Population dynamics and prey composition of *Tetragnatha* spiders  
(*Araneae: Tetragnathidae*) in semi-organic rice fields, Songkhla Province, southern Thailand

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| Keyword:                 | biological control, long-jawed spider, generalist predator, paddy field, rice growing stage |
Population dynamics and prey composition of *Tetragnatha* spiders

(Araneae: Tetragnathidae) in semi-organic rice fields,

Songkhla Province, southern Thailand

Abstract. *Tetragnatha* spiders are common predators in rice ecosystems. However, changes in their population numbers and availability of prey types at each rice growth stage are poorly understood. Therefore, this study assessed population dynamics of *Tetragnatha* spiders and their prey composition during four stages of rice growth, including vegetative, reproductive, ripening, and after-harvesting in semi-organic rice fields, Songkhla Province, southern Thailand. The results showed that species richness and abundance of spiders were significantly higher in the reproductive stage than in other stages. Main prey families captured by *Tetragnatha* spiders varied with different growth stages. Chironomidae and Corixidae were the main prey in the vegetative and reproductive stages, while Delphacidae was the most common prey in the ripening stage and there was dominant prey in the after-harvesting stage. Overall, the different growth stages provided different rice structures for web attachment and different prey, which influenced both the spider populations and prey composition.

Keywords: biological control, long-jawed spider, generalist predator, paddy field, rice growing season

Introduction

Predators play an important role in ecosystems by reducing the abundance and growth rates of prey populations (Nyffeler, 2000). In agricultural ecosystems,
population dynamics are of special interest because predators can maintain populations of insect pests at low equilibrium levels (Hassell, 1978).

Spiders are common generalist predators in agricultural ecosystems. They feed on various kinds of prey, especially insects. They exhibit high diversity in agroecosystems and serve to limit the numbers of prey populations (Nyffeler, 2000; Venturino, Isaia, Mona, Chatterjee, & Badino, 2008). Many agricultural entomologists and arachnologists have demonstrated the importance of spiders as major natural control agents which can regulate insect pest populations, especially in rice fields (Sigsgaard, 2000; Nyffeler & Sunderland, 2003; Sebastian, Mathew, Pathummal, Joseph, & Biju, 2005; Ludy, 2007; Tahir, Butt, & Sherawat, 2009). For example, researchers reported that spiders were the main predators of leaf folders, cut worms and stem borers. Additionally, they also trap small insect pests, such as thrips, planthoppers, and aphids (Landis, Wratten, & Gurr, 2000).

*Tetragnatha* (Latreille, 1804), or long-jawed spiders, are a dominant group of web-building spiders that exhibit prominent spatial and temporal dynamics in rice ecosystems (Sebastian et al., 2005; Tahir & Butt, 2008; Rattanapun, 2012; Tsutsui, Tanaka, Baba, & Miyashita, 2016). They prefer to live in wet habitats, especially during the rice-growing season. Previous studies showed that *Tetragnatha* species prey on various rice insect pests. Tahir et al. (2009) found that the main orders of prey caught in the webs of *Tetragnatha* spiders were Lepidoptera, Diptera, Homoptera, Coleoptera, Hymenoptera and Orthoptera. Moreover, the webs of *Tetragnatha* spiders either trapped mirid bugs or forced them onto the ground and into the hunting zone of wolf spiders (Takada, Kobayashi, Yoshioka, Takagi, & Washitani, 2013).
An increasing demand for improved sustainability in agriculture has promoted reducing the use of chemicals in rice ecosystems by applying biological control techniques. As spiders are amongst the potential biological control agents (Nyffeler & Sunderland, 2003; Tahir & Butt, 2008; Cotes et al., 2018), a better understanding is needed of how their populations and prey preference change with the rice growing season in tropical rice fields. However, most of the previous studies on spider populations and their prey were conducted in only one particular stage of rice growth (Wang, Yuan, Song, & Zhu, 2004; Tahir et al., 2009; Tsutsui et al., 2016) and only one study has covered all the stages of rice plant development (Butt & Tahir, 2010). Here, we examined population changes of *Tetragnatha* spiders and the composition and availability of prey in all the development stages of rice plants throughout the rice growing season in insecticide-free rice fields. As prey composition could change with the rice planting period, this study hypothesizes that the population dynamics and prey utilization patterns of *Tetragnatha* spiders are closely associated with the progression of the growth stages of the rice. The results of this study can inform future uses of the *Tetragnatha* spiders as biological control agents in rice fields.

**METHODS**

**Study site.** —This study was conducted in Bankhao, Ranot District, Songkhla Province, southern Thailand (7° 50’ N, 100° 13’ E) because rice farming is the major agricultural farming in this area. In this study, three semi-organic rice fields with using chemical fertilizers but not chemical insecticides or herbicides, were selected because there was a small proportion area of semi-organic if compare to conventional rice fields. All fields were limited areas and were under the supervision of the Agricultural
Extension Office of Ranot District, Songkhla Province for the purpose of producing safe, good quality rice. Rice in all selected fields was planting by seed sowing method. It provides more or less space between rice plant in all selected fields. Each rice field covered around 5 ha and was at the same growth stage as the other fields (planting was done simultaneously). Landscape structures surrounding the rice fields were generally similar among the three sites: namely, other semi-organic rice fields, ditches, small tracks of road and small patches of oil palm plantations. The cultivated rice variety was Pathumthani fragrant rice, which is the most common cultivar in this area.

**Vegetation measurements.** — Vegetation complexity of the rice crop was estimated by placing a 1.5-m measuring pole vertically in the ground and recording the height of the rice plants and the number of contacts between rice plants and the pole (Corcuera, Jiménez, & Valverde, 2008; McNett & Rypstra, 2000). The height of the rice plants continuously increased from the vegetative growth stage to the reproductive stage. Thereafter, it stayed relatively constant until the rice was harvested. Rice complexity changed between the different growth stages; increasing from the vegetative stage to the reproductive stage and from the reproductive stage to the ripening stage (Table 1).

**Field observations.** — Fieldwork was done from November 2015 to March 2016, covering the four stages of rice growth: vegetative (tillering sub-stage), reproductive (flowering sub-stage), ripening (maturity sub-stage) and after-harvesting stages. In this study, each sub-stage was chosen to represent in each stage because rice plant was utilized by many groups of insect. All observations were conducted between 1900h to 2200h because the feeding activity of *Tetragnatha* spiders is at its highest at this time (Kiritani, Kawahara, Sasaba, & Nakasuji, 1972; V. Saksongmuang, personal
observation). During this rice growing season, the air temperature and the relative humidity were recorded by data logger which was around $26.14 \pm 0.40$ °C and $90.77 \pm 3.09$ (mean ± S.D.), respectively. In the study period, rain fall ranged from 290-500 mm/month in November and December (2015) and ranged from 0-200 mm/month in January, February and March (2016) (Meteorological Department, 2016). However, the sampling was done in the night with no rain.

**Spider collection.** — *Tetragnatha* spiders were collected at 15 sampling points in each rice field during each growth stage. Sampling points were 10 m apart from each other. Specimens were collected by both visual searching and sweep netting adjacent to each other at each sampling point. In visual searching, spiders were captured by hand within a 1x1m quadrat. Sweep netting was carried out with a 35-cm diameter insect net that was swept five times over and around the rice plants at each sampling point which was 1 m from the paddy edge. **Sweeping net was used at canopy of rice plant to collect hiding spiders in rice leaves** (spiders may not be in their webs). Spider sampling was conducted for three days per rice field in each stage of rice growth. The captured *Tetragnatha* spiders were preserved in 75% alcohol. Adult spiders were identified to species level using the book Riceland Spiders of South and Southeast Asia (Barrion & Litsinger, 1995).

**Captured prey and prey availability.** — Captured prey were all arthropods found in *Tetragnatha* webs along a 50-m line transect. Searches lasted 60 minutes per rice field each night. All prey items (dead, alive, partially eaten, or even still in the possession of spider) as well as *Tetragnatha* spiders were collected using forceps, and preserved in 75% alcohol. Captured prey and *Tetragnatha* spiders were collected on three consecutive nights per rice growth stage per rice field. The time taken to remove
the spider and its prey from each web was not included in the 50 min of searching time.

of direct searching. Prey availability was estimated by sweep netting simultaneously
with *Tetragnatha* spider collection. The prey captured by spiders and the available prey
were assessed at the same time and in the same rice fields where the spiders were
collected. However, different sampling points were used for sampling *Tetragnatha*
spiders, captured prey and available prey. All preys were identified to family level using
the volumes Rice-Feeding Insects of Tropical Asia (Shepard, Banion, & Litsinger,
1995) and Arthropod Biodiversity, Taxonomy and Identification (International Rice
Research Institute [IRRI], 2010).

**Statistical analysis.** —To analyze the effect of the growth stages of the rice
(vegetative growth, reproductive, ripening and after-harvesting) on the total spider
abundance and the abundance of each, the study used a generalized linear model
(GLM) with a Poisson error distribution because the dependent variables are count data.
The fixed factor in the model was the rice stage, and the random factor was the identity
of the rice field. The model with lowest AIC value was selected as the best predictive
model. Function `lsmeans()` from the package `lsmeans` was used to perform pairwise
comparisons, and Tukey’s HSD adjustment was applied. All statistical analyses were
conducted with R-3.3.2 (R Development Core Team, 2016).

Prey selectivity of the spider webs was determined using Ivlev’s electivity index
(Ivlev, 1961) based on prey availability and captured prey compositions (Nentwig,
1985; Alderweireldt, 1994; Diehl, Mader, Wolters, & Birkhofer, 2013). These indices
were calculated only for dominant prey families that were present at all rice stages. The
Ivlev index (IE) was estimated using the following formula:

\[ IE = \frac{r - p}{r + p} \]
where \( r \) is the percentage contribution of individuals from a prey family to the captured prey composition and \( p \) is the percentage contribution of the same prey family to the available prey composition. The Ivlev index ranges from \(+1\) (prey family overrepresented in webs) to \(-1\) (prey family underrepresented in webs), where 0 indicates random feeding (i.e., prey family appears with the same percentage in captured prey and available prey).

**RESULTS**

A total of 192 spiders of *Tetragnatha* were collected in three semi-organic rice fields over four stages of rice plant growth. Among them, 83 adults and 27 juveniles were collected by visual searching, and 54 adults and 28 juveniles were collected by sweep netting. Only adult *Tetragnatha* spiders were identified to the species level. We found six species, including *Tetragnatha javana* (Thorell, 1890), *Tetragnatha mandibulata* (Walckenaer, 1841), *Tetragnatha maxillosa* (Thorell, 1895), *Tetragnatha nitens* (Audouin, 1826), *Tetragnatha vermiformis* (Emerton, 1884) and *Tetragnatha virescens* (Okuma, 1979). Two species, *T. javana* and *T. maxillosa* were the most abundant, representing 40.1% and 29.9% of the total adults, while *T. nitens*, *T. mandibulata*, *T. virescens* and *T. vermiformis* represented 11.6%, 9.5%, 8.0% and 1.4%, respectively.

**Effect of rice stage on *Tetragnatha* spiders.** — The growth stage of rice plants in the semi-organic rice fields significantly affected the abundance of *Tetragnatha* spiders, collected by visual searching (GLM, \( X^2 = 44.66, \text{df} = 3, p < 0.001 \)) as well as net sweeping (GLM, \( X^2 = 35.72, \text{df} = 3, p < 0.001 \)). The abundance of *Tetragnatha* spiders from both sampling techniques was significantly higher in the reproductive
stage of rice plant growth than in the other stages (p < 0.05) but was not significantly different between the vegetative stage, the ripening stage and the after-harvesting stage (p > 0.05) (Fig. 1).

The rice stage generally affected the number of species and also the abundance of each Tetragnatha species. Species richness and abundance varied at different stages of rice plant development. The highest number of Tetragnatha species (six species) were collected during the reproductive stage while the lowest number (two species) were found in the after-harvesting stage. In the vegetative growth stage, the abundance of Tetragnatha spiders did not differ between species. In the reproductive stage, T. javana and T. maxillosa were more abundant than other species. In the ripening stage, T. javana and T. maxillosa were the most abundant. T. javana was also a dominant group in the fields in the after-harvesting stage. The results showed that the abundance of T. javana and T. maxillosa fluctuated between stage, while the abundance of T. mandibulata, T. nitens, T. vermiformis and T. virescens were not significantly different between stages (Fig. 2).

Prey availability. — Estimated from the results of sweep netting, the numbers of insects rapidly increased from the vegetative growth stage to peak in the reproductive stage. After that, numbers gradually decreased in the ripening and after-harvesting stages. Dominant families of available prey varied between rice stages. In both the vegetative and reproductive stages, the most dominant family was Chironomidae, while Cicadellidae was the second most dominant. In the ripening stage, the number of chironomids decreased, while Cicadellidae increased and became dominant. In the after-harvesting stage, Chironomidae and Acrididae were the families most commonly found (Table 2).
Captured prey. —Among 928 prey items collected from Tetragnatha webs across all stages of rice plants, Chironomidae and Corixidae dominated. However, the dominant prey varied at different stages of rice growth. In the vegetative growth stage, the main prey families were Chironomidae and Corixidae. In the reproductive stage, a higher number of Corixidae, Chironomidae and Baetidae were collected. In the ripening stage, Delphacidae and Chironomidae were the main prey of Tetragnatha. There was no obvious dominant prey in the after-harvesting stage (Table 3).

From the proportions of captured prey and available prey estimated in each stage of rice growth, Corixidae was clearly overrepresented in Tetragnatha webs in the vegetative and reproductive stages (Ivlev index = 0.85 and 0.95, respectively). In the ripening stage, Cecidomyiidae, Delphacidae and Chironomidae were overrepresented (Ivlev index = 0.99, 0.97 and 0.81, respectively), as were Baetidae and Cecidomyiidae in the after-harvesting stage (Ivlev index = 1 and 0.83, respectively). In general, Acrididae, Cicadellidae and Pyralidae were underrepresented in spider webs in almost all stages of rice (Ivlev index < 0), even when they were more available as prey (Fig. 3).

DISCUSSION

Population dynamics of Tetragnatha spiders. —Our study showed that both abundance and species richness of Tetragnatha spiders was highest in the reproductive stage of rice plants, while they were lowest in the after-harvesting stage. That the highest spider abundance and species richness should occur in the reproductive stage of rice growth could result from the concurrence of certain conditions. The availability and diversity of prey peaked in this stage due to the wet habitat and the appearance of rice flowers. The flooded paddy provides a habitat for many species of aquatic insects such
as midge flies and water bugs (Zhi-yu, Hong, Feng-xiang, Qing, & Yang, 2011) and rice flowers can be used as a food source for a wide range of insects (Wilson, Ramakrishnan, Pavaraj, & Sevarkodyone, 2014). Therefore, many insects migrate into the rice field in the reproductive rice stage (Wilson et al., 2014). Previous studies reported that the density and growth rate of *Tetragantha* in rice fields had a significant positive correlation with the abundance of available dipterans (Takada, Takagi, Iwabuchi, Mineta, & Washitani, 2014; Tsutsui et al., 2016). According to our results, the number of *Tetragantha* spiders increased when the number of dipterous insects, especially insects in family Chironomidae and Tipulidae, increased in the early growing season. The rice reproductive stage also offers an optimum rice stem complexity to support spider webs, as in this stage the rice plants are neither too sparse (as in the vegetative stage) nor too dense (as in the ripening stage). Spiders can therefore effectively attach their webs and build them to an appropriate size and move easily across them to catch their prey (Rypstra, Carter, Balfour, & Marshall, 1999; Jayakumar & Sankari, 2010). According to many previous studies, the availability of attachment substrates for the webs of web-building spiders was determined by vegetation complexity because the increasing complexity of the habitat offers more shelter, food, and microhabitats for the spiders (McNett & Rypstra, 2000; Langellotto & Denno, 2004; Sudhikumar, Mathew, Sunish, & Sebastian, 2005; Öberg & Ekblom, 2006). On the other hand, both spider populations and species richness were low in the after-harvesting stage. At this stage, habitat in rice field was changed due to the harvesting process of the rice. Only rice straw and a small amount of vegetation remained in the rice fields, this may also cause physical factors in rice field changing. Thus the population of insect prey and microhabitats for supporting spider webs were reduced.
When the habitat is not suitable, spiders in rice fields normally move to other habitats which provide more suitable conditions such as levees or ditches (Yu et al., 2002; Bambaradeniya & Edirisinghe, 2008; Miyashita, Yamanaka, Tsutsui, 2014; Tsutsui et al., 2016). Therefore, our finding supports the hypothesis that the population dynamics of *Tetragnatha* spiders change with the progression of rice growth because of the temporal changes in the attachment substrate and the availability of insect prey.

**Prey compositions.** — In this study, the captured prey of *Tetragnatha* were different in different stages of rice growth. Chironomidae and Corixidae were the main prey family in the vegetative and reproductive growth stages. This may be because high water levels in rice fields support an abundance of these detritus and plankton-feeding insects. This is consistent with Ishijima et al. (2006) who found that dipterous insects, including chironomids (Chironomimdae), were an important alternative prey for spiders in the early cropping season. This finding corresponds to previous studies which suggested that non-pest insects such as dipterans may sustain spider populations in early growing stage of rice and strengthen the top-down effect of subsequent spider predation on insect pests when pest is blooming in the reproductive and the ripening stage (Settle et al., 1996; Bardwell & Averill, 1997; Ishijima et al., 2006; Motobayashi et al., 2006).

In the ripening stage, the main captured prey was Delphacidae (Hemiptera), common rice insect pests in southern Thailand (Rattanapun, 2012). An important finding of our study is that prey composition in *Tetragnatha* spider web and sweeping net was changed from detritivorus insects (Chironomimdae) to herbivorous insects (Delphacidae, Cicadellidae) along the rice growing season. This finding might be caused by flight activity of insect. In ripening stage, rice plant is too hard and opaque for feeding by sucking insect (Delphacidae, Cicadellidae), this may induce the insect to
move out for searching a new habitat which cause an increasing insect number in spider
web and net sweeping. (Pender, 1994; Hu et al., 2014)

The main captured prey of Tetragnatha spiders in this study were similar to those in previous studies of Rapp (1978) and Yoshida (1987), which found that Tetragnatha spiders mainly feed on midge flies (Chironomidae), mayflies (Baetidae), and other nematocerous dipterans of small body size. A number of previous studies demonstrated that small insects with many appendages and poor flying ability that are highly abundant at the same height as spider webs were easily caught in the webs. Examples of these insects are Chironomidae, Cecidomyidae, Tipulidae, some Hemiptera and small Ephemeroptera (Craig, 1986; Ludy, 2007; Tahir & Butt, 2009). The reason for the abundance of family Corixidae in spider webs is unclear. It is possible that they were trapped during their migratory flight from the rice fields to another place nearby when the water in the rice fields was drained out in the late reproductive stage (around 70 days after planting). Dispersal of water bugs is driven by a number of physical, environmental, ecological and physiological factors (Savage, 1989), including decreasing water level, habitat deterioration, an abundance of predators, and a high density of aquatic insects (Pajunen & Jansson, 1969; Boda & Csabai, 2009). Csabai, Kálmán, Szivák, and Boda (2012) revealed that the peak dispersal flight of Corixidae began at 1900 h, and reached its maximum at 2100 h, which corresponds to the highest feeding activity of Tetragnatha spiders (Kiritani et al., 1972). Our results are slightly in contrast to Butt and Tahir (2010), who studied the diet composition of T. javana in a rice ecosystem in Pakistan (observation time periods were 0630-0730 h and 1700-1800 h) and found that the main prey of T. javana were Lepidoptera, Diptera and Hemiptera. In our study, the incidence of Pyralidae
(Lepidoptera) was low in every stage of rice growth and Cicadellidae (Hemiptera) were
abundant in the reproductive and ripening stages, but were proportionally low in
*Tetragnatha* webs. This difference may be due to the difference in the observation times
and also prey flight activity (Perfect & Cook, 1982; Csabai et al., 2012) and available
prey composition in each location (McCoy, 1990). It would be interesting in the near
future to study the diet composition of *Tetragnatha* in rice fields over entire night
(1800-0600h) to obtain a more precise evaluation of the role of spiders in rice fields
because spiders are together with their web all night until they collect the web at the
dawn next day.

The calculated Ivlev’s electivity indices indicated that prey compositions in
*Tetragnatha* webs did not simply represent insect availability in the rice fields. Some
groups of insects were caught in webs disproportionately more than would be expected
from their estimated availability based on sweep netting. These insects included
Corixidae, Cecidomyidae, Delphacidae and Baetidae. The overrepresentation of
Corixidae which is aquatic insects in webs in the vegetative and reproductive growth
stages might be due to flight activity of this insect and observation time period by
sweeping method may not correspond, consequently such insects were proportionally
less in sweeping net (Savage, 1989; Csabai et al., 2012). On the other hand, some main
groups of available prey, including Acrididae (Orthoptera), Cicadellidae, Miridae
(Hemiptera), and Pyralidae (Lepidoptera), were represented less in *Tetragnatha* webs
than their estimated availability in the rice fields would indicate. The
underrepresentation of these groups in spider webs may be due to their ability to avoid
spider webs (Nentwig, 1980). Two reasons for this underrepresentation in spider webs
are considered here. First reason is because of flight behavior or their flight activity of
particular insects. They less flight for daily dispersal except for searching new habitat or
migration such as sap sucking insect (Cicadellidae) (Perfect & Cook, 1982; Hu et al.,
2014). The second reason for the low representation of these insects is avoiding or
escaping from spider webs thanks to morphological or physiological features such as
large body size, strong mandibles, good flying ability, or streamlined shape (Turnbull,
1973; Nentwig, 1987). For example, insects in the order Orthoptera have large bodies
and strong mandibles and can escape quickly when they are trapped in webs.

This study found that the main groups in the prey spectrum of Tetragnatha
spiders were detritus feeding, plankton feeding and sap- sucking insect (insect pests),
which were trapped in webs in a different proportion along rice growing season. It is
shown that Tetragnatha spiders feed on a diverse and a broad range of prey types which
may explain their potential survival and occurrence along a rice growing season. This
information is important for the understanding of this spider which might play an
important role in biological control in some stages of rice plant. Moreover, the effective
management of a natural control strategy across the rice growing season in a rice
ecosystem will demand an understanding of changes in the density and composition of
prey species of which Tetragnatha spiders are the main natural enemy.

CONCLUSIONS

This present study showed that the population of Tetragnatha spiders fluctuated
along the rice growing season in response to the changing availability of insect prey and
sites for web attachment. The prey composition of this spider also changed with the
growth and development of the rice crop. The findings also highlight the existence of
stable relationships between Tetragnatha spiders and their preys. The populations of
this spider in rice fields could be conserved and enhanced through the non-used of chemical agents. Biological control which maintains the high diversity and long-term sustainable of rice ecosystem should be given an importance in effective management strategies and deciding environmentally safe.

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LITERATURE CITED


Csabai, Z., Kálmán, Z., Szivák, I., & Boda, P. (2012). Diel flight behaviour and dispersal patterns of aquatic Coleoptera and Heteroptera species with special


Table 1: Description of rice growth in each stage of Pathumthani fragrant rice variety

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<th>Reproductive</th>
<th>Ripening</th>
<th>After-harvesting</th>
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<td>Days after planting</td>
<td>40-50</td>
<td>70-80</td>
<td>100-110</td>
<td>After 120</td>
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<tr>
<td>Height (cm)</td>
<td>40.50</td>
<td>90.100</td>
<td>80.90</td>
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<td>Vegetation complexity</td>
<td>3.0</td>
<td>5.5</td>
<td>7.9</td>
<td>(high)</td>
</tr>
<tr>
<td>(low)</td>
<td>(moderate)</td>
<td>(high)</td>
<td></td>
<td></td>
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<tr>
<td>Important characteristics</td>
<td>Active tillering</td>
<td>Culm elongation, emergence of the flag leaf, heading and flowering</td>
<td>Grain increases in size and weight, changes from green to gold color at maturity.</td>
<td>Straw</td>
</tr>
</tbody>
</table>

*Vegetation complexity defined as the mean number of rice plants in contact with the measuring pole.

Table 2. Prey availability estimated by sweep netting in each rice stage (A = Vegetative growth stage, B = Reproductive stage, C = Ripening stage, D = After-harvesting stage)

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<tr>
<th>Main family of available prey</th>
<th>Number of individual (Mean ± S.E.)</th>
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<tr>
<td>Diptera</td>
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<tr>
<td>Chironomidae</td>
<td>132.7±17.3</td>
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<td>Cecidomyiidae</td>
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<td>Tipulida</td>
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<td>Hemiptera</td>
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<td>Aranea</td>
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For Review Only

For Proof Read only
Table 3. Numbers of main insect prey captured by spider webs in each rice stage (A = Vegetative growth stage, B = Reproductive stage, C = Ripening stage, D = After-harvesting stage)

<table>
<thead>
<tr>
<th>Main family of captured prey</th>
<th>Number of individual (Mean ± S.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Diptera</td>
<td></td>
</tr>
<tr>
<td>Chironomidae</td>
<td>5.1±0.9</td>
</tr>
<tr>
<td>Cecidomyiidae</td>
<td>0.2±0.1</td>
</tr>
<tr>
<td>Tipulidae</td>
<td>-</td>
</tr>
<tr>
<td>Hemiptera</td>
<td></td>
</tr>
<tr>
<td>Corixidae</td>
<td>2.6±0.4</td>
</tr>
<tr>
<td>Delphacidae</td>
<td>-</td>
</tr>
<tr>
<td>Notonectidae</td>
<td>-</td>
</tr>
<tr>
<td>Odonata</td>
<td></td>
</tr>
<tr>
<td>Coenagrionidae</td>
<td>0.2±0.1</td>
</tr>
<tr>
<td>Ephemeroptera</td>
<td></td>
</tr>
<tr>
<td>Baetidae</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
<td>1.0±0.4</td>
</tr>
<tr>
<td>Unidentified</td>
<td>1.7±0.5</td>
</tr>
</tbody>
</table>
**Fig 1** Mean number of *Tetragnatha* spiders (± S.E.) at each stage of rice by visual searching method. The letters indicate the significant difference of mean numbers between rice stages (Tukey’s HSD test, P < 0.05).
Fig. 2 Mean number (± S.E.) of *Tetragnatha javana*, *T. mandibulata*, *T. maxillosa*, *T. nitens*, *T. vermiformis* and *T. virescens* in each stage of rice growth.
**Fig 3.** The Ivlev's electivity index of main prey families in each stage of rice plant development