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Research Article

Arthropod Diversity in the Tea Plantation within Several Years after Pruning in Pagilaran, Central Java

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ABSTRACT

The lush leaves of tea within several years after prune is expected to be followed by arthropod abundance and diversity. The study aimed to evaluate the arthropod abundance, diversity, evenness, and dominance, at the tea plantation within several years after the prune. The study was conducted at Pagilaran tea plantations, Central Java, during April to May 2018, at an altitude of 900 m asl. Arthropod samplings were done in four plots of tea plantation namely 1, 2, 3, and 4 years after pruning, hereafter they are called PY1, PY2, PY3, and PY4. The plot area was approximately 1 ha. The arthropod specimens were collected using sweep net and pitfall trap every day for 6 consecutive days. The arthropod identification and calculation were carried out in the Laboratory of Entomology, Faculty of Agriculture, Universitas Gadjah Mada. Analysis of variance was applied to determine the effect of PY on the arthropod abundance. The Shannon Wienner index, the Evenness index, and the Simpson index, were used to evaluate the arthropod diversity, evenness, and dominance, respectively. The results showed that the PY significantly affected the arthropod abundance. The arthropod number collected from PY1 (27 individuals/50 swings) was significantly lower as compared to the other PYs, while arthropod numbers amongst PY2, PY3, and PY4 (53, 93, and 67 individuals/50 swings, respectively) were relatively similar. Out of the total number of 1.432 arthropod specimens, it comprised of 10 orders at which Hemiptera was the highest order (48.04%), and 69 families at which Cicadellidae was the highest family (32.12%). Amongst specimens of Cicadellidae, there was *Empoasca* sp. which is an important tea pest. The Shannon Wienner index (H) of orders and families ranged from 1.24 to 2.69 indicates moderate arthropod diversity. The Evenness index (e') ranged from 0.57 to 0.91) indicates the arthropod evenly distributed. Meanwhile, the Simpson index (D) ranged 0.10–0.39 indicates that there was no dominance of the order or family.

Keywords: abundance, arthropods, diversity, Pagilaran, tea

INTRODUCTION

Tea (*Camelia sinensis*) grows in the tropical and subtropical regions between 200–2,000 m above sea level (asl), at 14–25°C, and requires rainfall at least 1,270 ml/year. Without pruning, tea shrub will become the tree, while cultivated tea plants will be pruned to maintain it growing short (Balitri, 2015). The *C. sinensis* grows well in several regions in Indonesia, including at Pagilaran plantation, Central Java. Tea plantations are a host for various members of Arthropod, both as a beneficial and pest (Ye *et al*., 2014). Some studies on various aspects of pest on tea plantation had been reported (Sumardiyono, 1996; Rahayu *et al*., 2000; Pachrudin *et al*., 2007; Wagiman & Triman, 2011; Indriati & Soesanthy, 2015; Fauziyah *et al*., 2018; Sari *et al*., 2019). Information about the arthropod diversity in the tea plantations especially at the Pagilaran plantation is still limited.

Biodiversity is related to number and organism diversity in a certain region and includes three components, i.e. species diversity, ecosystem, and genetic. Species diversity is related to the number of different species and the number of individuals of each species in a plantation. Species diversity is measured by species richness which is the number of different species that exist in an area. The more species found in an area means that the area is richer (Yadav & Mishra, 2013). Tea pruning is not only designed to maintain short shrub but also to increase shoot production.

Abundance and diversity of arthropod members considered increase along with the year after pruning (PY) due to the shrub forms a denser canopy. The arthropod presence is to understand because it is in relation to tea production. Globally 1,031 species of arthropod members associated with tea. Only 3% of arthropod in the world is being. All parts of the plant

(leaves, stems, roots, flowers, and seeds) are consumed by at least one pest species cause 11–15% of yield loss (Hazarika *et al*., 2009). From an anthropocentric point of view, the role of arthropod members can be divided into two, i.e. as natural enemies of insect pests (Das *et al*., 2010) and as insect pollinators (Bezbaruah, 1975 cit. Mitra *et al*., 2018).

MATERIALS AND METHODS

The study was conducted in April to May 2018, at Pagilaran tea plantations, at 900 m asl., and four years after pruning, i.e. PY1, PY2, PY3, and PY4 without considering variations of the clones. PY1 is the age of tea shrub after pruning in year 1, PY2 is the age of tea shrub after pruning in year 2, PY3 is the age of tea shrub after pruning in year 3, PY4 is the age of tea shrub after pruning in year 4. Each PY was approximately 1 ha as an observation plot. PY considered as treatments and the day of sampling on collecting arthropod as replications. A sweep net (35 cm in diameter) was used to collect arthropod from the tea canopy surface. The observation parameter was the abundance of arthropod members. The sample unit was a right and left swing of the sweep net, 10 times each. Collecting arthropod on each plot of the four PY was carried out every day within 6 consecutive days. Sampling in each plot of PY was 10 times swings of the sweep net to the right and left in five sub-plots in the range of 10 m in distance. Each time the sample was taken at a different tea plantation.

Arthropod specimens were put into chloroform and then packed in 10 ml vial bottles containing 70% alcohol. Specimens were identified and counted in the Laboratory of Entomology, Faculty of Agriculture, Universitas Gadjah Mada. Morphological identification of specimens was carried out to the order and family levels. Identification keys according to Chu (1949), Borror & White (1970), McAlpine *et al.* (1981,1983), Goulet & Huber (1993), Anderson (2000), Borror *et al.* (2005), Kury (2007), and Rocha & Carvalho (2009) were used to identify the specimens.

Data were analyzed using ANOVA ($\alpha = 0.05$) and then further analysis using DMRT ($\alpha = 0.05$) to determine the significant effect of the treatment (PY) to the arthropod abundance. The diversity, evenness, and dominance of the order and the family were analyzed with the following models:

Shannon-Wienner Index

Diversity of arthropods member measured by the Shannon-Wienner index (Odum, 1994).

$$H' = -\Sigma\{(Ni/N) \ln (Ni/N)\} \quad (1)$$

H' = order or family diversity index, Ni = number of individual of each order or family, N = the total number of order or family, and ln = natural logarithm.

Evenness Index

Evenness index values between order or family (*e'*) (Odum, 1994):

$$H'/\ln S = e' \quad (2)$$

e' = order or family evenness index, H' = Shannon index, S = number of order or family found, dan ln = natural logarithm. The higher the *e'* value means the order or family in the plantation are spreading.

Dominance Index

Dominance index was calculated by Simpson dominance index (Odum, 1994):

$$D = \Sigma (Ni/N)^2 \quad (3)$$

D = Simpson dominance index, Ni= number of individuals of each order or family, N = number of individuals of all order or family. Dominance index is the range between 0 to 1, the lesser the dominance index means there are no species dominating and vice versa (Odum, 1994).

RESULTS AND DISCUSSION

The Effect of Year After Pruning to the Arthropod Abundance

The result showed that PY had a significant effect on the abundance of arthropod. The abundance of arthropod at PY1 was the lowest compared to the denser tea canopy in PY2, PY3, and PY4 (Table 1). The abundance of arthropod between PY2, PY3, and PY4 was not significantly different ($\alpha = 0.05$).

The Variation of Order and Family of the Collected Arthropods

The total specimens of arthropods collected from shrubs at PY1 to PY4 for 6 days were 1,432 arthropods (Table 1), consisting of several orders and families (Tables 2 and 3). The most number of consecutive orders often found in the tea plantations was PY2, followed by PY1, PY3, and PY4 were 9, 8, 7 and 6 orders, respectively. The number of families from the most often found in the tea plantations was

Table 1. The arthropod abundance at fourth pruning year of tea plantation in Pagilaran, Central Java, 900 m asl.

PY	Arthropod abundance (individuals/50 swings) on the day of observation							
	1	2	3	4	5	6	Total	Mean ± SD
PY1	25	37	17	34	24	23	160	26.67± 7.45b
PY2	81	54	52	25	62	41	315	52.50± 18.94a
PY3	80	113	119	105	86	53	556	92.67± 24.65a
PY4	83	66	147	70	18	17	401	66.83± 48.10a
Total	269	270	335	234	190	134	1,432	

Remarks: Means ± SD followed by the same letter in each column were not significantly different, DMRT (α = 0.05).
SD = Standard Deviation, PY = Pruning Year

Table 2. The number of order and family of arthropods at fourth pruning year of tea plantation in Pagilaran, Central Java, 900 m asl.

Arthropod	Number of order or family collected within 6 days			
	PY1	PY2	PY3	PY4
Order	5–8	1–9	2–7	1–6
Family	6–17	1–32	2–17	1–22

Remarks: PY = Pruning Year

in PY2, followed by PY4, PY3, and PY1 (40, 37, 33 and 30 families, respectively). The total number of arthropod specimens consisted 10 orders, the Hemiptera was the highest order found in abundance viz. 48.04%, and 69 families at which Cicadellidae was the highest in abundance viz. 32.12% (Table 3).

Members of the Hemiptera especially the Cicadellidae are often found in tea plantations which one of them is the main pest of tea, i.e. *Empoasca vitis* Gothe. *E. vitis* is an important pest causes damage to tea plantations in China, India, Japan, Vietnam, Indonesia, and several other tea producing countries (Mu *et al*., 2012 *cit*. Indriati & Soesanthy, 2015). For only three *Empoasca* sp. per shoot can damage tea shoot from pale appearance turns into yellowish, and finally dry (Winasa, 1999 *cit*. Wagiman & Triman, 2011). A severe attack can decrease tea shoots production by 50% (Dharmadi,, 1999 *cit*. Wagiman & Triman, 2011). The lowest *Empoasca* population in the Experiment Plantation of PPTK Gambung Sand Sarongge in the area of productive tea plants of PY2 reached 12.5 arthropods/ shrub and the highest population reached 15.9 arthropods/shrub or more than the economic threshold in field trials (5 arthropods/shrub) (Sucherman *et al*., 2016).

In Pagilaran plantation, the families of arthropod in old age tea plantations (PY2, PY3, and PY4) were more varied than PY1. This condition was similar to Banerjee (1983) that the number of species of arthropod in old-age tea plants was more than those at a young age. The number of species from arthropod members increased in young tea plantations to 11-year old shrub, then remained high in plants aged 12–21 years, decreased sharply in plants aged 22–36 years, and continued to decline at the age of 36 years.

Canopy dense in PY1 was less than PY2, PY3, and PY4 that might affect the abundance of arthropod members. According to Silva *et al*. (2010), the abundance of arthropods in citrus orchards planted with the ground cover crop was higher than that without the ground cover crop. Bosco (2014) also reported that the abundance and species richness of arthropod members includes Araneae, Coleoptera, Diptera, Hemiptera, and Hymenoptera were higher in places with more ground cover crop. Planting ground cover crop close to the main plant is an effective method to increase the abundance of natural enemies such as spiders, ants, Hemipteran predators, and parasitoids, especially on annual plants. Paredes *et al*. (2013) stated that the abundance of Hemiptera predators was greater in vegetated soils compared to the land without vegetation.

Diversity of Arthropods in Tea Plantation

The arthropod diversity in the tea plantation at Pagilaran are presented in Table 4. The Shannon-Wienner Index (H') is an indicator of the diversity of arthropod in the tea plantation. The level of diversity according to Nisa *et al*. (2017) are low when H' < 1, moderate when H' = 1–3; high when H' > 3. The diversity index of arthropod orders and families at PY1, PY2, PY3, and PY4, ranged from 1.24 to 2.69, then according to Nisa *et al*., (2017) it is considered that the level of diversity of orders and

Table 3. The variation of orders and families of arthropods in the tea plantation at Pagilaran, Central Java, 900 m asl.

No.	Order (Σ individuals; %)	Total Families	Number of individuals per family (Σ individuals; %)
1	Araneae (127; 8.87)	6	Araneidae (73; 5.10), Lycosidae (1; 0.07), Salticidae (11; 0.77), Oxyopidae (35; 2.44), Theridiidae (1; 0.07), Thomisiidae (6; 0.42)
2	Blattodea (1; 0.07)	1	Blattelidae (1; 0.07)
3	Coleoptera (49; 3.42)	7	Carabidae (2; 0.14), Cerambycidae (2; 0.14), Chrysomelidae (19; 1.33), Coccinellidae (12; 0.84), Curculionidae (12; 0.84), Elateridae (1; 0.07), Tenebrionidae (1; 0.07)
4	Diptera (331; 23.11)	19	Agromyzidae (9; 0.63), Chloropidae (3; 0.21), Chironomidae (1; 0.07), Clussidae (2; 0.14), Diastatidae (3; 0.21), Dolichopodidae (23; 1.61) Empididae (11; 0.77), Lauxaniidae (192; 13.41), Muscidae (3; 0.21), Mycetophilidae (26; 1.82), Neriidae (1; 0.07), Phoridae (9; 0.63), Sciomyzidae (1; 0.07), Sepsidae (1; 0.07), Sphaeroceridae (3; 0.21), Stratiomyidae (1; 0.07), Tachinidae (7; 0.49), Tephritidae (26; 1.82%), Tipulidae (4; 0.28)
5	Hemiptera (688; 48.04)	9	Acanaloniidae (2; 0.14), Achilidae (6; 0.42), Aphididae (2; 0.14), Cercopidae (1; 0.07%), Cicadellidae (460; 32.12), Coreidae (17; 1.19), Dictyopharidae (1; 0.07), Flatidae (12; 0.84%), Miridae (187; 13.06)
6	Hymenoptera (145; 10.13)	14	Apidae (1; 0.07), Braconidae (46; 3.21), Ceraphoronidae (1; 0.07%), Chalcididae (2; 0.14), Euchartidae (1; 0.07), Eulophidae (6; 0.42), Eupelmidae (14; 0.98), Formicidae (50; 3.49), Ichneumonidae (10; 0.70), Mymaridae (6; 0.42), Platygasteridae (4; 0.28), Scoliidae (1; 0.07), Trichogrammatidae (1; 0.07), Vespidae (2; 0.14
7	Larva Lepidoptera (35; 2.44)	8	Gelechiidae (22; 1.54), Geometridae (1; 0.07), Lasiocampidae (1; 0.07), Noctuidae (2; 0.14), Pieridae (2; 0.14), Pyralidae (3; 0.21), Psychidae (2; 0.14), Saturniidae (2; 0.14)
8	Mantodea (1; 0.07)	1	Mantidae (1; 0.07)
9	Neuroptera (1; 0.07)	1	Hemerobiidae (1; 0.07)
10	Orthoptera (54; 3.77)	3	Gryllidae (17; 1.19), Pyrgomorphidae (3; 0.21), Tettigoniidae (34; 2.37)
Σ	10	69	1,432

Remarks: % of the total 1,432 individuals

Table 4. The diversity index (H'), evenness index (e'), and dominance index (D) of the order and family of arthropod at fourth pruning year of tea plantation in Pagilaran, Central Java, 900 m asl.

Index Value	Arthropods	Pruning Year			
		PY1	PY2	PY3	PY4
H'	Order	1.89	1.33	1.46	1.24
	Family	2.69	2.22	2.01	2.42
e'	Order	0.91	0.60	0.75	0.69
	Family	0.79	0.60	0.57	0.67
D	Order	0.16	0.39	0.29	0.37
	Family	0.10	0.29	0.23	0.21

families is moderate. Yadav & Mishra (2013) stated that rich biodiversity is comparable to plantation health. The diverse plantation is considered to have increased stability, increased productivity, and resistance to invasion and other disturbances.

Evenness of Arthropods in Tea Plantation

The result showed that the evenness value of arthropods based on the evenness index (*e'*) for orders and families in PY1, PY2, PY3, and PY4 was close to 1 (Table 4), which ranged from 0.60 to 0.79. The evenness index value approaching 1 means that the arthropod in Pagilaran tea plantations in the observation plot was evenly distributed (Amin *et al*., 2016).

Dominance of Arthropod in Tea Plantation

This study revealed that orders and families of arthropods in PY1, PY2, PY3, and PY4 according to Simpson dominance index (D) ranged from 0.16 to 0.29 (Table 4). It means that there are no order or family dominates another. Dominance value close to 1 indicates that in a plantation there are species that dominate another species, conversely if the dominance index value is 0 mean that in the

plantation there are no species that dominate another species (Riyanto, 2016). There was no dominant order and family in the four PYs as showed by Dominance Index (D). The dominance index in the plantation is closely related to diversity status. The high dominance index indicates the presence of one or several certain species that are very dominant. When this happens, then the level of diversity in the plantation is low. On the contrary, when the dominance index is low, then there are no species that overly dominant in the plantation, yet the level of biodiversity will be higher (Riyanto, 2016).

CONCLUSION

Arthropod abundance was significantly affected by the year after prune, with the highest mean of arthropod abundance was found in PY3 (93 arthropods/50 swings). Diversity of orders and families were categorized as moderate such as indicated by Shannon-Wienner index (H') ranged from 1.24–2.69. The arthropod was evenly distributed in the tea plantation such as indicated by the Evenness index (*e'*) ranged from 0.57–0.91. There were no dominant orders or families in the tea plantation such as indicated by Simpson dominance index (D) which ranged from 0.10–0.39.

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