Diversity of Pest Insects in Paddy Field Cultivation: A Case Study In Lae Parira, Dairi

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Abstract: The aim of study to determine insect diversity studies were conducted in paddy plots in Lae Parira Village, Dairi. Eight sampling visits consits of 4 phases, starting from the seedlings phase, flowering phase, milky phase and ripening of the grains phase. There are four sampling methods were used, i.e. sweeping net, sticky yellow trap, and core sampler. A total of 1365 individuals of insects, representing 37 species in 24 families and 8 orders. The most abundant insects were *C.medinalis* (178), *M.vittaticcollis* (83), *N.viridula* (81), *N.lugen* (78), *L.oratorius* (73) and *S.coarctata* (71). Family of Crambidae (Lepidoptera), Gryllidae (Orthoptera) and Pentatomidae from order Hemiptera and recorded the highest number of individuals for the whole study period, respectively. The comparison insects used three tools such as sweeping net (482 individuals), sticky yellow trap (730), core sampler (89) and pit fall trap (64). For the total sampling period, the biological indices calculated consist of Richness Margaleff (R1) is 1.84, Richness Menhinick (R2=0.79), the Shannon-Wiener diversity index (H') is 2.26, Shannon-Weiner evenness index (E) is 0.65 and index similarity Jaccard (Cj=0.68) respectively. However, no significant differences between the sampling sitesand growth phases of paddy cultivation with diversity of insects (p>0.05). Results indicated that diversity of pest insects in paddy field cultivated ensured a good balance between the populations of pests, beneficial insects (predators and parasitoids) of paddy development. Diverse of insects can be potential effective way to conserve, use and enhance biodiversity to sustainable food security in agricultural ecosystem in Lae Parira, Dairi.

Keywords: *Diversity, Pests Insect, Paddy, Cultivation, Traps, Lae Parira, Dairi*

I. INTRODUCTION

In Indonesia, paddy cultivation is an economically important agricultural activity terms for support national food security. There are adopted scientific techniques are being tested and by the local farmers each year to increase the quality and yield of the rice crop. According to (1,2), the paddy cultivation is still faced with various limitations ranging from climate, soil type and fertility, water supply, irrigation, pest and disseases problems. Meanwhile, (3) describes the increase has been achieved largely by higher yielding varietes of rice, high levels of fertilizer use, greater mechanization of farming, and widespread use of pesticides and herbicides. According to (4) The paddy field ecosystem is the main habitat for insects which utilize the paddy crop as their food source, from the seedlings to the harvesting phases in the rice field plantation.

The diversity and abundance of insects vary in the paddy ecosystem as well as the growth stages of the paddy plantation. Biological studies have been conducted on the various groups of insects found in the paddy field, which predating on the rice crop and weeds as well as their parasites, pests and predators (5). There are several natural predators in the rice fields that if conserved, can play an effective role in decreasing the pest population density (6,7). Several pests cause damage and yield loss on this crop (8). Pesticides can control many of the rice pests, but because of environmental risks, crop infection and killing of benefial insects (natural enemies and pollinators) are not efficient and safe method (9). Biocontrol, used of larva and adults Odonata are considered efficient predators in the rice fields (10,11). The carnivorous and voracious odonate larvae occupy at the apex of food chain of invertebrate life. The adults of Odonata as predators of pests of crops and plantations (12, 13).

The main objective of this study was to determine the diversity and population abundance of insects during the growing stages of the paddy plants in relation to biological control and sustainable management of the paddy crop. This study reports on the diversity of the insect in the paddy plots cultivated in Lae Parira Village, Dairi.

II. MATERIALS AND METHODS

A. Description of the study site

The study site, is a privately owned paddy field in Lae Parira, Dairi with situated altitiude 020 47' 06.44" and longitude 980 13'04.78" with 777 above sea level (asl) in the district of Sumbul, Dairi, Indonesia. The paddy plots have been cultivated for two consecutive seasons in a year. The surrounding land use comprises rural settlement interspersed and agroforestry with coffee plantation, rubber plantation, caccao plantation, etc.,covering an area of about 42.75 km^2 (Figure 1).

Figure 1. The map of Lae Parira Village, Sumbul District, Dairi

A. Methodology

The procedures used in this study include collecting of insect samples from the paddy field, specimen preservation, preparation and identification at the laboratory Pests and Diseases, Faculty of Agriculture USU, Indonesia. Eight sampling visits were conducted during April to August 2017, consist of phase 1 (active tillering stage); phase 2 (flowering stage); phase 3 (milky stage); and phase 4 (ripening stage). Five sampling methods were employed, namely the use of sweeping nets, yellow sticky traps, and pitfall traps.

For the sweeping net method, the paddy plots are randomly swept by a sweeping net in a zig-zag manner for a total of 100 sweeps per plot 3. The yellow sticky trap is made up of a sticky stiff cardboard (10 x10 cm) painted on both sides with a strong glue and pegged onto a short stick placed upright in the paddy plot. Flying insects are attracted to the food bait in the glue and get trapped onto the sticky surface of the cardboard. The opening is covered with a slightly raised lid to keep out predators and to prevent trapped animals from drowning when it rains. Insects, which are accidently trapped and drowned in the glass vessel, are collected every 48 h (2,4).

In sampling site in Lae Parira village, Dairi, specimens collected in the field are sorted, some being wet preserved in 75% alcohol, while others such as dragonflies and lepidopterans are preserved as dry specimens, later to be pinned and oven-dried at 40-45°C in the laboratory. Most of the specimens are identified up to the order and family levels while others are identified up to the species level, with the aid of standard references and by cross-referencing with type specimens from the recorded from (14-20), where they are pinned, oven-dried, identified, labeled and classified in the laboratory of Pests and Diseases of Plantation, Faculty of Agriculture.

B. Data analysis

Insect diversity and richness over the sampling period are determined by the Margalef (R1) and Menhinick richness index (R2), Shannon-wiener diversity index (H’), Simpson diversity index (1-D), Shannon Eveness (E) and Similaritas Jaccard (Cj) while significant differences between the insect populations in the paddy plots are statistically determined by the one-way ANOVA test used SPSS version 24.00 (21).

III. RESULTS AND DISCUSSIONS

The composition insects collected during the eight sampling visits at the Lae Parira Village, Sumbul district, Dairi yielded a total of 1365 insects, representing 37 species in 24 families and 8 orders. The higher percentage of insects in the paddy field recorded from *Cnaphalocrocis medinalis* (13.04%), followed by *Metioche vittaticollis* (6.08%) and Nezara virudula (5.93%), while the lowest percentage of insects consist of *Melanitis leda* (0.44%) , *Diplacodes trivialis* (0.37%) and *Spodoptera mauritia* (0.36%).

Table 1: List of insects collected from the paddy field in Lae Parira, Dairi

Order	Family	Species	Status	Specimen	Percentage
Aranea	Lycosidae	*Tetragrantha sp*	Predator	68	4.98
Coleoptera	Belostomatidae	*Pachybracius pallicornis*	Pest	24	1.76
Coleoptera	Belostomatidae	*Lepthocerus indicus*	Pest	17	1.24
Coleoptera	Coccinellidae	*Coccinella septempunctata*	Predator	38	2.78
Coleoptera	Coccinellidae	*Micrapis discolor*	Pest	65	4.76
Coleoptera	Chrysomelidae	*Leptispa sp*	Predator	14	1.02
Coleoptera	Scarabidae	*Anomala pallida*	Pest	22	1.61
Coleoptera	Staphylidae	*Paederus sp*	Predator	49	3.59
Diptera	Hesperidae	*Argyrophylax nigrotibialis*	Parasitoid	9	0.65
Diptera	Ephydridae	*Hydrellia sp*	Pest	43	3.15
Diptera	Muscidae	*Musca domestica*	Pest	14	1.02
Hemiptera	Chrysomelidae	*Nephotettix sp*	Pest	65	4.76
Hemiptera	Coreidae	*Lepticorisa oratorius*	Pest	73	5.34
Hemiptera	Coreidae	*Riptortus linearis*	Pest	47	3.44
Hemiptera	Delphacidae	*Nilaparvata lugens*	Pest	78	5.71
Hemiptera	Pentatomidae	*Nezara viridula*	Pest	**81**	**5.93**
Homoptera	Pentatomidae	*Scotinophara coarctata*	Insect	71	5.20
Hymenoptera	Formicidae	*Gryllotalpa orientalis*	Pest	9	0.65
Hymenoptera	Gryllotalpidae	*Componotus* sp.	Predator	10	0.73
Lepidoptera	Crambidae	*Cnaphalocrocis medinalis*	Pest	**178**	**13.04**
Lepidoptera	Crambidae	*Scirpophaga incertulas*	Pest	12	0.88
Lepidoptera	Crambidae	*Scirpophaga innotata*	Pest	17	1.24
Lepidoptera	Noctuidae	*Spodoptera mauritia*	Pest	**6**	**0.44**
Lepidoptera	Nymphalidae	*Melanitis leda*	Pest	**5**	**0.36**
Lepidoptera	Pyralidae	*Chilo supressalis*	Pest	31	2.27
Lepidoptera	Pyralidae	*Sesamia inferens*	Pest	21	1.53
Lepidoptera	Pyralidae	*Scirpophaga incertulas*	Pest	14	1.02
Orthoptera	Acrididae	*Oxyca chinensis*	Pest	41	3.00
Orthoptera	Gryllidae	*Metioche vittaticollis*	Pests	**83**	**6.08**
Orthoptera	Tettigoniidae	*Atractomopha crenulata*	Predator	42	3.07
Orthoptera	Tettigonidae	*Conocephalus longipennis*	Predator	24	1.76
Odonata	Coenagrionidae	*Agriocnemis pygmaea*	Predator	19	1.39
Odonata	Coenagrionidae	*Ischnura senegalensis*	Predator	19	1.39
Odonata	Libellulidae	*Acisoma panorpoides*	Predator	20	1.46
Odonata	Libellulidae	*Diplacodes trivialis*	Predator	**5**	**0.37**
Odonata	Libellulidae	*Pantala flavescens*	Predator	14	1.02
Odonata	Libellulidae	*Orthetrum sabina*	Predator	17	1.24

From the active tillering stage of paddy plant growth until the flowering stage (April 2017 until June 2017), the family Crambidae showed the highest recorded population, followed by Pentatomidae, Delphacidae and Coreidae. These four families also had the most abundant insect population for the entire growing period of the paddy crop described into Table 1. According to (22), *Scotinophara coarctata* was the dominant pentatomid beetle species found in the paddy area, probably due to the high adaptive capacity of this species. During its 200-day lifespan, *S. coarctata* predated on the paddy plants at the various stages of its development, but it was most predominant at the active tillering stage of the paddy plants. Then in paddy field recorded the *S. coarctata* collection as many as 71 individual (5.20%) in Lae Parira village, Dairi

Likewise, the family of Crambidae (Lepidoptera), Gryllidae (Orthoptera) and Pentatomidae from order Hemiptera and recorded the highest number of individuals for the whole study period, followed by Delphacidae and Coreidae (order Hemiptera) respectively. They are the main pests of paddy, particularly the sap feeders, which also act as vectors and carriers of viral diseases of paddy (22, 23, 24). Overall insect diversity in the field, during the growing period of the paddy crop as indicated is abundant and very diverse in Lae Parira village, Dairi. Table 1 shows that the sap feeders *L.oratoria* and *N. viridula* are the main herbivorous pests of paddy in the vegetative and early flowering stages. The carnivorous insects or natural enemies of paddy pests comprised members of the orders Hymeoptera, Coleoptera and Diptera. However, the ratio of the carnivorous to the pest species indicates that the number of the former was insufficient to control the population of pest insects in the study plots.

Otherwise, the six of insects were categorized into dominant species of paddy field in Lae Parira, Dairi described into Figure. There are *C.medinalis* (178 individuals), *N.lugen* (78), *M.vittaticollis* (83), *L.oratorius* (73), *N.viridula* (81), and *S.coarcata* (71).

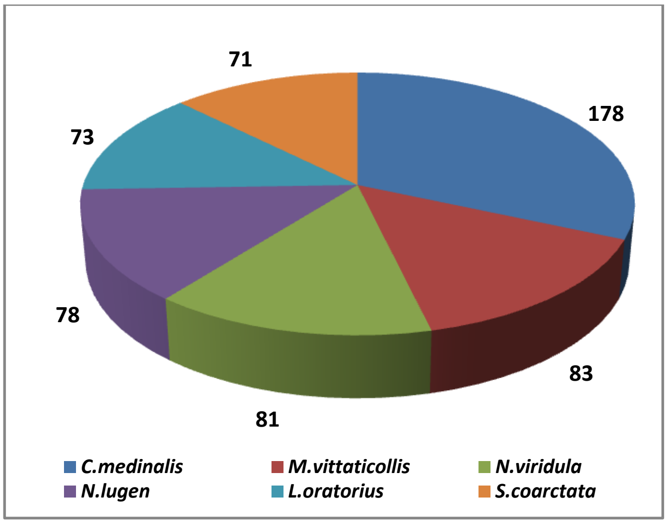

Figure 2. The dominant insects pest of paddy fieldin Lae Parira, Dairi

According to (23) noted in their study of this pest species in the Philippines that the beetle incurred serious damage to the rice crop, inflicting a net yield loss of 15-20%. Adults and larvae of *S. coarctata* usually attack the basal parts of the paddy plant, especially during daytime. Other species from the family Pentatomidae such as *Nezara viridula* have also been identified as dominant pests of paddy, sucking sap from the basal parts and causing growth retardation and yellowing of the stems and leaves. However, assumsed these pests only accounted for about 1% infestation of the paddy area in Indonesia (4, 24, 25, 33).

Several species belonging to the family Coccinellidae, Lycosidae, Tettigonidae, Coenagrionidae, Libellulidae were found to be dominant predators (i.e. beneficial insects) of paddy pests in plots paddy field of Lae Parira, Dairi. These species act as important biological control agents in the paddy field, thus avoiding the need for excessive use of chemical pesticides. Such as some dragonfly can use for Most members of *Argyrophylax nigrotibialis* are prevalent in the paddy habitat and a few species are useful parasitoids of the folded-leaf larvae, thus helping in reducing damage to the paddy plants (1, 25). When plants are under attack by insect herbivores, the plants begin to emit specific odorous volatiles that signal parasitic wasps to locate their host caterpillar larvae (26, 27). In the current study, *Micrapis discolor* and *Lemnia biplagiata* (Coccinellidae) were widely distributed.

The most important biological control agents in the paddy plots as predators of the main pest, *Nilaparvata lugens* larvae (28). *Nilaparvata lugens* or the brown planthopper outbreak is currently prevalent in Indonesia, Thailand and Phillippines. It had caused one of the biggest economic losses in rice production in the last five years. Possible causes could be the excessive use of urea as the nitrogenous fertilizer which increased the fecundity of the brown planthopper and the use of insecticides that reduced the population of the natural predators (4, 29, 33).

In most rice fields of Asia the increase in population of major insect pests such as planthoppers (*Nilaparvata lugens and Sogatella furcifera*), leaffolders (*Cnaphalocrocis medinalis*), and stem borers (*Scirpophaga incertulas, Chilo suppressalis, S. innotata, C. polychrysus* and *Sesamia inferens*) has been related to the longterm excessive use of nitrogenous fertilizers (30). Since used of traps and biological pesticide to control of *N. lugens* in paddy field, it can be concluded that the existing predators were highly effective in controlling the brown planthopper pests. During the sampling visits, the percentage abundance of insects decreased in tandem with the developmental stages of the paddy plants. However, other factors also played a role in affecting the population profile of the pest and non-pest insects, and these included the populations of prey and predator insects and vertebrates (e.g. birds, frogs and fishes), life cycle of each species, vegetation, sampling period, time (day or night), rainfall pattern and other meteorological factors. Furthermore, most orders of insects have close correlations with climate, food, and pathogens that can influence their daily activities and life cycles (17).

Warm climate and active vegetative growth phase of the host plants would stimulate insect development and abundance because of the availability of abundant food and optimum temperature for their proliferation (31). The proximity of forest vegetation to the paddy area could also influence the distribution pattern of insects, where their diversity would increase due to the abundance of a reservoir of host plants (32). However, the total number of competitors and enemies for the various Types of insects is in natural equilibrium, where reduced usage of pesticides and agrochemicals under the paddy cultivation has facilitated the adaptive balance between the herbivorous, carnivorous and omnivorus insect groups and this is crucial in controlling pestilence and pest outbreaks in the agricultural area (4, 31). The comparison insects used three tools such as sweeping net (482 individuals), sticky yellow trap (730), core sampler (89) and pit fall trap (64) can seen into Figure 3 below.

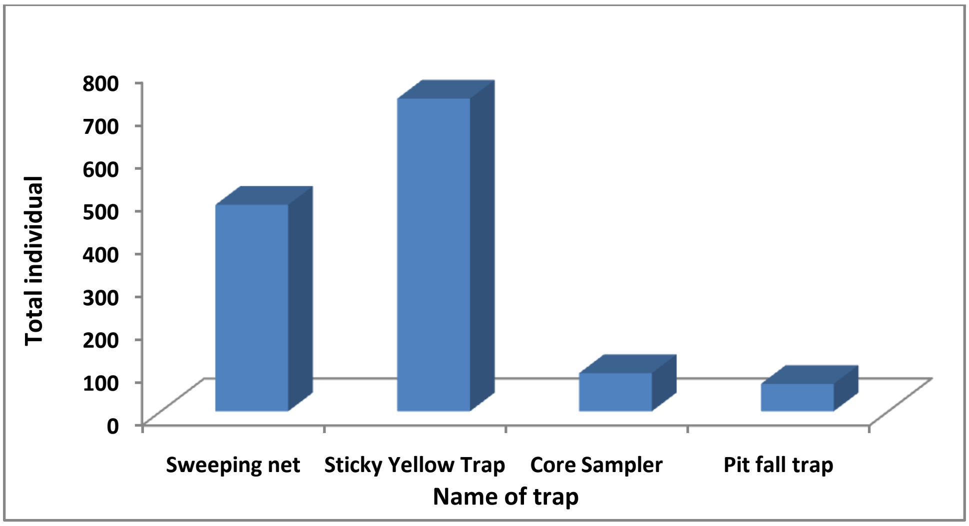

Figure 3. Comparion diversities of insects used three tools in paddy field, Lae Parira village, Dairi

Biological indices of insects of paddy fields in Lae Parira village, Dairi calculated were Richness Margaleff (R1) index value is 1.84, Richness Menhinick (R2=0.79), the Shannon-Wiener diversity index (H') value is 2.26, Shannon-Weiner evenness index (E) value is 0.65 and Similarity Jaccard (Cj) values is 0.68 at decreased in tandem with the growth stage of the paddy plants (Table 3). The Margalef richness index was relatively high for the overall insect population

(R1=1.84, R2=0.79). It can be concluded that the overall abundance, evenness and richness of insect population in paddy plots decreased in relation to the growth stage of the paddy plants from early growth to the ripening stage. Nevertheless, the T-test and one-way ANOVA did not show any significant difference ($p > 0.05$) in insect abundance between the paddy plots and the growth phases of the paddy plants.

Tabel 2. Biological indices of insects in paddy fields in Lae Parira village, Dairi

Name indices	Value	Categorized
Richness Margaleff (R1)	1.84	Good
Richness Menhinick (R2)	0.79	Good
Diversity Shannon-Wiener (H')	2.26	Moderate
Diversity Simpson (1-D)	0.74	Good
Eveness Shannon (E)	0.65	Good
Similaritas Jaccard (Cj)	0.68	Good

Both the indices show which the species richness, eveness and diversities was moderate in paddy field of Lae parira Village, Dairi. The diversity of Order of aquaatic insetcs were found very high variation in H' values (34).

Minimum insecticide application using Matador and Mipsin, then herbicide used by Rhodiamin and Ally in manik Rambung for two zones, lowland and terrace. According to (14) has discussed the cycling of organic and inorganic materials in modern rice farming in Japan, which treats it as an industry, as a threat to ecological stability and contrary to the long-term goals of human welfare. Succesion of the insect community structures in rice fields follows the patterns of water availabilty and phrases of rice growth (9). Odonata are striking aquatic and aerial component of wetland environment, in term of both biomass and their influence as predators. Then large amount of fertilizers and herbicides were applied to the actively growing rice plants. Nutrients availability coupled with high penetration of sunlight resulted in high production of organisms in the paddy plantation. The abundance of food resulted in proliferation of prey species which eventually led to an increase in predator abundance, it has been reported that the mean total density of macroinvertebrates was positively correlated with the densities of predators such as odonates and predatory midges (32).

CONCLUSIONS

In conclusion, the organic cultivation of paddy under the System of Rice Intensification (SRI) supported a high diversity of insects, represented by 34 species in 21 families and 8 orders in the study plots of Lae Parira, Dairi and these comprised members of Homoptera, Hymenoptera, Coleoptera, Orthoptera, Odonata, Lepidoptera, Hemiptera and Diptera. The highest population abundance was recorded for the Orthoptera (22.9%), while the highest species diversity was found in the Lepidoptera (13.8%). The overall insect diversity and richness decreased in tandem with the growth phase of the paddy plant, and although the overall population abundance of insects increased with the growth and development of the paddy plants, there were no significant difference recorded between plots and sampling visits ($p > 0.05$).

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References

[1] Uphoff, N. 2004. Development of the System of Rice Intensification in Madagascar in participatory research and development for sustainable agriculture and natural resource management: (http:// sri.ciifad.cornell.edu/).

[2] Yano, K. 1978. Faunal and biological studies on the insects of paddy field in Asia. Part 1. Introduction and Sciomyzidae from Asia (Diptera). Esakia **11**:1-27.

[3] Preap, V., Zalucki, M. P., Nesbitt, H. J. and Jahn G. C. 2001. Effect of fertilizer, pesticide treatment, and plant variety on realized fecundity and survival rates of *Nilaparvata lugens* (Stal); Generating Outbreaks in Cambodia. Journal of Asia Pacific Entomology **4**(1):75-84.
[4] Siregar, A.Z., Che Salmah Md. Rawi, and Zulkifli Nasution. 2017. Dynamics of aquatic organisms in a ricefield ecosystem: effects of seasons and cultivation phases on abundance and predator prey interactions. *Tropical Ecology* **58 (1)**: 177-191.
[5] Borror, D. J., De Long, D. M. and Triplehorn, C. A. 1981. An Introduction to the Study of Insects, (5th Ed.). Saunders College, Philadelphia. 827p.
[6] Mohyuddin, A.I. 1990. Biological control of *Chilo* spp in maize, sorghum, and millet. Insect Sci.Applic. 11: 721-732.
[7] Bonhof, M.L.Overholt, W.A. Van huis A & Polaszek, A. 1997. Natural enemies of cereal stemborers in east Africa: A review. Insect Sci. Applic. 17: 19-35.
[8] Datta, S.K. & Kush, G.S. 2002. Improving rice to meet foodand nutrient needs: Biotechnology approaches. Journal of Crop Production 6: 229-247.
[9] Heckman, C.W. 1979. Rice field ecology in north-eastern Thailand. The Hague: Junk.
[10] Khan, Z.R. Litsinger, J.A., Barrion, A.T., Villanueva, F.F.D., Fernandez, N.J. & Taylor, L.D. 1991. World bibliography of rice stem borers 1974-1990. International Rice Research Institutre and International Centre of Insect Physiology and ecology.
[11] Alonso Mejia, A. & Marquez, M. 1994. Dragonfly predation on butterflies in a tropical dry forest. Biotropica 26: 341-344.
[12] Kandibane, M, Raguraman, S. and Ganapathy, N. 2005. Relative abundance and diversity of Odonata in an irrigated rice field of Madurai, Tamil Nadu. Zoo's Print Journal 20 (11): 2051-2052.
[13] Siregar, A.Z and Darma Bakti. 2016. Diversity And Distribution Of Odonata In University Sumatera Utara, Medan, Indonesian. International Journal of Scientific and Technology Research 5(5); 229-234.
[14] Arai, Y. 1996. Adapatation of red dragonflies in Japanese paddy fields. The N. Insects 31 (8): 23-26.
[15] Asahnia, S .1979. An illustrated key to the dragonflies found in the padddy field of Thailand. IABCR-NEWS No.4.
[16] Barlow, H. S. 1982. An Introduction to the Moths of South East Asia. The Indonesian Nature Society, Kuala Lumpur. 305 p.
[17] Barrion, A.T. & J.A. Litsinger. 1994. Taxonomy of rice insect pests and their arthropods parasites and predators. In Heinrichs EA (Ed.). Biology and management of rice insects. Wiley Eastern Limited. New Age International Limited, New Delhi. Pp. 13-359.
[18] Carter, D. J. 1992. Butterflies and Moths (Eyewitness Handbooks). Dorling Kindersley Limited, London. 304 p.
[19] Orr, A.G. 2005. Dragonflies of Peninsular Malaysia and Singapore. Natural History Publications (Borneo), Malaysia. Pp.1-125
[20] Shanti Susanti. 1998. Mengenal Capung. Puslitbang Biologi-LIPI, Jakarta. Pp.1-81.
[21] Southwood, T. R. E. and Henderson, P. A. 2000. Ecological Methods (3rd Ed.). Blackwell Science, Oxford. 592 p.
[22] Adalla, C. B. and Alzona, F. D. 2007. Management of Malayan rice black bugs in the Philippines. In: Joshi, R. C., Barrion, A. T. and Sebastian, L. S. (Eds.). Rice Black Bugs. Taxonomy, Ecology, and Management of Invasive Species. Philippine Rice Research Institute, Science City of Muzoz, Philippines, pp. 427-434.
[23] Joshi, R. C., Barrion, A. T. and Sebastian, L. S. (Eds) 2007. Rice Black Bugs. Taxonomy, Ecology, and Management of Invasive Species. Science City of Muñoz, Nueva Ecija: Philippine Rice Research Institute. p. 1-793 Journal of Food, Agriculture & Environment, Vol.11 (3&4), July-October 2013 2865
[24] Siregar, A. Z., Che Salmah Md. Rawi, and Zulkifli Nasution**.** 2009. A Survey of Odonata in Upland Rice Field at Manik Rambung, Siantar, North of Sumatera. Jurnal Kultivar 1 (3): 21-30.
[25] Siregar, A. Z. And Indra M. 2016. Biodiversity Insects Used Three Traps Of Upland Ricefields In Simalungun District. *International Journal of Scientific & Technology Research* **6 (02):** 90-95p.
[26] Van Vreden, G. & Ahmadzabidi, A.L. 1986. Pests of rice and their natural enemies in Peninsular Malaysia. Wageningen (Netherlands): Centre for Agricultural Publishing and Documentation (Pudoc). 230 p.
[27] Turlings, T. C. J., Loughrin, J. H., Röse, U., McCall, P. J., Lewis, W. J. and Tumlinson, J. H. 1995. How caterpillar-damaged plants protect themselves by attracting parasitic wasps. Proceeding of the National Academy of Science USA **92**:4169-4174.
[28] Holt. J, Cook, A.G. Perfect, T.J. and Norton, G.A. 1987. Simulation analysis of brown planthopper (*Nilaparvata lugens*) populationdynamics on rice in the Philippines. *Journal of Applied Ecology* **24**:87- 102.
[29] Pinheiro, F., Diniz, I. R., Coelho, D. and Bandeira, M. P. S. 2002. Seasonal pattern of insect abundance in the Brazilian cerrado. Austral Ecology **27**:132-136.
[30] Lu, Zhong-Xian, Yu, Xiao-Ping, Heong, K-L, and Hu, C. 2007. Effect of nitrogen fertilizer on herbivores and its stimulation to major insect pests in rice. Rice Science **14**:56-66.
[31] Menalled, F. D., Marino, P. C., Gage, S. H. and Landis, D. A. 1999. Does agricultural landscape structure affect parasitism and parasitoid diversity. Journal Ecological Society of America **9**:634-641.
[32] Thorp, J.H. & Cothran, M.L. 1984. Regulation of freshwater community structure at multiple intensities of dragonfly predation. Ecol 65 (5); 1546-1555.
[33] Kirk-Springs, A. H. 1990. Preliminary studies of rice pests and some of their natural enemies in the Dumoga Valley, Sulawesi Utara, Indonesia. In: Knight, W. J. and Holloway, J. D. (Eds.). Insects and the rainforests of South East Asia (Wallacea), The Royal Entomological Society of London **30**:319-328.
[34] Metcalfe,J.L. (1989)."Biological Ware Quality Assessment of running Waters based on Microinvertebrate Cmmunities Histor and Present status in europe. Environm.Pollut.6: 101-139.