International Journal of Entomology Research
ISSN: 2455-4758
Impact Factor: RJIF 5.24
www.entomologyjournals.com
Volume 2; Issue 6; November 2017; Page No. 44-48

Influence of weather factors on flight of natural enemies that captured on the light traps mercury and CFL

[*1] Baehaki SE, [2] Tita Rustiati

[1] Entomological Society of Indonesia, Bandung Branch, Faculty of Agriculture, Padjadjaran University, Bandung-Sumedang street Km21-Jatinangor, West Java-Indonesia

[2] Indonesian Center for Rice Research (ICRR). Jl. Raya No.9, Sukamandi, Subang, West Java, Indonesia

Abstract

Influence of weather factors on flight of natural enemies that captured on the light traps. The Research was carried out in the 2013 at Sukamandi rice research station of Indonesian Center for Rice Research (ICRR). Natural enemies captured on the light traps of mercury lamp ML-160 watt and CFL-20 watt, while the weather data was collected from a meteorological cage within 200 m from the light trap. The results showed that the weather factors such as evaporation, wind velocity, light intensity, air temperature, relative humidity, rainfall and temperature of soil surface at 0 cm were insignificant effect to flight of *O. nigrofasciata* and *P. fuscipes* that captured on mercury lamp 160 watt and CFL-20 watt. The temperature of soil surface at 0 cm was significant positive influence to *Coccinella* sp. that captured on the mercury lamp 160 watt, while the *Coccinella* sp. that captured on the CFL bulbs 20 watt were significant negative influenced by rainfall and relative humidity. The facts explain that flight of *Coccinella* sp. were determined by environmental resultant factors between weather, lamp light capacity, and luminous power.

Keywords: light trap, weather factors, natural enemies, correlation, rice

1. Introduction

The lowland rice ecosystems as the main habitat of rice pests and its natural enemies in a tritrophic food chain. The diversity and abundance of pest and its natural enemies in a ecosystem varies one to another according to the environment that built by the local biotic and abiotic factors. Baehaki and Mejaya (2012) [1] reported in the North coastal of Java (especially of West Java) on the irrigation group-1 (water distribution to rice field area starting on 1 October from Jatiluhur dam) before the soil tillage, the abundance of phytophagous insects, predators and parasitoids were 31.56; 51,99 and 7,43% respectively, whereas in irrigation group-4 (water distribution starting on 15 November) situation of phyitophagous insect, predator and parasitoid were 96.26, 1.82 and 0.53% respectively. Natural enemies of predators that prey on insect pests consist of species of amphibians, birds, mammals, reptiles, spiders and predatory insects. The predators of the insect rice pests are spiders, *Cyrtorhinus lividipennis, Ophionea nigrofasciata, Paederus fuscipes,* coccinelid and libelulid.

The existence of predators in the rice field can be detected with a various of traps tools that one of them uses a light trap. The flight of winged natural enemies captured by light trap to give the important information as a biological control activity in the field. Various types of lights that can be used to attract insects are standard incandescent lamps, TL lamps (tubular lamp), ML lamps (mercury lamps), CFL lamps (compact fluorescent lamp), and LED (light emitting diode) with various wavelengths of color, especially the type of UV color (ultra violet).

The activities of predators will depend on the ratio of predator-pest, initial density, the age structure of the pests, the quality of the host, the kind of host plant and the physical environment in the form of weather. The quality of host can affect to the fitness of natural enemies, particularly in the koinobiont parasitoid that its host continues to feed after parasitization (=the host continues to develop and is only killed when the parasitoid reaches maturity). The fit winged of both predators and parasitoids have high activity and is able to fly out of their habitat. Fitness of predators and parasitoids will decrease as the quality of the host decreases [2]. Influence of the host quality on the fitness of predators has been pointed out by survival and growth rate of spider predator *Oligolophus tridens* were high on the *Drosophila melanogaster* (Diptera) and entomobryid Collembola (*Tomocerus bidentatus*/*Sinella curviseta* diets, and low on the *Folsomia candida* (Collembola), *Sitobion avenae* (Aphidoidea) and *Rhopalosiphum padi* (Aphidoidea) diets. The mixed diet caused a high early mortality, later a good survival and a high growth rate [3] and the ladybird predator *Orius insidiosus* (Say) responds to prey of *Aphis glycines* Matsumura and Soybean thrips *Neohydatothrips variabilis* (Beach) [4].

The natural enemy's fitness for predation and parasitization can change with the changing quality of prey or herbivores caused by changes in temperature and the effect of CO_2 on plants, so climate change has an indirect effect on the activity of natural enemies. Likewise the effectiveness of natural enemies in pest control will decrease if the distribution of pests moves out of the area of natural enemy distribution [5], however the direct impact of climate change on species distribution needs more clear evidence [6]. The information provides an image for the influence of weather factors on flight of pests and natural enemies, therefore this research was conducted to analyze the effect of weather factors on natural enemies that fly captured on lights trap.

2. Materials and Methods

Research on the effect of weather factors on natural enemies that captured on the light trap was carried out in Sukamandi rice research station of Indonesian Center for Rice Research (ICRR) at Ciasem- Subang district in 2013. The research using electric light traps of mercury (ML-160 watt) BSE-G3 and Solar cell light trap (CFL-20 watt) [7]. All light trap installed in the rice fields at a height of 150-250 cm from ground level to the distance between the light trap was 200 m. The Electric light trap is turned manually during 11-12 hours starting on 18.00 pm until 5:00 am, while the flame of solar light trap turned automatically when the sun was sinking. Various rice varieties was grown in the research station with various level of fertilizer doses, and various rice planting system. Baehaki *et al*., 2016 [7] has specified two kinds of light trap as follows:

2.1 The electric light traps of mercury (ML-160 watt) BSE-G3 model

Light traps of mercury (ML-160 watt) BSE-G3 model is an electric light trap equipped with mercury lamp ML160 W, funnel pests collector with the upper and lower part are 60 and 7 cm in diameter respectively, the cylinder bag pests collector with 31 cm in diameter and 80 cm in height, the rectangular roof to protect the lamp and pests catches especially from rain water. Description of ML160W (Mercury Lamp, Philips) colored cool daylight white light, luminance of 3150 lm, the voltage of 220-230 V, and the lamp light capacity is 160 Watts.

2.2 The Solar cell light trap (CFL-20 watt)

Solar cell light trap (CFL-20 watt) model is equipped by *compact fluorescent lamp* (CFL) bulbs, container box for collecting pests with a solution of soapy water. Description of CFL bulbs is cool daylight in color, luminance of 1200 lm, long life rays for 10 hours, the voltage of 220-240 VAC, and the lamp light capacity is 20 Watt

The predators from the two trap lights are separated and identified about the order, family, species of natural enemies, and calculated the sum of each species of natural enemy. In the same time, together with the daily observations of natural enemies, also observed a meteorological variable in the meteorological cage of the ICRR is located 200 m from the trap lights. Meteorological parameters observed at 17.49' o'clock of Western Indonesian time were air temperature, relative humidity, soil surface temperature of 0 cm, and wind speed. Other meteorological variables observed were light intensity with Gun-Belani, rainfall, and evaporation with open pan evaporimeter. All data on the number of pests and natural enemies in the form of cumulative 10 daily (dasarian) as well as meteorological data written in excel file.

Correlation and regression analysis is done to see the correlationship of each natural enemy as dependent variable and meteorological factors as independent variable to know the influence of independent variable on every natural enemy

3. Results and Discussions

The flight of Coleopteran imago that captured on both mercury and CFL light trap were the family of Coccinellidae (*Coccinella* sp. (lady beetle), Carabidae (*Ophionea nigrofasciata* (ground beetle), and Staphylinidae (*Paederus fuscipes* (rove beetle). *O. nigrofasciata* beetle were predators to brown planthopper, whitebacked planthopper, green leafhopper and larvae of leaf folder. *Coccinella* sp. beetle was predator polyphage prey to brown planthopper as its main prey as well as predators of eggs of leaf folder. *P. fuscipes* prey to brown planthopper and newly hatched larvae of rice stem borer. The natural enemies captured in the light trap was very importance data, because Sharma and Bisen (2013) [8] reported that the trap catch data provide valuable information on biocontrol agents (predatory) active in ecosystem. The spiders and *Cyrtorihnus lividipennis* as natural enemies not found in the light trap, although in the 1900s *C. lividipennis* were caught in light trap of 25 watts, except spiders.

3.1 The electric light traps of mercury (ML-160 watt) BSE-G3 model

The meteorological factor of temperature of soil surface at 0 cm (St) was positive correlated significant with *Coccinella* sp. (Coc) that captured on mercury lamps. Evaporation factors, light intensity, wind velocity, rainfall and air temperature were positive correlated insignificant with the occurrence of flight of *Coccinella* sp. which captured on mercury lamps, whereas relative humidity was negative correlated insignificant with occurrence of *Coccinella* sp. (Table 1).

The regression equation between *Coccinella* sp. with temperature of soil surface at 0 cm (St) was:

$$Coc_{mercury} = - 36.65624 + 1.51267\ St.$$
$$R^2 = 0.1731;\ Adj.\ R^2 = 0.1488$$

In the regression equation the coefficient of determination R^2 only 17.31% not much different from adjusted R^2 (corrected by degree of freedom) only 14.88% explain flight of *Coccinella* sp. was affected by temperature of soil surface at 0 cm.

The *Coccinella septempuncate* L. beetle is active during the day and is sensitive to light as a response of Circadian rhythm which is an endogenously formed biological rhythm. Illumination and temperature serve as modifying factors for the pattern and amplitude of the circadian rhythm of light sensitivity [9].

The annual flights on *Coccinella* sp. influenced by hot temperatures as a major factor, with warm temperatures as the initial defender for flight, on the other hand the second factor causing long distance dispersion is the low prey (aphid) as food [10].

Table 1: The correlation of weather factors with natural enemies flights on 160 watt mercury lamps

Weather Factors	*Coccinella* sp.	*O. nigrofasciata*	*P. fuscipes*
Evaporation (mm/day)	0.13962 0.4167	-0.03350 0.8462	0.21722 0.2032
Light intensity (calori/cm^2)	0.09568 0.5788	-0.09909 0.5653	0.11323 0.5108
Wind velocity (km/hour **	0.23242 0.1725	-0.01559 0.9281	0.21004 0.2189
Air temperature (^{o}C)**	0.04356 0.8009	0.04981 0.7730	0.22553 0.1860
Relative humidity (%)**	-0.22111 0.1950	0.10685 0.5351	0.01543 0.9288
Rainfall (mm/dasarian)	0.09297 0.5897	0.01090 0.9497	-0.05240 0.7615
Temperature of soil surface at 0 cm (^{o}C)**	0.41607* 0.0116	0.09019 0.6009	0.23411 0.1693

Remarks: Numbers in one column: Upper part is the partial correlation coefficient, lower part is the probability. *The correlation coefficient significantly when the probability is smaller than prob. 0.05, **Measurements on. 17.49 o'clock of Western Indonesian time

The meteorological factors of air temperature and relative humidity, precipitation, and temperature of soil surface at 0 cm were positive correlated insignificant with the occurrence of *O. nigrofasciata* flight captured by mercury lamps, whereas evaporation, light intensity, wind velocity were negative correlated insignificant with *O. nigrofasciata* (Table 1).

Evaporation meteorological factors, light intensity, wind velocity, air temperature, relative humidity, temperature of soil surface at 0 cm were positive correlated insignificant to the occurrence of *P. fuscipes* flight that captured by mercury lamps, while rainfall was negative correlated insignificantl to occurrence of *P. fuscipes* flight (Table 1). This insignificantly correlation is suspected that the *P. fuscipes* flight is more affected by the light. This case related with the others beetle *Paederus sp*. were attracted to black light sources at 18.00-06.00 they are *P. protensus, P. columbinus, P. brasiliensis*, and *P. mutans*. The variations of night temperature, relative humidity, wind speed, cloud, and moon phases do not appear to affect *Paederus* sp. flight [11]. Baehaki *et al*. (2017) [12] reported the flight *P. fuscipes* only 34.71% were explained by abundance of the brown planthopper, yellow stem borer, pink stem borer, leaf folder and black bug that caught on the light trap. of mercury (ML-160 watt) BSE-G3 models. The flight *Coccinella* sp that caught on the light trap about 43.65% were explained by the abundance of the brown planthopper, yellow stem borer, pink stem borer and leaf folder. In the other hand the flight of *O. nigrofasciata* did not determined by the flight of rice pests because the coefficient determination was negative [12].

3.2 The Solar cell light trap (CFL-20 watt)

The meteorological factors of rainfall (Rf) and relative humidity (Rh) were negative correlated significant with the occurrence of *Coccinella* sp. (Coc) that captured on CFL lamp. Evaporation factor, light intensity, air temperature, and temperature of soil surface at 0 cm were positive correlated insignificant to the occurrence of *Coccinella* sp. flight, while wind velocity was negative correlate insignificant with occurrence of *Coccinella* sp. (Table 2).

The regression equation between *Coccinella* sp. with relative humidity and rainfall was:

$$Coc_{CFL} = 98.71365 -1.035148\ Rh -0.35574\ Rf$$
$$R^2 = 0.4873;\ R^2\ Adj. = 0.4361$$

In the regression equation the coefficient of determination R^2 reach 48.73% not much different from adjusted R^2 that was 43.61% to explain flight of *Coccinella* sp. in CFL lamps is affected by relative humidity and rainfall.

Evaporation factor, air temperature, relative humidity, and temperature of soil surface at 0 cm were positive correlated insignificant to the occurrence of *O. nigrofasciata* flight, while light intensity, wind velocity, rainfall were negative correlated insignificant with the occurrence of *O. nigrofasciata* flight (Table 2).

Table 2: The correlation of weather factors with natural enemies flights on CFL 20 watt

Weather Factors	Coccinella sp.	*O. nigrofasciata*	*P. fuscipes*
Evaporation (mm/day)	0.19791 0.3653	0.00599 0.9783	-0.22756 0.2964
Light intensity (calori/cm^2)	0.21832 0.3169	-0.01361 0.9509	-0.39039 0.0655
Wind velocity (km/hour **	-0.08831 0.6886	-0.18613 0.3951	-0.07092 0.7478
Air temperature (^{o}C)**	0.39448 0.0625	0.02821 0.8983	-0.36096 0.0906
Relative humidity (%)**	-0.68092* 0.0003	0.13262 0.5463	0.18527 0.3974
Rainfall (mm/dasarian)	-0.56976* 0.0045	-0.04774 0.8287	0.13365 0.5432
Temperature of soil surface at 0 cm (^{o}C)**	0.34132 0.1109	0.09447 0.6681	-0.10880 0.6212

Remarks: Numbers in one column: upper part is the partial correlation coefficient, the lower part is the probability. *The correlation coefficient significantly when the probability is smaller than prob. 0.05, **Measurements on. 17.49 o'clock of Western Indonesian time

In this study the evaporation was calculated in each 1 day and the light intensity was measured at 6.49' o'clock, while wind speed, air temperature, relative humidity, rainfall and temperature of soil surface at 0 cm were measured at 17.49' o'clock when the insects started flight at night. Description results of research and literature shows that weather factors can have a positive or negative impact on the flight of pests and natural enemies that capture on light trap. It is difficult to find direct causes and relationships due to one factor to pest activity because the effects of weather factors on insects are usually interrelated one to another factors. The influence of weather factors is not fixed and uncertain, because of the discussion sometimes the weather factor is the opposite effect between research one with other research. The difference in effect is due to differences in place, time, and natural enemy population during normal conditions and during pest explosions. The abundance of natural enemies fly that captured on the light trap is due to a resultant of weather parameters or agroecosystem changes.

The results showed that the evaporation factor, wind velocity, light intensity, air temperature, relative humidity, rainfall and ground surface temperature of 0 cm were insignificant effect on the flight of *O. nigrofasciata* and *P. fuscipes* captured on both mercury and CFL light trap. From this data indicates that *O. nigrofasciata* and *P. fuscipes* are genuinely nocturnal predators whose flight is almost entirely influenced by light. Huang *et al*. (2009) [13] reported that the *P. fuscipes* beetle explosion was due to a suitable environment, light, moisture and lack of food in the crop.

The explosive character of nocturnal predators is supported by information from several countries of Sierra Leone, Sri Lanka, Brazil, Iran, Iraq, Turkey, Italy, China, and Indonesia. The information from the country showed that predator *P. fuscifes* caught in some places such as factories, hospitals, hotels and houses that emit lamp lights. Paederus or tomcat that comes in people's houses have negative effects caused irritation of the skin that called *P. dermatitis* (linear dermatitis) due to skin contact with hemolymph *P. fuscipes*, as happened in 2012 that tomcat attack in Surabaya-Indonesia. This beetle does not bite or sting, but accidental brushing against or crushing the beetle over the skin provokes the release of its coelomic fluid, which contains paederin ($C_{25}H_{45}NO_9$) is a toxic amide in the hemolymph of the genus Paederus, a potent vesicant agent. Symptoms can be like linear erythematous patches with central blisters, stellate patch of erythema with central blisters, and two small patches of erythema with erosions [14]. The toxin is not produced by Paederus itself but is produced by endosymbiont bacteria suspected from the Pseudomonas species (http://upikke.staff.ipb.ac.id/2012/03/20/fenomena-tomcat-atau-dermatitis-paederus/).

Meteorological factor of temperature of soil surface at 0 cm significantly positive correlated with *Coccinella* sp. which captured by mercury lamps ML-160W (Mercury Lamp, Philips) colored cool daylight white light, luminance of 3150 lm, and the voltage of 220-230 V. The occurrence of the *Coccinella* sp flight caught with CFL-20 Watt lamps cool daylight in color, luminance of 1200 lm, long life rays for 10 hours, the voltage of 220-240 VAC, and the power capacity is 20 Watt were significantly negative correlated with rainfall and relative humidity. From the appearance of the two light traps indicate that the flight Coccinella sp. determined by the environmental resultant between weather factors, lamp light capacity, and luminous power.

The effect of different colors on a light trap catches have been tried in six colors: blue, green, yellow, red, black and white. The highest number of insects observed in black light (UV light), while the lowest in red light, but generally the order of insects that often visit all the colored lights are Diptera, Coleoptera and Lepidoptera [15]. This fact related with a black light lamp (ultra violet), is the most attractive light source to *Paederus* sp., as well as moonlight attract predators, because the lowest catch occurs on the full moon [16]. Paederus beetle interested to black light source starting at 18:00 to 06:00, as well as the maximum temperature at night and low humidity affects the dipersal of the beetle [11].

On the other hand, Sharma and Bisen (2013) [8] reported that natural enemies of *Coccinella* sp. of the Coccinellidae family are attracted to a 15 watt ultra violet trap lamp. Likewise two predators coccinellid (*Harmonia axyridis* and *Propylea japonica*) and three chrysopids (*Chrysopidae* spp.) are most abundant in light trap [17]. Coccinelid captured by black lights at one hour after sunset until midnight was the most *Harmonia axyridis* and accompanied by species of *Coleomegilla maculata*, *Hippodamia convergens*, *C. septempunctata* [18]. Coccinella beetles are generally more sensitive to ultraviolet light (340 nm) and red light (649 nm) compared to green light (510 nm) or white light. The beetle response at various wavelengths is greater at high light intensity than in dim light (10 luks), so the phototactic response to the intensity of the illumination correlates with the wavelength of light [19]. Predator flight is also determined by the population of flying prey. Individual flights of *Coenosia attenuate* are influenced by environmental factors such as increased temperatures, number of prey flying and prey density of *Trialeurodes vaporariorum* [20]. Jeffries *et al*. (2013) [10] reported that the *Coccinellid* (*C. septempunctata* and *Harmonia axyridis*) can fly as far as 18 km and the peak of the flight is influenced by high temperatures in mid-summer and warm temperatures as the main driver of the flight of ladybugs.

The highest number of Coleoptera catches at 20:00-22:00 and Lepidoptera at 2:00-04:00 o'clock, while predatory insects are caught by light trap evenly throughout the night. From the light traps data can be regulated a beneficial-friendly trapping strategy was developed to reduce the numbers of beneficial insects trapped, which was based on differences in the nocturnal flight activity of pests and beneficial insects [17]. The light trap of solar cell (CFL-20 watt) used for monitoring of immigrant and emigrant pests, whereas electric light trap of mercury (ML-160 watt) BSE-G3, of BSE-G4 model, and BSE-Giant models used for monitoring and reducing of immigrant and emigrant pests [6]. Furthermore Baehaki *et al*. (2017) [12] reported those light traps reduce of rice pests population, but do not reduce population of predators and do not disturb to predators performance.

Integrated pest management requires efforts to urge insect pests to be actively captured on the mercury or CFL light trap. The effectiveness of the trap can be improved if the light of the lamp is set to its wavelength adjusted to the pest's interest. On the other hand, it is necessary to adjust the lighting time according to the character of flying time of the pest and natural enemies, in order to be maximum capture of pests, but minimum to captured of natural enemies.

4. Conclusions

Weather factors such as evaporation, wind velocity, light intensity, air temperature, relative humidity, rainfall and temperature of soil surface at 0 cm were insignificant effect on the flight of *O. nigrofasciata* and *P. fuscipes* captured by mercury and CFL light traps. The temperature of soil surface at 0 cm factor was positive correlated significant to the *Coccinella* sp. which captured on the mercury lamp, while the occurrence of flight *Coccinella* sp. captured on CFL lamp were negative correlated significant with rainfall and relative humidity. From the appearance of the two light traps indicate that the flight *Coccinella* sp. were determined by the environmental resultant between weather factors, lamp light capacity, and luminous power.

5. Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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