SPECIES RICHNESS AND ABUNDANCE OF SPIDERS INHABITING RICE

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SPECIES RICHNESS AND ABUNDANCE OF SPIDERS INHABITING RICE IN FRESH SWAMPS AND TIDAL LOWLANDS IN SOUTH SUMATRA, INDONESIA

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ABSTRACT

Species richness and abundance of arthropods can be affected by the growth stage of a plant and by specific planting methods in agroecosystems. Thus, there is a need to quantify arthropod assemblages, in order to analyze the species richness and abundance of spiders inhabiting rice. This study aimed to analyze the species richness and abundance of spiders inhabiting rice during both their vegetative and generative stages in fresh swamps and tidal lowlands of South Sumatra, Indonesia. The survey was carried out from February up to August 2012. Arboreal spiders were sampled using sweep nets, while soil-dwelling spiders were collected through pitfall traps. Families belonging to arboreal spiders present were: Araneidae, Tetragnathidae, Linyphiidae, Oxyopidae, Thomisidae, Theridiidae, and Salticidae. Soil-dwelling spiders present belonged to the family Lycosidae. Spider abundance was significantly greater in fresh swamps than in the tidal lowlands for both spiders (*Tetragnatha vermiformis* and *Oxyopes bikakaeus*) during the vegetative stage. On the other hand, the soil-dwelling spider *Arctosa tanakai* under family Lycosidae had a significantly greater abundance in fresh swamps than in tidal lowland ecosystems during the generative stage. Meanwhile, during the generative stage the average abundance of arboreal spiders was significantly greater in the fresh swamps than in the tidal lowlands, while there was no significant difference in species richness. For soil-dwelling spiders, there was no signifcant difference in abundance and species richness during the vegetative stage of rice. From the two groups of spiders for both ecosystems, the soil-dwelling family Lycosidae would make a better predator of rice pests.

Key words: arboreal, arthropod, rice field, soil-dweller

INTRODUCTION

Indonesian wetlands have two distinct ecosystems namely, tidal lowlands and fresh water ecosystems. Tidal lowlands are directly influenced by sea tides while fresh swamps are unaffected (Mulyani and Sarwani 2013). In tidal lowland ecosystems, the soil needs to be held in a specific technique due to its thick pyritic layers, thus the need for it to be preserved (Hidayat et al. 2010). Farmers from tidal lowlands cannot properly handle the soil soil to prevent pyritic layer degradation (Suriadikarta and Sutriadi 2007). Thus, they generally plant rice twice a year (planting index) through broadcast seeding, drum seeding, or planting seedlings in a dug hole ("tugal"), (Raharjo et al. 2013).

Farmers from fresh swamps usually grow rice through transplanting which is conducted only once a year (Mulyani and Sarwani 2013, Lakitan et al. 2018). Arthropod abundance and species richness can be affected by different techniques in rice planting, as well as by indices in both ecosystems (Zhang et al. 2013, Parry et al. 2015). Weedy paddies in directly planted ecosystems have a higher abundance of arthropods than in ecosystems with no weeds (Hu et al. 2012). The absence of either soil or conservation tillage in rice fields also support a higher abundance of arthropods (Pereira et al. 2010). The absence of synthetic insecticides in fresh swamp ecosystems also increase the abundance of predatory arthropods (Herlinda et al. 2004, Herlinda et al. 2008, Heong et al. 2007, Furlan et al. 2018).

The growth stage of a plant also influences species richness and arthropod abundance (Zhong-xian et al. 2006). During the vegetative and generative growth stages in rice, there is a higher abundance and species diversity of soil-dwelling arthropods in tidal lowlands than in fresh swamp ecosystems (Khodijah et al. 2012, Herlinda et al. 2014). However, arboreal arthropods are more abundant and diverse in fresh swamp ecosystems than in tidal lowlands (Khodijah et al. 2012, Sunariah et al. 2016). Spiders play an important role in controlling the populations of planthoppers and leafhoppers (Ooi and Shepard 1994). Wolf spiders (*Pardosa pseudoannulata*) and dwarf spiders (*Atypena formosana*) are important predators of brown planthoppers (BPH) and *Nephotettix virescens* (Sigsgaard and Villareal 1999, Sigsgaard et al. 2001). Both spiders can also prey on leaffolders, stem borers, whorl maggot flies, and caseworms (Shepard et al. 1987, Rubia et al. 1990). Thus, species richness and abundance of spiders inhabiting rice can provide information on the regulation of the population of insect pests. Therefore, there is a need to quantify arthropod assemblages in order to determine species richness and abundance of spiders in rice, specifically during both their vegetative and generative stages, in fresh swamps and tidal lowland ecosystems in South Sumatra, Indonesia.

MATERIALS AND METHODS

Study site

Arthropod sampling was conducted in rice production areas of both fresh swamps and tidal lowlands in South Sumatra, Indonesia. The survey was conducted from February up to August 2012, and the identification of arthropod samples was done from September 2012 up to March 2013. Four survey sites from fresh swamp ecosystems were: (1) Gandus, Palembang City; (2) Pelabuhan Dalam Village in Ogan Ilir District; (3) Maryana Village in Banyuasin District; and (4) Sungai Waru Village in Kabupaten Banyuasin District. Eight survey sites from tidal lowlands were all from Banyuasin District, namely: (1) Banyu Urip Village in Tanjung Lago Subdistrict; (2) Telang Karya Village in Muara Telang Subdistrict; (3) Telang Rejo Village in Muara Telang Subdistrict; (4) Srikaton Damai Village in Air Saleh Subdistrict; (5) Srimulyo Village in Kecamatan Air Saleh Subdistrict; (6) Makarti Jaya Village in Makarti Jaya Subdistrict; (7) Tirta Mulya Village in Makarti Jaya Subdistrict; and (8) Tirta Kencana Village in Makarti Jaya Subdistrict. In each site, three sampling plots, with a minimum size of 1 ha per plot, were surveyed twice during a single rice season (4 months). The first survey was conducted when the rice was 4 weeks old upon transplant, while the second survey was during the milk grain stage (9 weeks old upon transplant). Ciherang was the rice variety type grown in fresh swamps, whereas Inpara was grown in tidal lowland ecosystems.

Sampling

Spiders sampled included both web-building and non-web-building spiders. Web-building spiders use their webs to catch prey while non-web-building spiders are more of hunters (Leroy and Leroy 2003). Web-building spiders have become habitat specialists, while the non-web-building spiders tend to be less specific in habitat preference (Gillespie 1999). Arboreal spiders inhabit plant canopies and consist mostly of web-building spiders, while soil-dwelling spiders consist mostly of non-web-building spiders (Leroy and Leroy 2003).

Arboreal spiders

Arboreal spiders were collected using sweep nets, based on the methods from Herlinda et al. (2014). Sweeping involved ‘double swings’, with a total of 30 swings/ha for each plot. The total number of plots were 12 in fresh swamps and 24 from tidal lowland ecosystems.

Soil-dweller spiders

Soil-dwelling spiders were collected using pitfall traps, based on the methods developed by Herlinda et al. (2004). Plastic pitfall traps (60 mm in diameter and 90 mm in height) were filled to a volume of 70 mL 4% formaldehyde solution, buried in the ground, and flushed with soil. Traps were set up to a density of 18 trap units/ha, spaced in a grid of 3 x 6, and then collected after 48 hours. All specimens collected were cleaned, sorted from other debris, and stored in glass vials (volume 30 ml) containing 70% ethanol. Identification of the specimens up to family- and species-levels was carried out at the Laboratory of Entomology, Plant Pest and Disease Department, College of Agriculture, Universitas Sriwijaya, using taxonomic keys provided by Barrion and Litsinger (1995).

Data Analysis

Spider abundance data of specimens from fresh swamps and tidal lowland ecosystems were not normally distributed. Insect counts in this study were found to fit a negative binomial distribution and were analyzed by Proc Genmod using SAS University Edition (SAS Institute Inc., Cary, NC, U.S.A.). Species richness was analysed using Menhinick's index (D) (Magurran 1988).

RESULTS AND DISCUSSION

Planting Methods and Index for Fresh Swamps and Tidal Lowlands

In fresh swamp ecosystems, farmers used a transplanting system involving sequential steps. The first step was full tilage soil preparation, then seedling preparation using a floating seedbed, and lastly, by transplanting the seedlings. The rice seedlings should be protected from pests, but local farmers seldom do so because this is not their main concern. Most farmers from fresh swamps only grow rice annually from May-September (one planting index). Farmers in tidal lowlands, on the other hand, use a direct planting system and grow rice two to three times a year (two to three planting indexes). The sequential steps for planting rice in tidal lowlands involved soil preparation using minimum tillage, and spreading seeds directly by hand, or by a tool or machine. To protect rice from pests, local farmers sprayed synthetic pesticides if there are any pest or weed problems. Thus, the planting methods and index of rice are specific and different for each ecosystem.

Arboreal spiders from fresh swamp and tidal lowland ecosystems

During the vegetative growth stage of rice, seven families of arboreal spiders were present in both fresh swamp and tidal lowland ecosystems. Tetragnathidae was the most dominant family observed, while the other families of arboreal spider present were: Araneidae, Linyphiidae, Oxyopidae, Thomisidae, Theridiidae, and Salticidae (Table 1). A total of 92.750 spiders/30 nets were observed from fresh swamp ecosystems, while a total of 62.875 spiders/30 nets were captured from tidal lowland ecosystems. However, there was no significant difference ($P = 0.312$) between both ecosystems. The abundance of *Tetragnatha vermiformis* ($P = 0.001$) and *Oxyopes bikakaeus* ($P = 0.007$) from fresh swamp ecosystems were both significantly higher than their abundance in tidal lowland ecosystems. But, in the case of the other arboreal spiders, there was no significant difference. A total of 26 arboreal spider species was observed from fresh swamp ecosystems, while 23 species were present in tidal lowland ecosystems. However, there was no significant difference in species richness between fresh swamps ($P = 0.186$) and tidal lowland ecosystems. Thus, web-building spiders were more abundant in fresh swamps since these ecosystems are not exposed to synthetic insecticides.

Table 1. A comparison of arboreal spider abundance between fresh swamps and tidal lowland ecosystems during the vegetative growth stage of rice in South Sumatra, Indonesia.

No.	Family and Species	Average Spider Abundance (Individuals/30 Nets)		$P_{value\ (0.05)}$
		Fresh Swamps	**Tidal Lowlands**	
	Araneidae	6.5	2.75	0.15
1.	*Araneus inustus*	1.5	0.63	0.3
2.	*Cylosa insulana*	1.75	0.75	0.24
3.	*Cylosa mulmeinensis*	0.5	0	0.23
4.	*Gea subarmata*	2.75	1.38	0.55
	Tetragnathidae	54.25	32.75	0.18
5.	*Tetragnatha javana*	8.25	12	0.5
6.	*Tetragnatha virescens*	21	8.88	0.11
7.	*Tetragnatha mandibulata*	8.5	8.5	1
8.	*Tetragnatha ilavaca*	1	0.13	0.09
9.	*Tetragnatha maxillosa*	3	1.5	0.5
10.	*Tetragnatha desaguni*	1.25	0.75	0.68
11.	*Tetragnatha vermiformis*	8.25	0.75	0.001*
12.	*Tetragnatha okumae*	1.75	0	1
13.	*Dyschiriognatha hawigtenera*	1.25	0.25	0.2
	Linyphiidae	8.75	9.38	0.94
14.	*Bathyphantes tagalogensis*	4.75	7.13	0.69
15.	*Atypena adelinae*	3.250	2.250	0.773
16.	*Erigone bifurca*	0.75	0	1
	Oxyopidae	18	13.88	0.62
17.	*Oxyopes javanus*	6.25	7.25	0.84
18.	*Oxyopes matiensis*	5.75	6.25	0.84
19.	*Oxyopes bikakaeus*	3.25	0.13	0.007*
20.	*Oxyopespingasus*	2.75	0.25	0.12
	Thomisidae	0.750	0.75	1
21.	*Diaea tadtadtinika*	0.5	0.5	1
22.	*Stiphropus sangayus*	0.25	0.25	1
	Theridiidae	0.25	0.25	1
23.	*Coleosoma octomaculatum*	0.25	0	0.36
24.	*Theridion* sp.	0	0.25	0.5
	Salticidae	4.25	3.13	0.75
25.	*Myrmarachne bidentata*	0.5	0.25	0.68
26.	*Simaetha damongpalaya*	3	0.75	0.42
27.	*Hyllus maskaranus*	0.75	2.13	0.48
	Total Abundance (N)	92.75	62.88	0.31
	Average Abundance	13.25	8.98	0.31
	Species Richness (D)	1.7	1.2	0.19

*= significantly different

During the rice generative stage, five families of arboreal spiders were observed from fresh swamp ecosystems, namely: Araneidae, Tetragnathidae, Linyphiidae, Oxyopidae, and Salticidae. In tidal lowland ecosystems, seven spider families were present, namely: Araneidae, Tetragnathidae, Linyphiidae, Oxyopidae, Thomisidae, Theridiidae, and Salticidae), (Table 2). However, there was no significant difference in abundance between fresh swamp and tidal lowland ecosystems among members of families Araneidae (P = 0.803), Tetragnathidae (P = 1.000), Linyphiidae (P = 0.720), Oxyopidae (P = 0.096), Theridiidae (P = 1.000), and Salticidae (P = 0.633). Furthermore, there was no significant difference in total abundance of spiders between fresh swamp ecosystems (47.750 spiders/30 nets) and tidal lowlands (54.250 spiders/30 nets) (P = 0.521). However, there was a significant difference in average abundance of spiders between fresh swamps (6.82 spiders/30 nets) and tidal lowland ecosystems (1.42 spiders/30 nets), (P = 0.000).

Table 2. A comparison of arboreal spider abundance between fresh swamps and tidal lowland ecosystems during the generative growth stage of rice in South Sumatra, Indonesia.

No.	Family and Species	Average Spider Abundance (Individuals/30 Nets)		P_{value} (0.05)
		Fresh Swamps	Tidal Lowlands	
	Araneidae	5	4.5	0.803
1.	*Araneus inustus*	0.75	1.13	0.48
2.	*Cylosa insulana*	1	0.5	0.33
3.	*Cylosa mulmeinensis*	0.75	0.13	0.26
4.	*Gea subarmata*	2.5	2.75	0.91
	Tetragnathidae	26	26	1
5.	*Tetragnatha javana*	7.25	7.25	1
6.	*Tetragnatha virescens*	7.25	7.75	0.55
7.	*Tetragnatha mandibulata*	3.5	4.38	0.55
8.	*Tetragnatha ilavaca*	0	0.88	1
9.	*Tetragnatha maxillosa*	0.5	1.13	0.32
10.	*Tetragnatha desaguni*	0	0	1
11.	*Tetragnatha vermiformis*	6.75	4.63	0.19
12.	*Tetragnatha okumae*	0.75	0	1
13.	*Dyschiriognatha hawigtenera*	0	0	1
	Linyphiidae	6.25	4.75	0.72
14.	*Bathyphantes tagalogensis*	3.25	0.88	0.12
15.	*Atypena adelinae*	3	3.88	0.72
16.	*Erigone bifurca*	0	0	1
	Oxyopidae	8.5	15.63	0.1
17.	*Oxyopes javanus*	3.75	7.63	0.06
18.	*Oxyopes matiensis*	4.75	6.13	0.56
19.	*Oxyopes bikakaeus*	0	1.25	1
20.	*Oxyopespingasus*	0	0.63	1
	Thomisidae	0	0.375	1
21.	*Diaea tadtadtinika*	0	0.25	1
22.	*Stiphropus sangayus*	0	0.13	1
	Theridiidae	0	0.25	1
23.	*Coleosoma octomaculatum*	0	0.25	1
24.	*Theridion* sp.	0	0	1
	Salticidae	2	2.75	0.63
25.	*Myrmarachne bidentata*	0	0.25	0.5
26.	*Simaetha damongpalaya*	1.25	2.5	0.56
27.	*Hyllus maskaranus*	0.75	0	1
	Total Abundance (N)	47.75	54.25	0.52
	Average Abundance	6.82	1.42	0*
	Species Richness (D)	1.47	1.57	0.81

*= significantly different

Among the arboreal spiders, families that were observed during both rice growth stages and ecosystems were: Araneidae, Tetragnathidae, Linyphiidae, Oxyopidae and Salticidae. These families consisted of both web-building (Araneidae, Tetragnathidae, and Linyphiidae) and non-web-building (Oxyopidae and Salticidae) species, commonly found in either fresh swamps or tidal lowland ecosystems (Schmidt and Tscharntke 2005). The abundance of *T. vermiformis* (Tetragnathidae) and *O. bikakaeus* (Oxyopidae) was significantly greater in fresh swamps than in tidal lowland ecosystems. Members from families Tetragnathidae and Oxyopidae were more dominant in wetland ecosystems (Betz and Tscharntke 2017), since fresh swamps are commonly submerged for a longer period of more than 6 months (November to April) than tidal lowland ecosystems (3 months, November to January), (Mulyani and Sarwani 2013). Furthermore, members from families Tetragnathidae and Oxyopidae were more abundant in fresh swamp ecosystems since farmers did not use synthetic insecticides in controling rice pests. The presence of more abundant tetragnathid web- or other types web-building spiders can be used as an indicator for farmers not to spray synthetic pesticides (Betz and Tscharntke 2017).

Sixteen species of arboreal spiders were observed in fresh swamp ecosystems, while 21 species were present in tidal lowlands. However, there was no significant difference in species richness of arboreal spiders between fresh swamp ecosystems (P = 0.8067) and tidal lowlands. Both the arboreal spiders *T. virescens* and *T. javana*, classified as keystone species (Barrion et al. 2012), were both abundant in fresh swamps and tidal lowland ecosystems. They play a critical role in maintaining the population of rice insect pests, such as leafhopper, by preying on these pests (Betz and Tscharntke 2017). Species from the family Tetragnathidae were the dominant web-building spiders present in wetland ecosystems in the Philippines (Shepard et al. 1987) and in India (Betz and Tscharntke 2017), with a greater abundance of spiders observed during the rice vegetative stage than during the generative stage. The abundance of spider from family Tetragnathidae was influenced by the number of leafhoppers (Homoptera), which commonly occur during the vegetative growth stage of rice (Betz and Tscharntke 2017). Both *T. virescens* and *T. javana* are predators of rice insect pests, such as insects belonging to the orders Homoptera and Lepidoptera (Tahir et al. 2009). In Indian rice fields, the highest increase of members from family Tetragnathidae was in accordance with an increasing abundance of members from Lepidoptera and Homoptera (leafhoppers), (Betz and Tscharntke 2017).

By comparing the total abundance (N) between tables 1 and 2, total abundance was higher during the vegetative growth stage than the generative growth stage for both fresh swamps and tidal lowland ecosystems. Abundance is also closely related with the population of their prey, attracting spiders to the area (Riechert and Lockley 1984, Widiarta et al. 2006). Insect pests, such as brown planthoppers, are the main prey of arboreal spiders (Karindah 2011). Brown planthoppers have a higher population during the vegetative growth stage of rice than during the generative stage, which results in a corresponding increase in spider abundance during the vegetative stage. Planthoppers, such the brown planthopper (BPH), were the dominant insect pests observed during the vegetative growth stage of rice, whereas rice bugs were the dominant insect pests present during the generative stage (Arofah et al. 2013). Thus, spider abundance is also affected by the growth stage of rice from both ecosystems.

However, in terms of average abundance, there was no significant difference between both ecosystems during the vegetative stage because synthetic insecticides were not yet applied. However, in tidal lowlands, spraying with synthetic insecticides generally occur when the rice reaches flowering or from panicle initiation to booting, which explains the significantly lower average spider abundance in this ecosystem during the generative stage.

Soil-dwelling spiders in fresh swamps and tidal lowland ecosystems

During the vegetative growth stage in rice of fresh swamp ecosystems, only one soil-dwelling spider families (Lycosidae) and one arboreal (Linyphiidae) were observed. Meanwhile, during the vegetative phase in tidal lowlands, one soil-dwelling family (Lycosidae) and four arboreal spider families (Theridiidae, Araneidae, Linyphiidae, Thomisidae) were captured by pitfall traps (Table 3). No spiders belonging to the arboreal spider families Araneidae, Thomisidae, and Theridiidae were found in fresh swamp ecosystems. The most dominant family of soil-dwelling spiders observed during the rice vegetative growth stage in both ecosystems was Lycosidae, with *Pardosa pseudoannulata* being the most dominant species. Six soil-dwelling spider species were found in fresh swamp ecosystems and six species were observed from tidal lowlands. Nonetheless, there was no significant difference in species richness (P = 0.5290) among soil-dwelling spiders between fresh swamp and tidal lowland ecosystems. Soil-dwelling spiders from both ecosystems had no significant difference in abundance and species richness. This was due to the minimum soil tillage in tidal lowlands and fields, while in fresh swamps rice was not grown for six months (the rice fallow period).

Table 3. Abundance of spiders observed in the soil in fresh swamps and tidal lowland ecosystems during the vegetative growth stage in rice in South Sumatra, Indonesia.

No.	Family and Species	Average Spider Abundance (Individuals/18 Traps)		$P_{value\ (0.05)}$
		Fresh Swamps	**Tidal Lowlands**	
	Lycosidae	24.25	22.13	0.67
1.	*Pardosa pseudoannulata*	17	14.63	0.62
2.	*Pardosa sumatrana*	3.75	2.63	0.18
3.	*Pardosa birmanica*	0.75	0.63	0.84
4.	*Pardosa mackenziei*	0.5	1.88	0.14
5.	*Pardosa patapensis*	0.25	0	0.36
6.	*Hogna rizali*	0	1.75	1
7.	*Arctosa tanakai*	2	0.63	0.24
	Araneidae	0	1.63	1
8.	*Araneus inustus*	0	0.5	1
9.	*Cylosa insulana*	0	0.88	1
10.	*Gea subarmata*	0	0.25	1
	Linyphiidae	5	1.25	1
11.	*Bathyphantes tagalogensis*	2.5	0.25	0.01
12.	*Atypena adelinae*	2	0.5	0.11
13.	*Erigone bifurca*	0.5	0.5	1
	Thomisidae	0	0.88	1
14.	*Diaea tadtadtinika*	0	0.75	1
15.	*Stiphropus sangayus*	0	0.13	1
	Theridiidae	0	0.38	1
16.	*Coleosoma octomaculatum*	0	0.13	1
17.	*Theridion* sp.	0	0.25	1
	Salticidae	0	0	1
18.	*Hyllus maskaranus*	0	0	1
	Total Abundance (N)	29.25	26.25	0.45
	Average Abundance	4.88	4.38	0.47
	Species Richness (D)	0.98	1.27	0.53

*= significantly different

However, during the generative growth stage of rice, three families (Lycosidae, Araneidae, and Linyphiidae) were observed in the soil surface of fresh swamp ecosystems, while four families

(Lycosidae, Araneidae, Linyphiidae, and Salticidae) were present in the soil surface of tidal lowlands (Table 4). Lycosidae was the most dominant family of soil-dwelling spiders present, with five species of soil-dwellers from fresh swamp ecosystems and six from tidal lowlands. However, there was no significant difference in species richness (P = 0.981) of soil-dwelling spiders between both ecosystems during the generative growth stage.

In fresh swamp ecosystems, members of Lycosidae and Linyphiidae were observed on the soil surface while spiders belonging to families Lycosidae, Araneidae, Linyphiidae, Thomisidae, Theridiidae, and Salticidae were observed in tidal lowlands. In particular, arboreal web spiders belonging to families Araneidae, Linyphiidae, and Theridiidae, were also observed on the soil surface during their immature stage as a result of ballooning where they could move with the wind and descend, or fall on the soil surface (Iida and Fujisaki 2007, Suana and Haryanto 2013).

Table 4. Abundance of spiders observed in the soil in fresh swamps and tidal lowland ecosystems during the generative growth stage of rice in South Sumatra, Indonesia.

No.	Family and Species	Average Spider Abundance (Individuals/18 traps)		$P_{value\ (0.05)}$
		Fresh Swamps	Tidal Lowlands	
	Lycosidae	27.25	20	0.04*
1.	*Pardosa pseudoannulata*	15.75	12.25	0.33
2.	*Pardosa sumatrana*	5.5	5.13	0.7
3.	*Pardosa birmanica*	0.5	0.5	1
4.	*Pardosa mackenziei*	0	0	1
5.	*Pardosa patapensis*	0	0.63	1
6.	*Hogna rizali*	1.5	0.25	0.14
7.	*Arctosa tanakai*	4	1.25	0.01*
	Araneidae	0	0.25	0.5
8.	*Araneus inustus*	0	0.13	0.74
9.	*Cylosa insulana*	0	0	1
	Gea subarmata	0	0.13	0.74
	Linyphiidae	4.5	4.88	0.94
10.	*Bathyphantes tagalogensis*	3	2.25	0.75
11.	*Atypena adelinae*	1.25	2.25	0.53
12.	*Erigone bifurca*	0.25	0.38	0.72
	Thomisidae	0	0	1
13.	*Diaea tadtadtinika*	0	0	1
14.	*Stiphropus sangayus*	0	0	1
	Theridiidae	0	0	1
15.	*Coleosoma octomaculatum*	0	0	1
16.	*Theridion* sp.	0	0	1
	Salticidae	0	0.13	0.74
17.	*Hyllus maskaranus*	0	0.13	0.74
	Total Abundance (N)	31.75	25.25	0.3
	Average Abundance	5.29	4.21	0.33
	Species Richness (D)	1.06	1.05	0.98

*= significantly different

There was no significant difference in total abundance and species richness of soil-dwelling families between both ecosystems. Nonetheless, the family Lycosidae had a significantly higher abundance (P=0.04) in fresh swamps than in tidal lowlands during the generative growth stage, especially for *Arctosa tanakai* (Table 4). This could be due to the absence of synthetic insecticides, with only a rare occurrence of synthetic insecticides in fresh swamp ecosystems in South Sumatra (Herlinda 2010). Such ecosystems tend to produce a high diversity of invertebrate fauna (Mahrub 1999, Rizali et al. 2002). Rice ecosystems, without synthetic insecticides use, have a higher abundance of predatory arthropods, especially spiders in Indonesia (Herlinda et al. 2008, Herlinda et al. 2004) and China (Zi-yang et al. 2011). Furthermore, Lycosidae was also the most dominant family of soil-dwelling spiders, with *P. pseudoannulata* or wolf spider, being the most dominant species. Wolf spiders are considered as a keystone species that are critical in preying on leafhoppers (Barrion et al. 2012, Lou et al. 2013). Their high mobility allows them to move, run, or jump to capture their prey (Ishijima et al. 2006).

For soil-dwelling spiders, there was no significant difference in abundance and species richness during the vegetative growth stage. However, during the generative stage, family Lycosidae specifically *Arctosa tanakai* had a significantly higher abundance in fresh swamps than in tidal lowland ecosystems. The reason for such an increase in abundance during the generative stage was that it was during this stage when farmers from tidal lowlands would start spraying synthetic insecticide. Farmers from fresh swamps do not use synthetic insecticides at all, hence the increase in abundance of soil-dwelling spiders during the generative stage in fresh swamp ecosystems.

Spider abundance was significantly greater in fresh swamps than in tidal lowlands for both the arboreal spiders *Tetragnatha vermiformis* and *Oxyopes bikakaeus,* but only during the vegetative stage), (Table 1). For the soil-dwelling spiders under family Lycosidae, specifically *Arctosa tanakai,* abundance was significantly greater in fresh swamps than in tidal lowlands during the generative stage (Table 4). Between the two groups of spiders selected from the arboreal and soil-dwelling spiders, the family Lycosidae is more effective in controlling populations of main insect pests, such as brown planthopper, because they could attack their prey directly. Members of the family Lycosidae are more aggressive in hunting their prey (the insect pest) than *Tetragnatha vermiformis* and *Oxyopes bikakaeus* (Shepard et al. 1987).

Rice is grown twice to three times a year in South Sumatra. Because of the occurrence of BPH problems in rice fields, most farmers (more than 50%) from tidal lowlands spray under a calendar pattern to control pests, such as spraying every two weeks or every month. The dose of insecticide was determined through trial and error, traditional habits, or from information from other farmers. They seldom knew the active ingredient of the insecticide used, some knew just the commercial names. The farmers practiced minimum tillage and because of that, outbursts of weeds always occured. To control such weed occurrence, farmers generally use more than 80% synthetic herbicides which could decrease spider populations (Heong et al. 2007; Barrion et al. 2012).

CONCLUSION

The families of arboreal spiders observed in South Sumatra, Indoesia were: Araneidae, Tetragnathidae, Linyphiidae, Oxyopidae, Thomisidae, Theridiidae, and Salticidae. For soil-dwelling spiders, only the family Lycosidae was present. During the vegetative growth stage in rice, spider abundance was significantly greater in fresh swamps than in the tidal lowlands for the arboreal spiders *Tetragnatha vermiformis* and *Oxyopes bikakaeus*. However, during the generative stage, the abundance of soil-dwelling spiders under family Lycosidae, specifically *Arctosa tanakai,* was significantly greater in fresh swamps than in tidal lowlands. From the two groups of both arboreal and soil-dwelling spiders that exhibit significantly greater abundance, the family Lycosidae would make a better predator of rice pests.

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