feeding potential of spider was done in jar measuring 19x15 cm2 as arena under laboratory condition (temperature of 252 °C and relative humidity of 705 percent) at varied prey densities of 10, 20, 30, 40, and 50 BPH nymphs. Jar was kept at laboratory temperature of 252 °C. At regular intervals of one day, observations on the eating habits of spiders were recorded. In each of the three trials, one, two, and three spiders were used at each of the prey densities, while the levels of CO_2 that were present ranged from ambient to high. There were three separate runs of each experiment. BPH densities offered to the spider at increased CO_2 levels (570 25 ppm) in comparison to those offered at ambient CO_2 levels Density T1: 3:10 (3 spiders/ 10 BPH). There are three spiders for every ten BPH. T2: 3 minutes and 20 seconds (3 spiders/ 20 BPH). T3: 3 minutes and 30 seconds (3 spiders/30 BPH) T4: 3:40 (3 spiders/40 BPH) T5: 3:50 (3 spiders/50 BPH) Timing results in parentheses.

It was reported that BPH populations grown independently in OTCs under ambient CO2 and increased CO2 had different feeding rates when monitored by predators in jars under laboratory conditions.

An examination of the wolf spider's probable food sources: The Holling disc equation was used in order to investigate the functional response of the spider with regard to BPH while it was grown under increased CO_2 and ambient CO_2. The functional response parameters, namely handling time (Th) and attack rate (a), were calculated using the Holling disc equation and then changed with reciprocal linear transformation based on the density of the prey. Activities performed by predators include looking for prey and taking care of prey (chasing, killing, eating and digesting).

ANALYSIS

In the laboratory, a glass jar was used to conduct research on the functional reaction of wolf spiders to varying concentrations of third- and fourth-stage BPH nymphs. This research was done in connection to diverse prey densities. The research was carried out using BPH nymphs that were grown utilising three different spiders under settings of increased CO2 and ambient CO2 levels, respectively. During the course of the experiment, three spiders were exposed to five different BPH densities over the course of three days. These densities included 10, 20, 30, 40, and 50 BPHnymphs of the third and fourth instars. The average number of prey killed ranged from 10 to 31 hoppers and three spiders under natural conditions, and the consumption rate of the predator ranged from 100 to 62 percent with an increase in prey density (Table 1). The average quantity of prey killed rose under conditions of enhanced CO_2 from 10 to 33 hoppers and 3 spiders, but the consumption rate of predators reduced from 100 to 64 percent with increasing prey density (Table 2). When compared to the CO_2 levels in the ambient air, it was shown that the rate of prey mortality was marginally greater under elevated conditions (Fig. 2). On the basis of a research of predation, the number of prey that were attacked (Ha) and the density of prey per unit area during a certain amount of time (HT) were calculated. The functional type II reaction of the wolf spider on the BPH nymph was shown by regression of 1/Ha on 1/HT in the jar both under ambient CO2 and high CO2 (Fig. 1).

Prey density (H)	Spider density	Total prey offered	Total prey killed	Mean no(H_a)	1/Ha	1/HT	Proportion killed
10	3	30	30	10.0±0.0	0.1	0.03	1
10	3	60	58	19.34±0.34	0.0517	0.017	0.97
10	3	90	82	27.67±0.88	0.036	0.01	0.91
10	3	120	59	29.67±.67	0.034	0.008	0.74
10	3	150	93	31.0±1.0	0.032	0.0067	0.62

Table 1: The functional response characteristics of the wolf spider Pardosapseudoannulata were determined by placing the spider in a container of 19 centimetres by 15 centimetres and exposing it to a constant level of carbon dioxide.

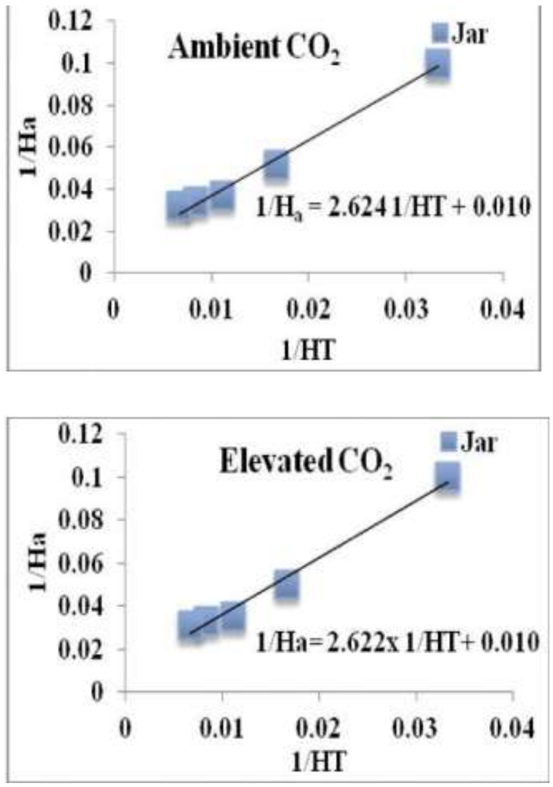

Fig. 1: The wolf spider's $1/H_a$ and 1/HT ratios in the lab, both at normal levels of CO_2 and at higher concentrations of CO_2

When compared to the CO_2 levels found in the ambient environment, the attack rate, the maximum attack rate, and the efficiency metrics of the predator were, correspondingly, greater, while the handling time was reduced. because increased CO_2 presumably caused a decrease in the quality of the rice plant, which in turn caused a decrease in the quality of the prey. In order to make up for the inferior nutritional quality of their food, predators may have ingested a greater quantity of prey when increased CO_2 levels were present as opposed to when ambient CO_2 levels were present. In this research, the feeding potential of the spider Lycosapseudoannulta was investigated in a glass jar under laboratory conditions, with both normal and increased levels of carbon dioxide. In the experiment, the consumption rate dropped with increasing prey density in all of the studies, demonstrating that the predator reaction corresponded to the functional type-II response. This was similar with the past observations of type-II insects-predator responses in the cases of Neosconatheisi (Xaaceph and Butt, 2014) and Adaliafasciatopunctatarevelierei (Atlihan and Borra, 2010).

In the past, it was discovered that the functional type-II reaction of predators was the most generally fitting response to the insect predator behaviour (Saleh et al., 2010; Xaaceph and Butt, 2014). According to research done by Claver et al. (2003), when there was a higher density of prey, predators required less time to seek for prey and spent more time attacking and digesting the prey, which boosted the predator's capacity for predation. The functional reaction of predators gave valuable information that was used in the process of comprehending the impacts of biocontrol agents in the field (Waage and Greathead, 1988). Plants that are exposed to excessive CO_2 have a low C:N ratio, which causes them to be deficient in nutrients. As a result, herbivores need to graze on these plants for a longer amount of time in order to make up for the lack of nutrients. Therefore, herbivores extend their exposure to their natural enemies, which in turn leads to increased rates of predation (Barbosa et al., 1982) or parasitism (Barbosa et al., 1982). (Stiling et al., 2002). The current research found that the eating rate of wolf spiders was greater under raised CO_2 in comparison to ambient CO_2. It also indicated that the death rate of wolf spiders was 8.34 to 22.34 under elevated CO_2 and 8 to 21.3 hoppers under the condition of ambient CO_2. Under conditions of high CO_2, predator attack rate, maximum attack rate, and efficiency metrics rose, but handling time dropped up to a certain threshold. This is in comparison to prior conditions, which also featured ambient CO_2. The parasitism of Aphidiuspicipes on the wheat aphid, Sitobionavenae, was shown to increase in conditions of high CO_2, according to Chen et al(2007) findings. It is possible that this is due to the fact that higher levels of CO_2 caused a decrease in the amount of protein found in plants, which could affect the amount of protein found in herbivores (Guerenstein and Hildebrand, 2008), thereby reducing the nutritional value of plants to natural enemies that are dependent on them. The poor quality of the prey might lead to an increase in the number of attacks by predators while also lowering the fitness of natural predators (Chen et al., 2005).

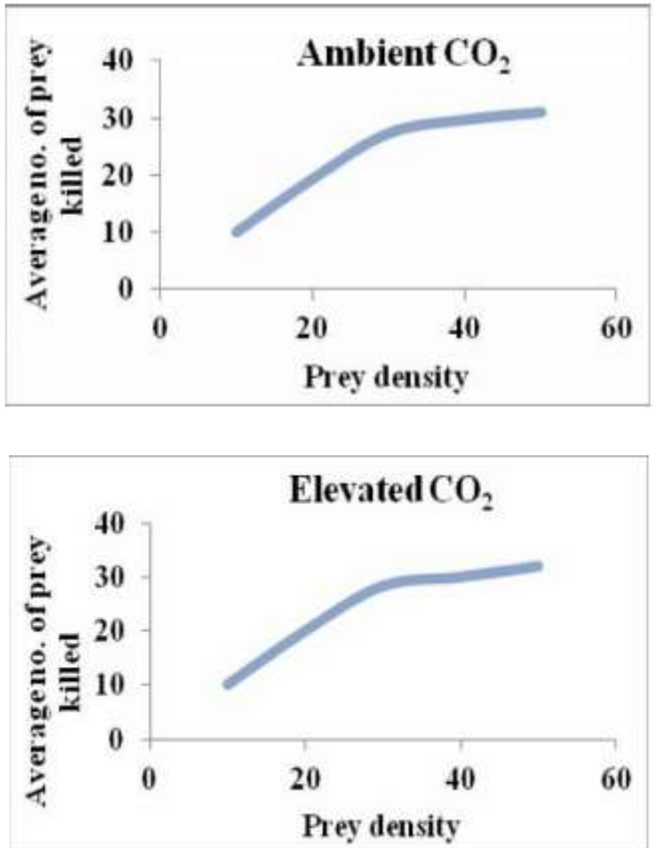

Fig. 2: A comparison of the wolf spider's predation rate in the lab at ambient CO_2 and high CO_2 levels

Table 2 :Functional response characteristics of the wolf spider Pardosapseudoannulata on varying BPH nymph densities in jars measuring 19 centimetres by 15 centimetres when exposed to increased levels of carbon dioxide.

Prey density(H)	Spider density	Total prey offered	Mean no. of prey killed(Ha)	Total prey killed	$1/H_a$	1/HT	Proportion killed
10	3	30	10.0±0.0	30	0.1	0.033	1
10	3	60	20.0±0.0	60	0.05	0.0167	1
10	3	90	28.34±0.88	85	0.035	0.01	0.94
10	3	120	30.0±1.15	90	0.0333	0.008	0.75
10	3	150	32.0±0.34	96	0.0329	0.0067	0.61

According to Boullis et al. (2015), inconsistent findings have been reported in relation to the sensitivity of insect pests to their respective predators under conditions of high CO2.

CONCLUSION

The elevated CO2 probably lowered the quality of rice plants, which ultimately lowered the quality of prey, elevated CO2 also influenced the interaction between wolf spiders and BPH, where it was observed that the predation rate was slightly higher compared to ambient CO2. The reason for this is that elevated CO2 influenced the interaction. When compared to the CO2 levels found in the ambient environment, higher CO2 levels may have caused predators to devour a greater quantity of prey in order to make up for the lower nutritional content of the prey. These findings on the varying effects of increased CO2 on natural enemies may aid in the development of innovative ways for the control of pests in the future, especially in light of the danger posed by rising CO2 levels in the atmosphere.

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