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Functional Group of Spiders in Cultivated Landscape Dominated by Paddy Fields in West Java, Indonesia

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Distribution of spiders in all colonized environments is limited by biotic and abiotic factors requiring adaptations with respect to, for example microhabitat choice and hunting behavior. These two factors were frequently used to group spiders into functional groups. In this study our objectives were to (i) group of genera of spiders into functional group based on their microhabitat specificity, hunting behavior, and daily activity; and (ii) compare the number and composition of functional group of spider at each habitat type and period of paddy growth. The study was conducted at a landscape dominated by paddy fields in Cianjur Watershed for a period of 9 months. Four different habitat types (paddy, vegetable, non-crop, and mixed garden), were sampled using five trapping techniques (pitfall traps, farmcop suction, sweep netting, yellow-pan traps, and sticky traps). The Unweighted Pair-Group Average and the Euclidean Distances were used to generate dendrogram of functional group of spider. We found 14 functional groups of spider at genus level. The number of functional group of spider at four habitat types was differing, but the composition was similar, because all habitats were closed to each other. Habitat structure diversity and disturbance level influenced the number of functional group of spider. Different architecture of vegetation and availability of differ prey during paddy growth, causing the composition of functional group of spider in each period of paddy growth was changed, although its number was unchanged.

Key words: spiders, functional group, agricultural landscape, Cianjur Watershed

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INTRODUCTION

The concept of functional groups tries to categorize species that utilize the same resource in similar ways (Polis & McCormick 1986; Canard 1990). As in other organisms, the small-scale distribution of spiders in all colonized environments is limited by biotic and abiotic factors (Foelix 1996). Those require adaptations with respect to, for example microhabitat choice and hunting behavior. These two factors were frequently used to group spiders into functional groups (Bultman *et al*. 1982; Canard 1990). Spiders belonging to the same functional group should therefore, characterized by a similar microhabitat choice and hunting behavior. Hence, it can be expected that they use a very similar resource, so that their role is more or less similar in ecosystem. Describing the spider diversity in terms of these groups allows for greater insight into how habitat differences might reflected their life history strategies (Whitmore *et al*. 2002).

Agroecosystem crop represent one example of spider microhabitat. Spiders can explore all parts of crop, however, they have a pronounce niche segregation based on hunting behavior. Marc and Canard (1997) documented that at apple trees, the two spiders *Clubiona bravipes* and *Ballus depressus* hunt in leaf and branch, but *C. bravipes* hunt at night (nocturnal) while *B. depressus* hunt at daytime (diurnal). Other spider species make a frame-web at the ends of small branch (*Anelosimus vittatus*), make a sheet-web between low leaves (*Linyphia trianguralis*), or make an orb-web between branches (*Araneus diadematus*). The spider colonized at different parts of apple trees and used differences range of prey. Therefore, a diverse assemblage of different spiders functional groups should be successful in controlling a large variety of different insect pest.

In this study, spiders occurring in a cultivated landscape dominated by paddy fields in West Java were classified into functional groups based on their microhabitat specificity, hunting behavior, and daily activity. Based on microhabitat, Whitmore *et al*. (2002) categorized spiders into three types of functional groups, i.e. ground wanderers, plant wanderers, and web builders. However, Canard (1990) differentiated spiders with respect to their hunting behavior into web builders and wanderers. Based on daily activity, two functional groups of spiders can be distinguished as nocturnal and diurnal species (Canard 1990). While based on web type, spider distinguish into three type of functional group, i.e. frame-web, sheet-web, and orb-web (Canard 1990). The objectives of this research were to: (i) group genera of spider into functional group based on microhabitat specificity, hunting behavior, and daily activity; and (ii) compare the number and composition of functional group of spider at each habitat type and period of paddy growth.

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MATERIALS AND METHODS

Study Area and Study Sites. Research was conducted in a landscape dominated by paddy fields in Cianjur Watershed, Cianjur District, West Java, Indonesia (Figure 1). Cianjur is one of agricultural-belt in West Java with various kinds of agricultural products, such as paddy, and tropical highland vegetables. Its landscape diversities ranged from upland to downland – result on variety of productions.

Three villages, i.e. Nyalindung (879-1,010 m asl; S 06°47’22.7" E 107°03’30.6"), Gasol (665–693 m asl; S 06°48’17.0" E 107°05’40.1"), and Selajambe (346–351 m asl; S 06°48’09.0" E 107°12’52.9"), were selected as study sites. These three villages are located in catchment area of Cianjur Watershed, ranged from upper to the lower of the slope gradient of Mount Gede (2,958 m). In Nyalindung and Gasol, there were four different habitat types, i.e. paddy, vegetable, non-crops (i.e. wild herbs), and mixed garden. There was no

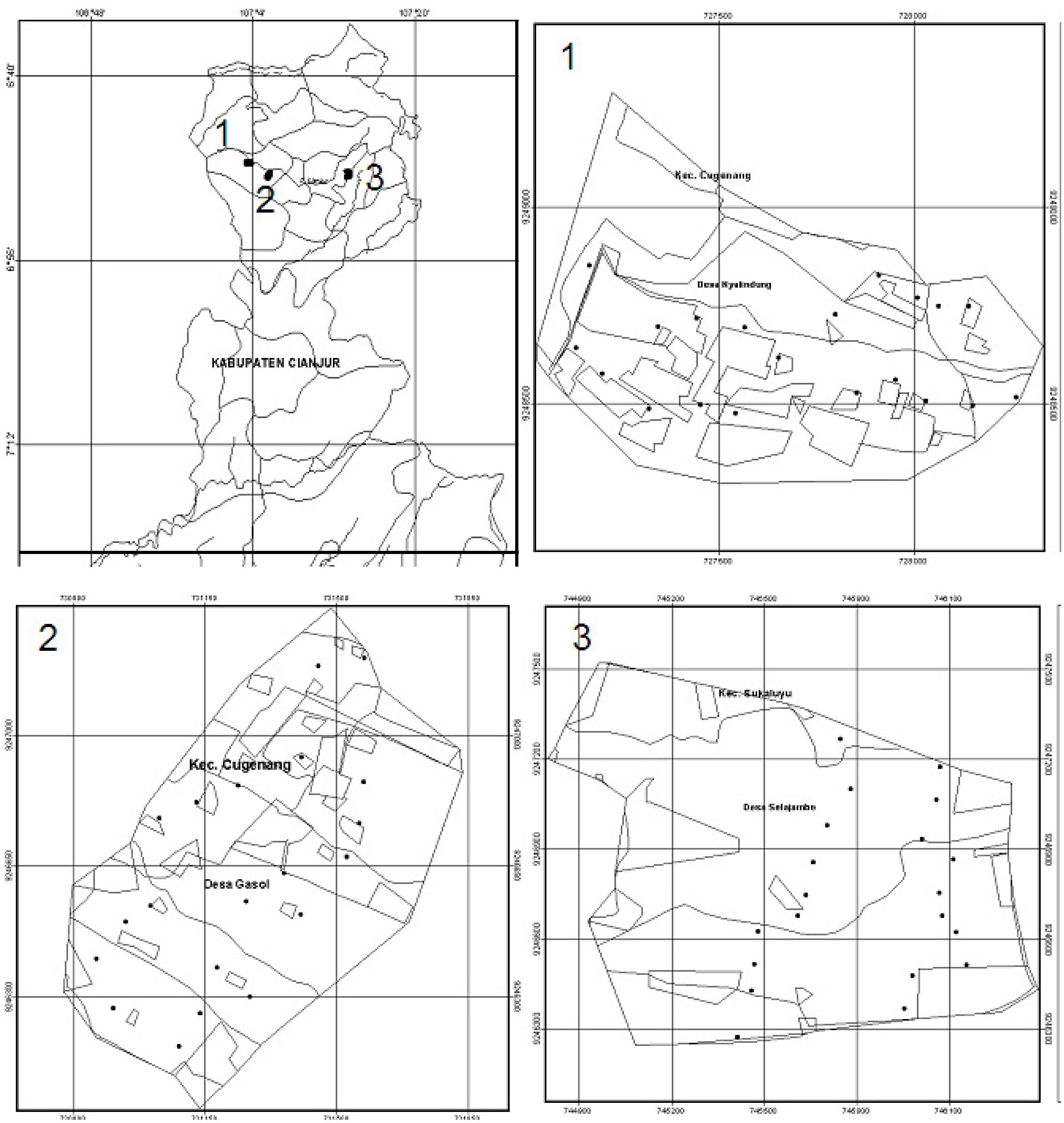

Figure 1. Study area in Kabupaten (=District) Cianjur, West Java. The three study sites are indicated by numbers: 1 = Desa (=Village) Nyalindung (S 06°472 22.73 E 107°032 30.63), 2 = Desa Gasol (S 06°482 17.03 E 107°052 40.13), 3 = Desa Selajambe (S 06°482 09.03 E 107°122 52.93). Black dots on the study site maps are indicating sampling sites.

vegetable field in Selajambe, hence it consists of three different habitat types, i.e. paddy, non-crops, and mixed garden.

Paddy cultivated in Nyalindung was a local cultivar-Pandanwangi (long-lived and higher habitus), while in Selajambe, there was new cultivar of paddy-IR64 (short-lived and lower habitus). Gasol is located at the ecotone between highland and lowland paddy fields, where local, and new cultivar of paddy are available. Highland vegetables, i.e. carrot, onion, sweet corn, tomato, red chilly, and cabbage were cultivated in Nyalindung. In Gasol, vegetable fields dominated by sweet corn. Non-crops habitat was available surround paddy and vegetable field, dominated by wild herbs, i.e. *Ageratum conyzoides* L., *Galinsoga parviflora* Cav., and *Spilanthes paniculata* Wall. ex. DC. Mixed garden is a parcel of land located outside the boundary of the house plot where several kinds of annual and perennial crops are intercropped.

Mean annual temperature was different in the three villages because of the altitude differences. Data from the Cugenang and Cianjur Climatologically Stations (1993-2003), gave the mean annual temperature was 21 ^{o}C in Nyalindung and Gasol, and 26 ^{o}C in Selajambe. The mean annual precipitation was 3,572 mm in Nyalindung and Gasol, and 1,858 mm in Selajambe. The year consists of a dry season (June to September) and rainy season (October to May).

Sampling of Spiders. Field work was conducted for 9 months from January to September 2003. Five trapping techniques were used to sample spiders: pitfall traps, farmcop suction, sweep-netting, yellow-pan traps, and sticky traps (Levi & Levi 1990; Barrion & Litsinger 1995; Marc *et al.* 1999) were used to sampling spiders. At each study area, 20 sampling sites were selected. At all sampling sites, spider assemblages were collected by five different trapping techniques resulting in a total of 100 samples from each site. Samples were taken in intervals of two weeks following paddy growth stage, started from two weeks after transplanting until harvesting (14 weeks after transplanting).

Pitfall traps were a standard method to catch spiders hunting on the ground, e.g. Lycosidae (Levi & Levi 1990; Barrion & Litsinger 1995; Marc *et al*. 1999). Pitfall traps used in this study had a diameter of 7 cm and a depth of 10 cm. Traps were inserted into the ground so that the lip was flush with the soil surface and contained a 25 ml solution of water and detergent. Pitfall traps were exposed in the field for 24 hours.

Yellow-pan trap size was 15 x 24 cm with 5 cm depth, contained of solution of water and detergent. Yellow-pan traps were exposed in open places for 24 hours to trap spiders attracted by the yellow color, e.g. Salticidae (Barrion & Litsinger 1995).

Spiders foraging in the herb layer, e.g. Tetragnathidae, Araneidae, etc., were sampled with farmcop suction (Barrion & Litsinger 1995). A square sampling frame (0.5 x 0.5 x 0.9 m) made of wood and lint sheets to enclose paddy or other vegetation was placed at random in the field. Spiders inside the enclosure were sucked up using farmcop suction for five minutes, and kept in vials of 70% ethanol.

A sweep net of 30 cm diameter was swept to the herb layer to collect spiders. One sample consisted of 20 sweeps on each habitat type. The contents from the sweep nets were placed into a vial with 70% ethanol to kill the spiders.

Sticky traps were made of yellow-board 18 x 28 cm in size prepared with glue and set up at the top of a 3 m bamboo stanchion. Sticky trap were exposed in the field for 24 hours. Spiders sticking on yellow-board were removed with a smooth brush. All samples were transferred to vials filled with 70% ethanol for later identification in the laboratory.

Parameters for Identifying Functional Groups. Parameters used to identify functional groups were microhabitat specificity, hunting behavior, and daily activity (Table 1). Microhabitat specificity: spiders were defined to four different microhabitats, i.e. ground, lower-, middle-, and upper vegetation layer. Hunting behavior: web builders and wanderers were differentiated as well. The web builders were categorized as four web types, i.e. vertical orb-web, horizontal orb-web, sheet-web, and frame-web. The wanderers were differentiated as a hunter and an ambusher. Daily activity: spiders were defined as nocturnal or diurnal due to their main activity period (Canard 1990 and personal observations).

Spiders were identified by using identification key from Barrion and Litsinger (1995). We also used pictorial key from Levi and Levi (1990), and Yaginuma (1986) to identified the spiders.

Data Analysis. Dendrogram of functional group of spider was made at genus level. Data used to construct new functional group were microhabitat specificity, hunting behavior, and daily activity of spiders genera. The Unweighted Pair-Group Average (UPGMA) and the Euclidean Distances were the parameters selected to generate dendrograms. The statistical analysis program Statistica for Windows 5.0 (Statsoft 1995) used to construct dendrogram and calculate the similarity index of functional group composition among habitat types.

All statistical analysis was performed using SPSS for Windows 11.0 (SPSS 2001). One way ANOVA was performed to test for significant differences among habitat types for functional groups of spider.

RESULTS

Functional Groups of Spiders. In Figure 2, the genera of spiders were separated first into wanderer and web-builder. Within the wanderers, two functional groups were possible, as a ground and a vegetation wanderer. The next classification based on hunting behavior, as a hunter and an ambusher. The final classification based on daily activity, as a diurnal and a nocturnal spider. Within the web-builder, two functional groups were possible, as a ground and a vegetation web-builder. The next classification based on web type; as an orb-, a frame-, and a sheet-web builder. The final classification based on web position, as a horizontal and a vertical web. Thus, at genus level, there were 14 functional groups of spider.

The wanderer spiders were classified as a ground/vegetation diurnal hunter (*Pardosa*), a ground/vegetation nocturnal hunter (*Heteropoda*), a ground diurnal hunter (*Pirata, Opopaea, Ischnothyreus*, and *Castianeira*), a ground nocturnal hunter (*Poecilochroa, Phrurolithus, Micaria*, and *Langbiana*), a vegetation nocturnal hunter (*Cheirachantium*), a vegetation diurnal hunter (*Simaetha, Plexippus, Phintella, Oxyopes, Myrmarachne, Marpissa, Harmochirus, Cosmophasis*,

Table 1. Characteristics of recorded spider genera

Genus	Species number	Microhabitat specificity	Hunting behavior	Daily Activity
Achaearanea	1	Middle vegetation	Frame-web builder	Diurnal
Anelosimus	1	Middle vegetation	Frame-web builder	Diurnal
Araneus	2	Middle vegetation	Vertical orb-web builder	Diurnal
Araniella	1	Middle vegetation	Vertical orb-web builder	Diurnal
Argiope	3	Middle vegetation	Vertical orb-web builder	Diurnal
Artema	1	Middle vegetation	Frame-web builder	Diurnal
Atypena	2	Middle vegetation	Sheet-web builder	Diurnal
Bionar	1	Upper vegetation	Hunter	Diurnal
Castianeira	1	Ground	Hunter	Diurnal
Cheirachantium	2	Upper vegetation	Hunter	Nocturnal
Chrysso	3	Middle vegetation	Frame-web builder	Diurnal
Coleosoma	7	Middle vegetation	Frame-web builder	Diurnal
Cosmophasis	1	Upper vegetation	Hunter	Diurnal
Cyclosa	2	Upper vegetation	Horizontal orb-web builder	Diurnal
Cyrtarachne	1	Middle vegetation	Vertical orb-web builder	Diurnal
Dipoena	2	Ground, lower vegetation	Frame-web builder	Diurnal
Dyschiriognatha	1	Upper vegetation	Horizontal orb-web builder	Diurnal
Enoplognatha	2	Middle vegetation	Frame-web builder	Diurnal
Erigone	2	Lower vegetation	Sheet-web builder	Diurnal
Harmochirus	1	Upper vegetation	Hunter	Diurnal
Heteropoda	2	Ground, lower vegetation	Hunter	Nocturnal
Ischnothyreus	1	Ground	Hunter	Diurnal
Langbiana	2	Ground	Hunter	Nocturnal
Larinia	1	Middle vegetation	Vertical orb-web builder	Diurnal
Leucauge	2	Upper vegetation	Horizontal orb-web builder	Diurnal
Lysiteles	1	Upper vegetation	Ambusher	Diurnal
Marpissa	1	Upper vegetation	Hunter	Diurnal
Mesida	1	Middle vegetation	Vertical orb-web builder	Diurnal
Micaria	1	Ground	Hunter	Nocturnal
Misumena	1	Upper vegetation	Ambusher	Diurnal
Myrmarachne	2	Upper vegetation	Hunter	Diurnal
Neoscona	1	Middle vegetation	Vertical orb-web builder	Diurnal
Opopaea	1	Ground	Hunter	Diurnal
Oxyopes	1	Upper vegetation	Hunter	Diurnal
Pardosa	3	Ground, lower vegetation	Hunter	Diurnal
Perenethis	1	Lower vegetation	Ambusher	Diurnal
Phintella	1	Upper vegetation	Hunter	Diurnal
Phonognatha	1	Middle vegetation	Frame-web builder	Diurnal
Phoroncidia	1	Middle vegetation	Frame-web builder	Diurnal
Phrurolithus	1	Ground	Hunter	Nocturnal
Pirata	1	Ground	Hunter	Diurnal
Plexippus	1	Upper vegetation	Hunter	Diurnal
Poecilochroa	1	Ground	Hunter	Nocturnal
Runcinia	1	Upper vegetation	Ambusher	Diurnal
Simaetha	1	Upper vegetation	Hunter	Diurnal
Tetragnatha	7	Upper vegetation	Horizontal orb-web builder	Diurnal
Theridion	2	Middle vegetation	Frame-web builder	Diurnal
Thomisus	2	Upper vegetation	Ambusher	Diurnal

and *Bionar*), lower vegetation diurnal ambusher (*Perenethis*) and upper vegetation diurnal ambusher (*Thomisus, Runcinia, Misumena*, and *Lysiteles*).

Within web-builder, spiders were classified as a ground sheet-web builder (*Erigone*), a ground frame-web builder (*Dipoena*), a vegetation sheet-web builder (*Atypena*), a vegetation frame-web builder (*Theridion*, *Phoroncidia, Phonognatha, Enoplognatha, Coleosoma, Chrysso, Artema, Anelosimus*, and *Achaearanea*), a vegetation horizontal orb-web builder (*Tetragnatha*, *Leucauge*, *Dyschiriognatha*, and *Cyclosa*) and a vegetation vertical orb-web builder (*Neoscona, Mesida, Larinia, Cyrtarachne, Argiope, Araniella,* and *Araneus*).

Effects of Habitat Type on the Number and Composition of Functional Groups of Spiders. Overall, web-building spiders were the most abundant and widely distributed. They comprised 65% of all spiders sampled (total individual = 6,915). Wandering spiders comprised 35% (total individual = 3,724). Vegetation-living spiders were more abundant than that of ground-living spiders. They comprised 80% of all spiders sampled (total individual = 8,511), while ground-living spiders comprised 20% (total individual = 2,128). In all habitat type, nocturnal spiders were the minority group. They represented only 10% (1,064 individuals). Diurnal spiders were the majority group in all habitat type (total individual = 9,575). The number of functional group of spider at four habitat types (paddy, vegetable, wild grass, and mixed garden) was different one another. Paddy has the most functional group of spider, and significantly different ($F_{3,61}$ = 19.08; P = 0.00) with vegetable, wild grass, and mixed garden (Figure 3). Nevertheless, the composition of functional groups of spider at each habitat type is more or less similar (Table 2).

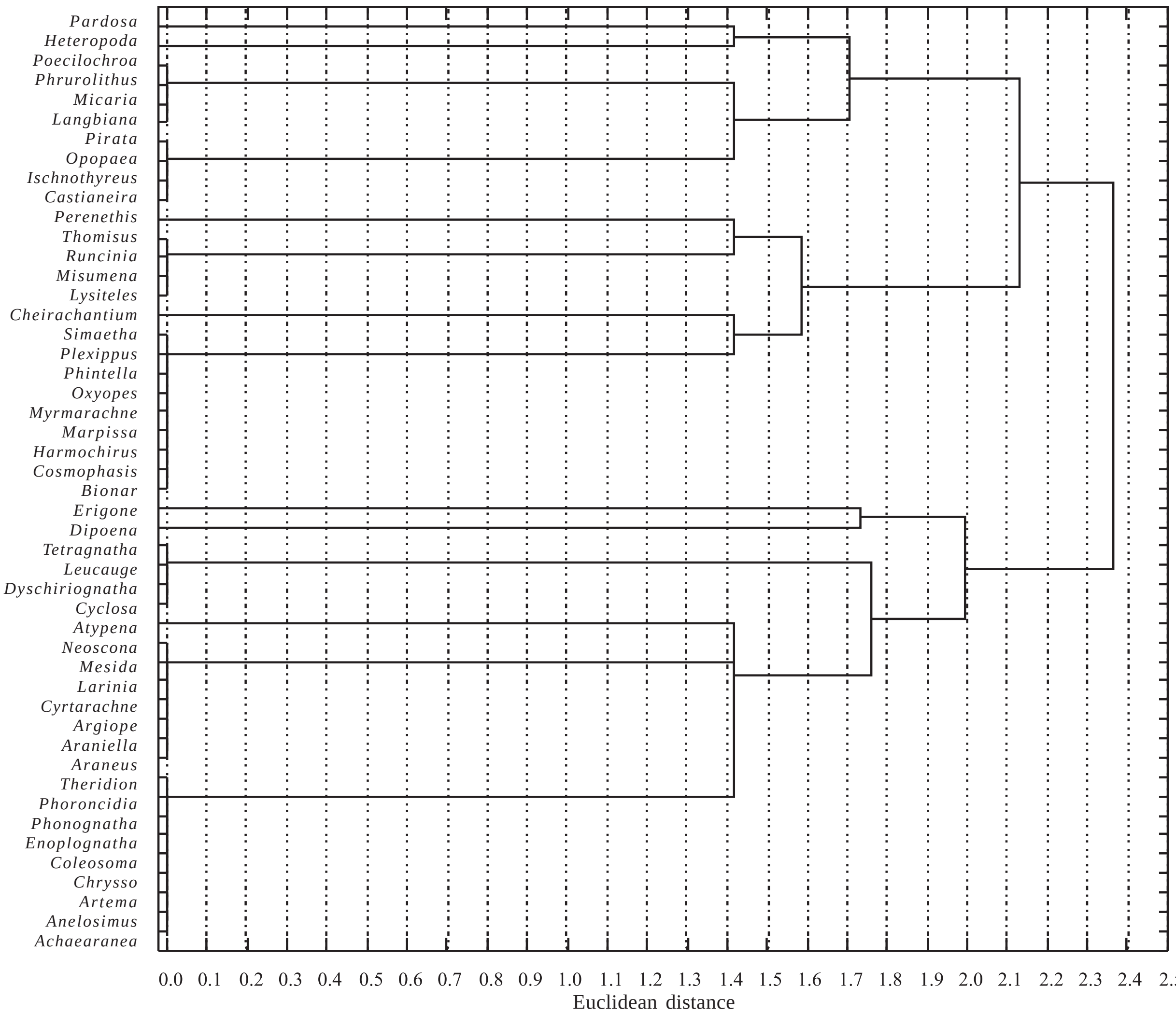

Figure 2. Proposed spider functional group classification dendrogram at genus level.

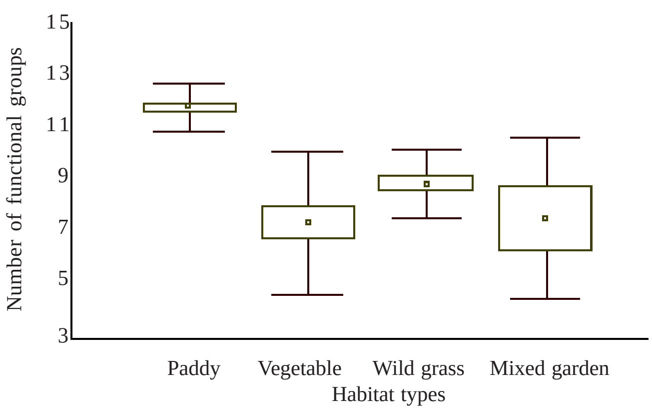

Figure 3. Effect of habitat type to the numbers of spider functional groups, represented by the mean (□), ± standard deviation (T), and ± standard error (□), on the number of spider functional groups at agricultural landscape in Cianjur Watershed.

Table 2. Matrix of similarity index (NESS) of functional group composition among habitat types

	Paddy	Wild grass	Vegetable	Mixed garden
Paddy	1.00			
Wild grass	0.98	1.00		
Vegetable	0.96	0.97	1.00	
Mixed garden	0.95	0.94	0.94	1.00

Effects of Period of Paddy Growth on the Number and Composition of Functional Groups of Spiders. Figure 4 showed the number and composition of functional group of spider in each period of paddy growth. In each period of paddy growth, the number of spider functional group was equal (13 functional groups), except in 10 weeks after transplanting (wat) paddy which have 14 functional groups. On the other hand, the composition of functional group of spider was differing in each period of paddy growth stage. The composition of web-building spiders increased with paddy growth stage (Figure 5); however, it was not the case in the composition of wandering spiders. They tended to decrease as long as paddy growth stage (Figure 6).

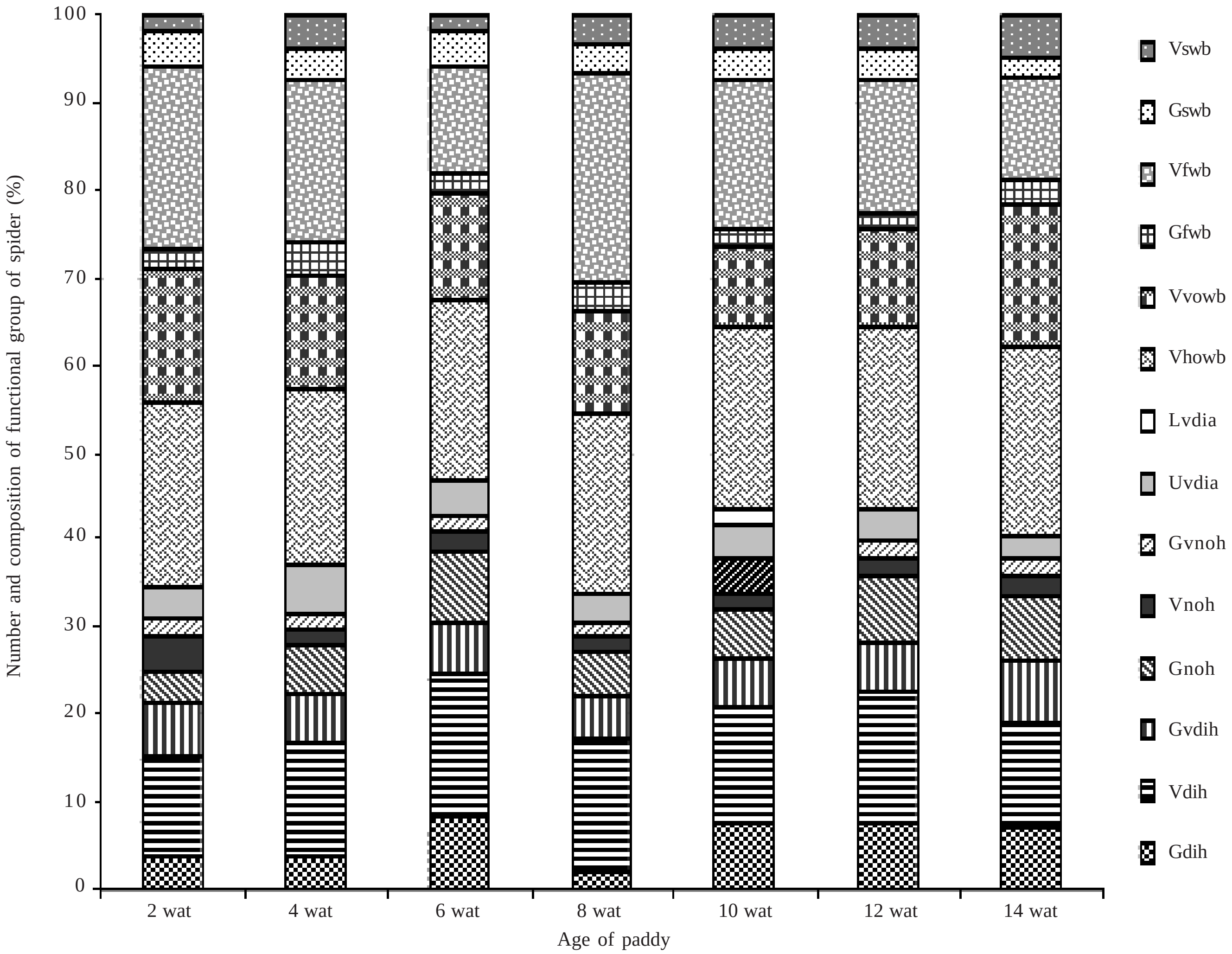

Figure 4. Number and composition of spider functional group at genus level at each period of paddy growth. Wat = weeks after transplanting, Vswb = vegetation sheet-web builder, Gswb = Ground sheet-web builder, Vfwb = vegetation frame-web builder, Gfwb = ground frame-web builder, Vvowb = vegetation vertical orb-web builder, Vhowb = vegetation horizontal orb-web builder, Lvdia = lower vegetation diurnal ambusher, Uvdia = upper vegetation diurnal ambusher, Gvnoh = ground vegetation nocturnal hunter, Vnoh = vegetation nocturnal hunter, Gnoh = ground nocturnal hunter, Gvdih = ground vegetation diurnal hunter, Vdih = vegetation diurnal hunter, Gdih = ground diurnal hunter.

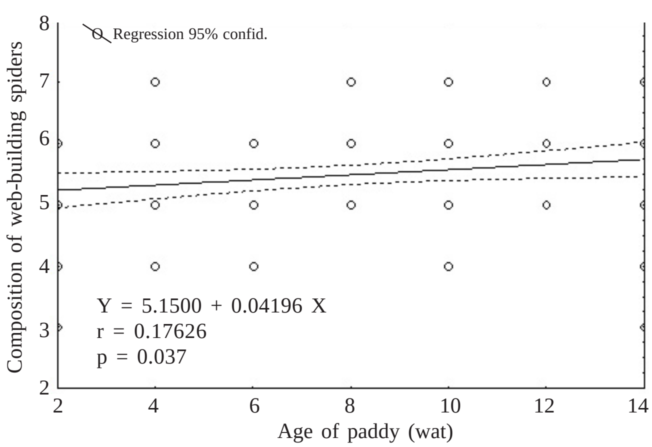

Figure 5. Effect of paddy growth period on the composition of web-building spiders at agricultural landscape in Cianjur Watershed.

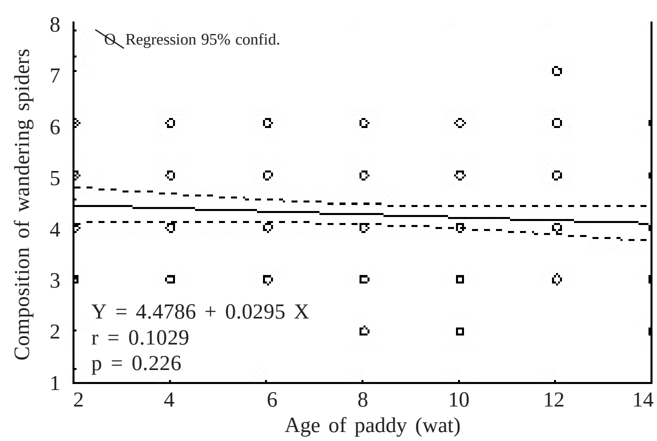

Figure 6. Effect of paddy growth period on the composition of wandering spiders at agricultural landscape in Cianjur Watershed.

DISCUSSION

Several researchers classified spider functional group up to family level, i.e. 8 functional group mentioned by Riechert and Lockley (1984), and Uetz *et al.* (1999), while 7 functional groups proposed by Canard (1990) (Table 3). Spider functional groups at family level have several weaknesses since not all taxa in the family have similar microhabitat and hunting behavior. For example, Clubionidae often classified as a nocturnal spider; however, the genus *Castianeira* member of this family, is a diurnal one. Clubionidae is also grouped as a vegetation-living spider, though its member (e.g., *Castianeira*), is a ground-living spider. Several members of web-building spider families such as Linypiidae, Agelenidae, and Hahniidae, move frequently and often forage off of the web, while others are sedentary (Uetz *et al*. 1999).

The family Lycosidae poses particular problems in functional group classification as well. For example, some lycosids are diurnal (e.g., *Schizocosa*, *Pardosa*), while others are nocturnal (e.g., *Rabidosa*). Others forage as sit-and-wait ambush predators at a burrow entrance (e.g., *Geolycosa*) while others actively move about in searching their prey (e.g., *Schizocosa*, *Pardosa*). *Hogna helluo*, actively disperse and change sites at night, but forage in a sit-and-wait behavior during the day (Uetz *et al*. 1999). Based on this phenomenon, the functional group of spider ideally was classified at genus or species level. Results of this study showed that based on genus level, we found 14 functional groups of spiders.

Habitat structure diversity and disturbance level influenced the number and composition of spider functional group as well (Young & Edwards 1990). Vegetable structure is simpler than that of paddy, and also it accept higher disturbance level than paddy. In our study area, the farmers sprayed insecticide to the vegetable more intensive than to paddy. This resulted less spider numbers functional group at vegetable plantation than that of paddy. Habitat structure can increase spider groups diversity (Uetz 1991) and showed their role in insect pest population control (Riechert & Bishop 1990; Marc & Canard 1997). Furthermore, habitat structure complexity enable many spider groups assemblage in these habitats.

There is a difference in number of spider functional group at all habitat types. However, their compositions were similar which might be due to their close habitats as stated by Polis *et al.* (1997) that spiders composition can be influenced by their close habitats.

In each period of paddy growth stage, numbers of spider functional group was remaining unchanged; however, they showed alteration at different paddy growth stage. Having simple architecture in the early of paddy growth stage, low composition of web-building spiders occurred. As it grow, paddy architecture performed more complex structure. These paddy architecture complexities were a suitable place to construct spider web; hence, increased the composition of web-building spider.

Table 3. Classification of spider functional group according to some researchers

Family	Riechert and Lockley (1984) (8 functional groups)	Canard (1990) (7 functional groups)	Uetz *et al.* (1999) (8 functional groups)
Agelenidae	-	Sheet-webs	Sheet Web Builders
Amaurobiidae	Sheet Web Builders	Funnel-webs	Sheet Web Builders
Anyphaenidae	Nocturnal Running	-	Foliage Runners
Araneidae	Orb Weavers	Orb-webs	Orb Weavers
Atypidae	-	Funnel-webs	-
Clubionidae	Nocturnal Running	Nocturnal or Crepuscular	Foliage Runners
Dictynidae	Hackled Band Weavers	Frame-webs	Space Web Builders
Dysderidae	-	-	Ground Runners
Eusparassidae	Crab	-	Foliage Runners
Filistatidae	-	-	Sheet Web Builders
Gnaphosidae	Nocturnal Running	Nocturnal or Crepuscular	Ground Runners
Hahniidae	-	-	Sheet Web Builders
Hippasinidae	-	Sheet-webs	-
Linyphiidae	Sheet Web Builders	Sheet-webs	Wandering Sheet/Tangle Weavers
Liocranidae	-	Nocturnal or Crepuscular	-
Lycosidae	Diurnal Running	Diurnal Wanderers	Ground Runners
Metidae	-	-	-
Micryphantidae	-	-	Wandering Sheet/ Tangle Weavers
Mimetidae	-	Diurnal Wanderers	Stalkers
Oonopidae	-	-	-
Oxyopidae	Diurnal Running	-	Stalkers
Philodromidae	Crab	Ambush Hunters	Ambushers
Pholcidae	Scattered Line Weavers	-	Space Web Builders
Pisauridae	Diurnal Running	Ambush Hunters	Ambushers
Salticidae	Jumping	Diurnal Wanderers	Stalkers
Tetragnathidae	Orb Weavers	Orb-webs	Orb Weaver
Theridiidae	Scattered Line Weavers	Frame-webs	Space Web Builders
Thomisidae	Crab	Ambush Hunters	Ambushers
Uloboridae	Orb Weavers	-	Orb Weavers
Zodariidae	-	-	-

On the other hand, the composition of wandering spider tend to decrease as paddy grow. This is due to the different of prey in each period of paddy growth stage that change the wandering spider composition. In this study, wandering spiders was dominated by *Pardosa pseudoannulata*. Tulung (1999) stated that 51% of *P. pseudoannulata* diet was leafhoppers, where they mounted at early of paddy growth. Their population was decreased as paddy grow since the appearance of another pest, such as *Leptocoryza acuta*.

As we learned from this study, habitat structure diversity, and disturbance level influence the number and composition of functional group of spider. Diverse assemblage of different functional groups of spiders should be particularly successfull in controlling a large variety of different pest species. Since spiders can be used to control the insect pest, they can reduce pesticide usage. Hence, we should maintain the heterogenity of agricultural landscape structure to insure the spider diversity.

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REFERENCES

Barrion AT, Litsinger JA. 1995. *Riceland Spiders of South and Southeast Asia*. Wallingford: CAB International and IRRI.

Bultman TL, Uetz GW, Brady AR. 1982. A comparison of cursorial spider communities along a successional gradient. *J Arachnol* 10:23-33.

Canard A. 1990. Heathland spider communities, a functional group study. In: Koponen S, Lehtinen PT, Rinne V (eds). *Acta Zool Fenn* 190. Helsinki: Finnish Zool Publ Brd. p 45-50.

Foelix RF. 1996. *Biology of Spider*. 2nd ed. New York: Oxford Univ Pr and Georg Thieme Verlag. p 110-149.

Levi HW, Levi LR. 1990. *Spider and Their Kin*. New York: Golden Pr.

Marc P, Canard A. 1997. Maintaining spider biodiversity in agroecosystems as a tool in pest control. *Agric Eco Environ* 62:229-235.

Marc P, Canard A, Ysnel F. 1999. Spiders (Araneae) useful for pest limitation and bioindication. *Agric Eco Environ* 74:229-273.

Polis GA, Anderson WB, Holt RD. 1997. Toward an integration of landscape and food web ecology: the dynamics of spatially subsidized food webs. *Ann Rev Ecol Syst* 28:289-316.

Polis GA, McCormick SJ. 1986. Scorpions, spiders and solifugids: predation and compensation among distantly related taxa. *Oecologia* 71:111-116.

Riechert SE, Bishop. 1990. Prey control by an assemblage of generalist predators: spiders in garden test systems. *Ecology* 71:1441-1450.

Riechert SE, Lockley T. 1984. Spiders as biological control agents. *Ann Rev Entomol* 29:229-320.

SPSS. 2001. *SPSS for Windows 11.0*. USA: Lead Tech.

StatSoft. 1995. Statistica for Windows 5.0. Tulsa: StatSoft.

Tulung M. 1999. Ecology of Spiders in Ricefields with the Emphasis on *Pardosa pseudoannulata* (Boes.& Str.) [Dissertation] (*text in Bahasa Indonesia*). Bogor: Bogor Agricultural Univ.

Uetz GW. 1991. Habitat structure and spider foraging. In: Bell SS, McCoy ED, Mushinsky HR (eds). *Habitat Structure: the Physical Arrangement of Objects in Space*. London: Chapman & Hall.

Uetz GW, Halaj J, Cady AB. 1999. Guild structure of spiders in major crops. *J Arachnol* 27:270-280.

Whitmore C, Slotow R, Crouch TE, Dippenaar-Schoeman AS. 2002. Diversity of spiders (Araneae) in a savana reserve, Northern Province, South Africa. *J Arachnol* 30:344-356.

Yaginuma T. 1986. Spiders of Japan in Color. New Edition. Osaka: Hoikusha.

Young OP, Edwards GB. 1990. Spiders in United States field crops and their potential effect on crop pests. *J Arachnol* 18:1-27.