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RESEARCH ARTICLE

SPECIES DIVERSITY AND ABUNDANCE OF ANTS (HYMENOPTERA: FORMICIDAE) ON TIDAL SWAMP RICE IN INDRAGIRI HILIR, INDONESIA

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Abstract

Indonesia has a high diversity of ant species, but much remains unreported. In agricultural habitats, ants can act as predators, decomposers, and bioindicators for agricultural ecosystems' health. This research aimed to study the species diversity of Formicidae on tidal swamp rice fields in Indragiri Hilir District. Sampling was carried out in two periods of rice planting. Samples were conducted in 4 sub-districts of rice production centers, namely Batang Tuaka, Keritang, Reteh, and Tembilahan Hulu, using four sampling techniques (i.e., insect net, malaise trap, yellow pan trap, and pitfall trap). Diversity index (H'), Species richness index (d), Species Evenness index (J'), and Similarity Index (Is) were calculated. We found 5,754 individuals consisting of 5 subfamilies and 43 species of Formicidae at the four studied areas. Subfamily Myrmicinae has the highest individual abundance, 2,578 individuals, followed by subfamily Formicinae 1,823 individuals, subfamily Ponerinae 776 individuals, subfamily Dolichoderinae 575 individuals, and subfamily Pseudomyrmecinae 2 individuals. Diversity of plant species and environmental factors can affect the diversity index, species abundance, and abundance of individual Ants.

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Introduction:-

Indonesia is a tropical region with a very high diversity of flora and fauna. Indonesia is rich in biodiversity, Indonesia has about 25% of the total insect species in the world, namely 251,109 species of insects as a result of exploration from various islands [1]. Insects are organisms found in nature, but much of their diversity has not been clearly described [2]. Insects are an interesting fauna to study. One of them is an ant.

Ants are social insects that belong to the order Hymenoptera and the family Formicidae. These organisms are known for their regular colonies and nests. Ants are divided into worker, soldier, male, and queen ants. These organisms have approximately 12,000 species scattered in the world, and most of them are in the tropics [3]. In agricultural habitats, ants are insects that have high abundance and community and have many roles, including as predators, decomposers, herbivores, and bioindicators for the health of agricultural ecosystems.

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Some ant species have habitat preferences and respond relatively quickly to environmental disturbances. Environmental disturbances or changes can lead to reduced ant diversity, changes in species composition, and reduced ecological functions played by ants[4]. The trophic potential of ants in the ecosystem is significant in the ecosystem. Ants act as herbivores, predators, omnivores, and detritivores. As detritivores or decomposers, ants play a role in breaking down organic matter into inorganic soil. As predators, ants are the potential to be used as biological control agents in integrated pest management (IPM) programs.

Indragiri Hilir Regency has the most extensive rice harvest area in Riau Province, which is 23.432 Ha, and is also the largest contributor to Riau Province's rice production[5]. Pest attack is the leading cause of not achieving optimal productivity. Thus, it is necessary to carry out integrated pest management. One way is to optimize the role of predator ants in rice cultivation. Ants potentially as predators that become natural enemies of insect pests in rice fields. The first step that needs to be done is to examine the diversity of ant species and their abundance in rice cultivation in the Indragiri Hilir district.

Material and Methods:-

Insect collection:

Ants were collected at two planting periods at each location. In each planting period, the collections were done three times at different rice cultivation stages: before planting, vegetative stage, and generative stage in every location. Before planting, the condition was referred to as the stage before the land was cultivated, and there was still vegetation. In the vegetative stage, Ants was collected when the rice plants were about one month old. In the generative phase, the Ants were collected when the rice plants were about two months old.

In every sub-district, one area of peatland rice with a minimum size of 1.000 x 500 m was assigned as a sampling location. Two transect lines (1.000 m length each) were made in every area with a minimum distance between transect lines of 300 m. There were ten sampling plots (1x1 m) in each line, with a space between sample plots of 100 m. So, in each transect line, there were ten sampling plots. In each plot, the sample plant was determined systematically by making a diagonal line of sub-samples of 1x1 m. Ants were collected using the malaise trap, sweep net, yellow pan trap, and pitfall trap.

Malaise trap:

Malaise trap was installed at each research location, each with one malaise trap. The installation of the malaise trap was based on the wind's direction, which was facing north or south. Generally, insects that are actively flying and foraging prefer light like sunlight. If these insects fly and pass through these traps, the insect is more easily trapped than mounting according to the sun's rise because this trap is designed for insects from the side, not from the front. Trapped insects were collected in a bottle that was filled with 96% alcohol. This trap was installed for one week in each phase of rice cultivation. Then the trapped sample was transferred to the sample bottle and labeled.

Sweep net:

A sweep net was set up on each sample. We did ten double swings. Insects that were caught immediately put into a film bottle containing 96% alcohol. In the laboratory, Ants were separated from other insects, and each morphospecies was separated, then inserted into 2 ml Eppendorf, which contained 96% alcohol for identification purposes.

Yellow pan trap:

Yellow pan trap was used to catch insects interested in yellow. Collecting insects with a yellow pan trap was done by placing one yellow pan trap on each sample bed. The yellow pan trap was filled with detergent water to reduce the water's surface pressure so that the insects that enter will sink and die. Installation of a yellow trap was done in the morning before 09.00 A.M., then taken back in the afternoon. The trapped insects were filtered and taken using a brush so as not to damage parts of the insect. Then the insects were inserted into a film bottle that has been filled with 96% alcohol to be identified in the laboratory.

Pitfall trap:

Pitfall traps are made of used plastic cups of mineral water, which have a diameter of ± 7 cm and a height of ± 10 cm. The glass is filled with ± 50 ml of detergent solution to reduce surface tension so that the trapped insects will drown and die. Trap traps are used to trap Hymenoptera, which is active at ground level. Trap traps are installed by burying them into the ground and the top parallel to the soil surface. Two traps were installed in each sample plot. The installation was carried out diagonally in a 1 x 1 m² sample plot. Trap traps are set for 24 hours.

Identification of Ants:

Ants were sorted to morpho-species level at the Insect Bioekologi Laboratory, Faculty of Agriculture, Universitas Andalas. Then identified in Laboratory Ecology, Biology Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang. Ant specimens were identified using the identification key of Goulet & Huber (1993), Antwiki[6], and Bugguide[7]. The ant specimens were deposited in Insect Bioekologi Laboratory, Faculty of Agriculture, Universitas Andalas.

Data analysis:

Several parameters were calculated in data analysis. The diversity index (H') was calculated using the Shannon-Wiener formula. Species richness index (d) was using the Margalef formula. Species Evenness Index was calculated using the Pielou's Evenness (J') formula, which measured each species' proportion in a population at a certain place and time according to the formula by Krebs (2000). Species Similarity Index was calculated to determine the proportion of species similarity between two communities using the Jaccard species similarity index. Benchmark values use the evenness index Krebs (2000)[8].

Results and Discussion:-

The abundance of the Ants in the studied areas of Indragiri Hilir Regency is shown in Table 1. During a collected Formicidae in Indragiri Hilir district, 5.754 individual of ants consisting of 5 subfamily and 43 species were collected using Pitfall trap, Sweep net, Yellow pan trap, and Malaise traps. Myrmicinae subfamily has the highest individual abundance, 2.578 individuals, followed by Formicinae 1.823 individuals, Ponerinae 776 individuals, Dolichoderinae 575 individuals, and Pseudomyrmecinae 2 individuals.

Myrmicinae is a subfamily of ants with the largest number of genera; more than 900 species in the world have been described. Myrmicinae subfamily is spread across the globe both in tropical, subtropical, and temperate areas[9]. The most number of the individual that was collected belongs to *Pheidole* sp. (1.054 individuals). This species was reported from all studied areas. From an abundance aspect, Batang Tuaka (43 individuals), Keritang (817 individuals), Reteh (43 individuals), Tembilahan Hulu (151 individuals). The diversity of plant species and environmental factors can affect the diversity index, species abundance, and abundance of individual Ants.

The characteristic of the genus *Pheidole* is the antenna consists of 12 segments including the scape; three segments at the end of the larger antenna (club segment); mandible with a triangular type; Thoracic seen from the lateral, dorsal side of the propodeum lower than the pronotum (experiencing narrowing in the mesonotum); propodeum has a pair of spines; petiole has two nodes; This genus is generally dimorphic in which minor, and primary workers can be distinguished clearly [10].

Formicinae is the second-largest ant subfamily after Myrmicinae[10]. Formicinae species are found almost worldwide, with more than 3.700 species and 49 genera [11]. The structure of species composition and the relative abundance of Formicidae family (all the collected samples using Sweep net, Yellow pan trap, and Malaise traps) in Indragiri Hilir Regency is shown in Table 2. According to collected data (Table 2), *Nylanderia taylori* (9.91%) has the highest relative abundance among other formicines.

The characteristics of the genus *Nylanderia* are generally between 1.0-4.0 mm of total length; the mandible has 6-7 teeth; clypeus with a subrectangular type; the antenna consists of 12 segments; compound eyes are located on the midline of the head or on the anterolateral side, do not have ocelli or are not clearly visible; the pronotum is seen from the lateral direction, the dorsal side is slightly convex; on the pronotum, there are two pairs of macro setae; the mesonotum is usually flat or slightly more convex, there are two pairs of macro setae; propodeum doesn't have a setae macro; long petiolar foramen; gaster large and oval [12].

We found 776 individuals subfamily Ponerinae consisting five species, one of them is *Odontomachus*. The ant genus *Odontomachus* is reviewed for Sumatra, the sixth largest island in the world and located in western Indonesia. Previously three species were recorded from the island: *O. simillimus* F. Smith, *O. rixosus* F. Smith, and *O. latidens* Mayr.[13]. In this study, we found *Odontomachus rixosus* (F. Smith, 1857) and *Odontomachus simillimus* (F. Smith, 1858).

Table 1:-The abundance of Formicidae on tidal swamp rice field in Indragiri Hilir District.

No.	Species name	The abundance of species in the study locations				Total
		Batang Tuaka	Keritang	Reteh	Tembilahan Hulu	
Subfamily Dolichoderinae		155	223	66	131	575
1	sp. 1	2	12	4	2	20
2	sp. 2	7	26	4	3	40
3	sp. 3	0	0	0	1	1
4	<i>Dolichoderus thoracicus</i> (F. Smith, 1860)	4	0	0	0	4
5	<i>Tapinoma melanocephalum</i> (Fabricius, 1793)	79	111	28	67	285
6	<i>Technomyrmex albipes</i> (F. Smith, 1861)	7	19	0	19	45
7	<i>Technomyrmex butteli</i> (Forel, 1913)	0	6	5	0	11
8	<i>Technomyrmex modiglianii</i> (Emery, 1900)	56	49	25	39	169
Subfamily Formicinae		375	457	457	534	1.823
9	<i>Anaplolepis gracilipes</i> (Smith, 1857)	79	33	99	245	456
10	<i>Camponotus</i> (Tanaemyrmex) sp.	23	39	59	31	152
11	<i>Camponotus</i> sp.	1	0	0	0	1
12	<i>Colobopsis</i> sp. 1	4	22	0	2	28
13	<i>Colobopsis</i> sp. 2	13	0	0	2	15
14	<i>Echinopla lineata</i> (Mayr, 1862)	0	0	0	11	11
15	sp. 1	2	0	0	0	2
16	sp. 2	0	0	5	0	5
17	<i>Nylanderia taylori</i> (Forel, 1894)	158	153	127	132	570
18	<i>Oecophylla smaragdina</i> (F. Smith, 1960)	19	87	123	19	248
19	<i>Paratrechina longicornis</i> (Latreille, 1802)	59	108	13	87	267
20	<i>Philidris</i> sp.	12	0	3	1	16
21	<i>Polyrhachis arcuata</i> (Le Guillou, 1842)	0	1	8	0	9
22	<i>Polyrhachis carbonaria</i> (F. Smith, 1857)	1	0	1	0	2
23	<i>Polyrhachis illaudata</i> (Walker, 1859)	2	2	15	1	20
24	<i>Polyrhachis bicolor</i> (F. Smith, 1858)	2	12	4	3	21
Subfamily Myrmicinae		596	1.265	216	501	2.578
25	<i>Cardiocondyla wroughtonii</i> (Forel, 1890)	21	67	6	7	101
26	<i>Monomorium floricola</i> (Jerdon, 1851)	235	97	34	251	617
27	sp. 1	2	0	0	0	2
28	sp. 2	0	0	1	1	2
29	sp. 3	0	8	0	16	24
30	<i>Pheidole</i> sp.	43	817	43	151	1.054
31	<i>Pheidole plagiaria</i> (F. Smith, 1860)	285	269	132	71	757
32	<i>Proatta butteli</i> Forel, 1912	3	3	0	0	6
33	<i>Tetramorium bicarinatum</i> (Nylander, 1846)	7	4	0	4	15
Subfamily Ponerinae		83	95	174	424	776
34	<i>Diacamma rugosum</i> (Le Guillou, 1842)	0	0	0	3	3
35	<i>Hypoponera bugnioni</i> (Forel, 1912)		4			4
36	<i>Leptogenys kraepelini</i> (Forel, 1905)	16	36	146	364	562
37	<i>Leptogenys</i> sp.	0	6	0	7	13
38	<i>Odontomachus rixosus</i> (F. Smith, 1857)	11	0	0	0	11
39	<i>Odontomachus simillimus</i> (F. Smith, 1858)	1	0	0	14	15
40	sp. 1	2	2	0	0	4
41	sp. 2	53	42	28	3	126
42	sp. 3	0	5	0	33	38
Subfamily Pseudomyrmecinae		0	0	0	2	2
43	<i>Tetraponera nitida</i> (F. Smith, 1860)	0	0	0	2	2
	Total	1.209	2.040	913	1.592	5.754

In this study, only one species of the Pseudomyrmecinae subfamily was found, namely *Tetraponera nitida*. Subfamily Pseudomyrmecinae being one of the more distinctive groups inhabiting this environment. Ants belonging to the genus *Tetraponera* F. Smith, 1862 (Hymenoptera: Pseudomyrmecinae: Formicidae) are distributed throughout the Paleotropics with 94 species and 19 subspecies [14][15].

Table 2:- Percentage of Formicidae abundance on tidal swamp rice field in Indragiri Hilir District.

No.	Species name	Relative abundance percent in the study locations				Total
		Batang Tuaka	Keritang	Reteh	Tembilahan Hulu	
1	<i>Anaplolepis gracilipes</i> (Smith, 1857)	1.37	0.57	1.72	4.26	7.92
2	<i>Camponotus</i> (Tanaemyrmex) sp.	0.40	0.68	1.03	0.54	2.64
3	<i>Camponotus</i> sp.	0.02	0.00	0.00	0.00	0.02
4	<i>Cardiocondyla wroughtonii</i> (Forel, 1890)	0.36	1.16	0.10	0.12	1.76
5	<i>Colobopsis</i> sp. 1	0.07	0.38	0.00	0.03	0.49
6	<i>Colobopsis</i> sp. 2	0.23	0.00	0.00	0.03	0.26
7	<i>Diacamma rugosum</i> (Le Guillou, 1842)	0.00	0.00	0.00	0.05	0.05
8	<i>Dolichoderinae</i> sp. 1	0.03	0.21	0.07	0.03	0.35
9	<i>Dolichoderinae</i> sp. 2	0.12	0.45	0.07	0.05	0.70
10	<i>Dolichoderinae</i> sp. 4	0.00	0.00	0.00	0.02	0.02
11	<i>Dolichoderus thoracicus</i> (F. Smith, 1860)	0.07	0.00	0.00	0.00	0.07
12	<i>Echinopla lineata</i> (Mayr, 1862)	0.00	0.00	0.00	0.19	0.19
13	Formicinae sp. 1	0.03	0.00	0.00	0.00	0.03
14	Formicinae sp. 2	0.00	0.00	0.09	0.00	0.09
15	<i>Hypoponera bugnioni</i> (Forel, 1912)	0.00	0.07	0.00	0.00	0.07
16	<i>Leptogenys kraepelini</i> (Forel, 1905)	0.28	0.63	2.54	6.33	9.77
17	<i>Leptogenys</i> sp.	0.00	0.10	0.00	0.12	0.23
18	<i>Monomorium floricola</i> (Jerdon, 1851)	4.08	1.69	0.59	4.36	10.72
19	Myrmicinae sp. 1	0.03	0.00	0.00	0.00	0.03
20	Myrmicinae sp. 2	0.00	0.00	0.02	0.02	0.03
21	Myrmicinae sp. 3	0.00	0.14	0.00	0.28	0.42
22	<i>Nylanderia taylora</i> (Forel, 1894)	2.75	2.66	2.21	2.29	9.91
23	<i>Odontomachus rixosus</i> (F. Smith, 1857)	0.19	0.00	0.00	0.00	0.19
24	<i>O. similimus</i> (F. Smith, 1858)	0.02	0.00	0.00	0.24	0.26
25	<i>Oecophylla smaragdina</i> (F. Smith, 1960)	0.33	1.51	2.14	0.33	4.31
26	<i>Paratrechina longicornis</i> (Latreille, 1802)	1.03	1.88	0.23	1.51	4.64
27	<i>Pheidole</i> sp.	0.75	14.20	0.75	2.62	18.32
28	<i>Pheidole plagiaria</i> (F. Smith, 1860)	4.95	4.68	2.29	1.23	13.16
29	<i>Philidris</i> sp.	0.21	0.00	0.05	0.02	0.28
30	<i>Polyrhachis arcuata</i> (Le Guillou, 1842)	0.00	0.02	0.14	0.00	0.16
31	<i>Polyrhachis arbonaria</i> (F. Smith, 1857)	0.02	0.00	0.02	0.00	0.03
32	<i>Polyrhachis illaudata</i> (Walker, 1859)	0.03	0.03	0.26	0.02	0.35
33	<i>Polyrhachis bicolor</i> (F. Smith, 1858)	0.03	0.21	0.07	0.05	0.36
34	Ponerinae sp. 1	0.03	0.03	0.00	0.00	0.07
35	Ponerinae sp. 2	0.92	0.73	0.49	0.05	2.19
36	Ponerinae sp. 3	0.00	0.09	0.00	0.57	0.66
37	<i>Proatta butteli</i> Forel, 1912	0.05	0.05	0.00	0.00	0.10
38	<i>Tapinoma melanocephalum</i> (Fabricius, 1793)	1.37	1.93	0.49	1.16	4.95
39	<i>Technomyrmex albipes</i> (F. Smith, 1861)	0.12	0.33	0.00	0.33	0.78
40	<i>Technomyrmex butteli</i> (Forel, 1913)	0.00	0.10	0.09	0.00	0.19
41	<i>Technomyrmex modiglianii</i> (Emery, 1900)	0.97	0.85	0.43	0.68	2.94
42	<i>Tetramorium bicarinatum</i> (Nylander, 1846)	0.12	0.07	0.00	0.07	0.26
43	<i>Tetraponera nitida</i> (F. Smith, 1860)	0.00	0.00	0.00	0.03	0.03
	Total	21.01	35.45	15.87	27.67	100.00

The diversity index and species evenness index in the studied localities were calculated (Table 3). Batang Tuaka and Tembilahan Hulu have more total species (31 species) than the other studied localities. However, the highest individual abundance is in Keritang District (2.040). Then, there is a difference in diversity values. According to the Shannon-Wiener index, Reteh had a higher species diversity (2,48) than the other studied localities. However, according to the Species richness Margalef index (d), Batang Tuaka had a higher species diversity (4,23) than the other studied localities.

Environmental factors significantly affect the presence of ants in a habitat. This is because the ants have an individual tolerance to environmental physicochemical characteristics and are sensitive to environmental changes. Several environmental factors that significantly influence ants' abundance and diversity in agricultural areas are sunlight intensity, temperature, humidity, wind, water, season, cropping patterns, interspecific competition, variations in source availability[16]

Similarity levels of species of Formicidae on tidal swamp rice in the four studied areas were classified as low until high. The similarity of species is highest in the Keritang and Tembilahan Hulu (0,64) and followed by the similarity of species in the Keritang and Batang Tuaka (0,59), Keritang and Reteh (0,59), Tembilahan Hulu and Batang Tuaka (0,59), Tembilahan Hulu and Reteh (0,54), Batang Tuaka and Reteh (0,54). It means that the composition of Formicidae is relatively the same between one sub-district and another in Indragiri Hilir District. Then, there are several species of Formicidae that only exist in one location, and also many species that exist in various locations (Table 4).

Table 3:- Alpha diversity index of Antson tidal swamp rice field in Indragiri Hilir District.

Diversity index	Studied location			
	Batang Tuaka	Keritang	Reteh	Tembilahan Hulu
Total species	31	28	23	31
Total individuals	1.209	2.040	913	1.592
Diversity index Shannon-wiener (H')	2,46	2,25	2,48	2,42
Species richness Margalef index (d)	4,23	3,54	3,23	4,07
Species Evenness (J)	0,72	0,67	0,79	0,70
Simpson index (D)	0,87	0,80	0,89	0,88

Table 4:- Similarity index of species of Ants among the four studied areas on tidal swamp rice field in Indragiri Hilir District.

Sub-district	Batang Tuaka	Keritang	Reteh
Batang Tuaka	-	-	0,54
Keritang	0,59	-	0,59
Tembilahan Hulu	0,59	0,64	0,54

Total species and species richness Margalef index of Formicidae in this study showed a higher diversity at the generative phase than before planting phase and vegetative phase (Table 5). The many pests likely caused this in this phase. But, according to the Diversity index Shannon-wiener, before planting phase in the second period has higher diversity than another phase. Our finding is in line with the result of the previous study that Hymenoptera diversity has a high diversity at the time before planting, then decreases in the vegetative phase, and increases in the generative phase [17]. Ants potentially as predators become natural enemies of insect pests in rice fields with paddy cultivation with a high abundance of ants.

Table 5:- Total of species, individuals, alpha diversity index of Formicidae at three different stages on tidal swamp rice field in Indragiri Hilir District, Indonesia.

Diversity index	First period			Second period		
	Before planting	Vegetative phase	Generative phase	Before planting	Vegetative phase	Generative phase
Total species	26	17	28	26	22	30
Total individuals	1.225	444	791	1.013	842	1.439
Diversity index Shannon-wiener H')	2,45	2,28	2,73	2,68	2,31	2,03
Species richness Margalef index(d)	3,52	2,62	4,05	3,61	3,12	3,99
Species Evenness Pielou's index (J)	0,75	0,80	0,82	0,82	0,75	0,60
Simpson index (D)	0,87	0,87	0,91	0,91	0,87	0,72

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