Journal of Tropical Crop Science Vol. 1 No. 2, October 2014
www.j-tropical-crops.com

The Potential of Flowering Weeds as Refugia for Predatory Insects at Bantimurung-Bulusaraung National Park, South Sulawesi

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Abstract

A study on identification of flowering weeds as predatory insect alternative foods was conducted at Bantimurung-Bulusaraung National Park, South Sulawesi, Indonesia in February 2013. Among the plants that naturally grow in the national park area *Cassia siamea* and *Clerodendron paniculatum*, which were source of nectar for insects, particularly butterflies. Visits of predatory insect to flowering weeds and species of both insects and flowering weeds were recorded. The preferred flowering weeds visited by the predatory insects are *C. striata* (Papilionaceae), *A.conyzoides* (Asteraceae) and *L. camara* (Verbenaceae) followed by *S. nodiflora* (Asteraceae), *S. rhombifolia* (Malvaceae) and *L. crustacea* (Scrophulariaceae). A large number of adults and pupae of *Coccinella* sp. was found in the Bantimurung-Bulusaraung National Park.

Keywords : nectar, pollen, alternative host, weeds, Indonesia

Introduction

Modern agricultural system has reduced the population and activities of predatory insects. The development of strategies to conserve and maximise the abundance of insects is crucial to enhance biological control of agricultural crop pests. Flowering weeds in a naturally diverse habitat can potentially benefit the predatory insects by providing alternative source of pollens and nectar particularly during off-season planting (Hassan, 1998; Nentwig, 1998; Fox and Landis, 2002). Even during the growing seasons vegetable crops are normally harvested before they flower; those grown until flowering do not flower all year round so sources of food (nectar, pollen) for insects were not always available. Pollen and nectar from flowering weeds play an important role to increase longevity, fecundity, and survival for predatory insects (Jervis and Kidds, 1996). Flowering weeds also provide a suitable microclimate for the predatory insects (Landis *et. al.*, 2000).

The predatory insects can be seen either with the naked eye or magnifying glasses to feed on the nectar or pollens of Euphorbiae and Umbelliferae species. Buckwheat (*Fagopyrum esculentum*, Polygonaceae) nectar is normally abundant in the morning and attracted different species of nectar feeders (Lee and Heimpel, 2002). The larvae/nymph and adult stages of predatory insects especially holometabolous vary considerably in their nutritional requirement and food ecology (Wackers *et al.*, 2007). One of the predatory insects that commonly found in the crop production area is Coccinelids. *Coccinella* sp adults were first attracted to floral color and odor before they feed on the pollen. Pollen can improve the longevity and fecundity of the other predatory insect such as Mirids *Macrolophus pygmaeus* to control whiteflies (Vandekerkhove and de Clerqc, 2010).

Increased habitat diversity in crops can increase population densities of locally available predators to enhance biological control of pests. Conservation which involves protection and maintenance of natural enemy population has proved crucial for maintaining native natural enemies in ecosystems (Sharma et al, 2013). The use of persistent pesticide can kill insects particularly predatory insect that live around the crop production areas. Habitat management for enhancement of predatory insects is an important component to reduce pesticide application (Pickett and Bugg, 1998). Pesticide application methods can be modified, e.g. pesticides can only be applied when the pest population exceeds specified levels (Sharma et al, 2013).

Conservation of natural enemies can also be achieved by changing the active ingredient, rates, formulations, timing, and location of pesticide applications or by maintaining refuges (Hulls and Beers, 1985). Predatory insects such as Coccinellids are normally found to live on the cultivated crops and on the weeds that produces nectar and pollens. Reduced pesticide application could increase the roles of insect natural enemies to control crop pests (Nentwig, 1998).

Bantimurung- Bulusaurung National Park in South Sulawesi which spreads from Maros to Pangkep districts (4.9000° S, 119.7500° E) is found to be the

natural habitat for predatory insects from Coleopteran, Hemipteran, Hymenopteran and Dipteran orders (Aminah Ngatimin and Syatrawati, 2010; Aminah Ngatimin, Saranga and Junaedi, 2014). Flowering weeds can provide shelters or refugia to support the lives of predatory insects particularly during the extreme environmental condition as well as during non-growing seasons (Landis et al, 2000).

The objectives of research were to identify the species of predatory insect and the flowering weeds that serve as alternative source of foods for the predatory insects at Bantimurung-Bulusaraung National Park, Maros District, South Sulawesi, Indonesia.

Material and Methods

A survey was conducted in Bantimurung-Bulusaraung National Park, Maros District South Sulawesi between February to April 2013. The elevation of the park is about 500 m above the sea level with average precipitation of 1,500-2,100 mm per year, maximum and minimum air temperature ranging from 23-32°C, relative humidity ranging 65-88% and soil pH of 5.47.

The national park covers the area of 43,750 ha and contains large and steep karst area, a small pond and has more than 250 caves. The area of the National Park covered in the study was approximately 700 m^2. Teak (*Tectona grandis*), bitti (*Vitex cofassus*) and Johar (*Cassia siamea*) were planted on some area of the national park. Samples were taken systematically according to the methods developed by Landis et al (2000). The survey was conducted at ten sampling points, i.e. two points near the lake, two points on the grass fields, two points among teak, bitti and other forestry trees, two on the wild bushes, and the rest in the butterfly cultivation area.

Predatory Insects Collection

All predatory insects that use flowering weeds as food sources and refugia were recorded. Visual observation on the pattern of predatory insects' visit to flowering weeds was conducted every day from 0800-1300 hours in five consecutive days per month between February to April 2013.

Insects from the ten sampling points were identified on site using naked eye or magnifying glass. Small insects such as ants and Coccinellids were collected using tweezers and kept in glass bottles containing 90% alcohol. Pupae were collected along with the leaves or other plant parts and kept in petri dishes using filter paper as bases. All collected insects were brought to Bantimurung-Bulusaurung laboratory for further identification using insect identification reference by Kalshoven (1981), Kristensen et al. (1991) and Hill (1994). All pupae of Coccinelids were returned back to the natural habitat after identification.

The diversity of predatory insects was calculated using the Shannon Index Diversity (Langmack *et al.*, 2001).

Flowering Weeds Collection

The flowering weeds that were visited by predatory insects were collected and identified using Everaarst (1981), Soerjani et al. (1987) and van Steenis (1988) as references.

Results and Discussion

Flowering Weeds as Bio-resource for Predatory Insects

Plant species that naturally grow in the national park include *Caesalpinia pulcherrima* (Fabaceae), *Clerodendrum paniculatum* (Verbenaceae) and *Hibiscus rosa-chinensis* (Malvaceae). They grow mainly around the limestone hills of the park.

Our study demonstrated that the predatory insects visited flowering weeds, particularly those with broad leaves. Different insects has different preference to flowering weed species, whereas different weed species were visited by insects for different functions, i.e. as refugia, source of nectar and pollen. Plant canopies and root surfaces also function as refugia for pupae of Coccinellids. *A. conyzoides*, *C. striata* and *L. camara* were visited by the predatory insects for their nectar (Table 1).

Using magnifying glass we observed that Coccinellids visited Asteraceae, Papilionaceae and Verbenaceae flowers and fed on their nectar, clearly seen by the feeding movement of their mouth. Using binocular microscope at the laboratory, pollens were found on the mandibles of the Coccinellids. The elongated proboscis of the butterflies from Pieriade and Papilionidae was observed when they visited the weed flowers.

Predatory insects chose the *A. conyzoides*, *C. striata* and *L. camara* as their preferred nectar sources (Table 1) whereas *M. pudica* was the main source of pollen for pollinator insects (honey bees). These findings confirmed that the flowering weeds are natural resource of nectar and pollen for insects. Their function as non-prey food increased insect survival (Takasu and Lewis, 1995; Hassan 1998; Nentwig, 1998, Lewis et al., 1998). Previous studies conducted by Soejono (2006) and Bàrberi et al (2010) reported that *A. conyzoides* flowers were the source of nectar for *Coccinella arquata*, a potential predator that controls Mirid bugs (*Cytorhynus lividipennis)* on horticultural crops.

Similar finding on the functions of weeds as refugia, source of nectar and pollen for insects were reported by

Table 1. Flowering Weed Species Visited by Predatory Insects in Bantimurung-Bulusaraung National Park, South Sulawesi

Plant Family	Species	Function		
		Nectar	Pollen	Refugia
Asteraceae	*Ageratum conyzoides* L.	√	-	-
	Synedrella nodiflora (L.) Gaertn	-	-	√
Capparidaceae	*Cleome rutidosperma* DC	-	-	-
Malvaceae	*Sida rhombifolia* L.	-	-	√
Mimosaceae	*Mimosa pudica* L.	-	√	-
Papilionaceae	*Crotalaria striata* DC	√	-	√
Scrophulariaceae	*Lindernia crustacea* (L.) F.v.M	-	-	√
Verbenaceae	*Lantana camara* L.	√	-	-

Nentwig (1998). We observed the movement of the insect's mouthparts while feeding on the flowers of Asteraceae, Papilionaceae and Verbenaceae species. Nentwig (1998) reported that predatory insects fed on both nectar and pollens from Asteraceae, Papilionaceae and Verbenaceae flowers, and pollens from Mimosaceae flowers.

Nectar of the flowering weeds vary in their carbohydrate composition.The viscosity and concentration of sugar solution affect the ease of the predatory insects to feed them (Karise et. al., 2006). Sugar provides energy and extends the life span of *Microplitis croceipes* (Takasu and Lewis, 1995). Hover-flies Syrphidae have a strong respond to sucrose and glucose over other insects and concentration of sugar affect the response rate of predatory insects (Lundgren, 2009). The nectar concentration vary with season and plant health status (Lundgren, 2009). Nectar concentration is usually higher during the dry season (Lundgren, 2009). Nectar is not only source of sugar but also nitrogenous substances that improve longevity, fecundity and foraging of predatory insects (Wackers and Fadamiro, 2005; Jervis and Kidds, 1996).

The Weeds Performance and Insect Visitors

Our study revealed that the flowering weeds were not only visited by the predatory insects but also by insect pollinators such as honey bees and butterflies. Our survey found predatory insects from Coccinellidae, Syrphidae and Formicidae family. Adults of *Coccinella* sp. were mostly found on *C. striata* (0.122), *L. camara* (0.048) and *A. conyzoides* (0.028, Table 2).

Studies by Nentwig (1998) and Peggie and Amir (2009) reported that *L. camara* attracted honey bees and butterflies *P. demolion* and *C. scylla*. Floral characteristic and nectar abundance within the flowers are the main reason for insect visiting a flower. Floral and extra floral nectar are important food sources for many Coccinellids. *Stethorus puctillum*, which normally die within 4-5 days on water alone, can survive for 43.2 days on a diet from borage flowers *Borago officinalis* (Nentwig, 1998). Adults of *Coccinella* sp.was found to be the dominant insect in *C. striata* (0.122), followed by *L. camara* (0.048) and *A. conyzoides* (0.028, Table 2).

We found 0.184 individual pupae on the *C. striata* stems and barks (Table 2). *C. striata* has a yellow long corolla and aphids colony was found living on the floral buds. Flower anatomy, colour and odor (Fox and Landis, 2002), the presence of preys and honeydew (Bàrberi et al., 2010) are amongst the factors that attract predatory insects. Honeydew is an important indicator of aphid presence on the plants. Honeydew is nutritious and can serve as an alternative food for the predatory insect. In hover-fly (Syrphidae) for example, predatory insect with short proboscis were unable to feed on the nectar of flowers with long corolla (Jervis and Kidd, 1996; Wackers et al., 2007), and Coccinellids prefer a flat flower base (Nentwig, 1998). Floral morphology and flower base size also affects insect visits (Lundgren, 2009). Long corolla tends to reduce nectar evaporation, making it more attractive to insect visitors especially predatory insects (Lundgren, 2009).

We observed aphid colony on *C. striata* whereas many Coccinellids pupae were found on *L. camara*, a flowering weed that is mostly found growing nearby or around *C. striata. Coccinella* sp. pupae were found to live on stem and near the roots, and they fed on aphids. A study by MacLeod *et al.* (2004) reported that the densities of the predators Carabids and Staphylinids (*Agrostis stolonifera*, *Dactylis glomerata*, *Holcus lanatus* and *Lolium perenne)* on a grassy bank habitat during winter (i.e. extreme environment) were greater in the bank than in the boundary of the field in which the bank was situated. The bank was protected them from the rain and floods. Other insect such as *Dolichoderus* sp chose the *L. crustaceae* as their refuges near their nets (MacLeod et al., 2004). The weeds species visited

Table 2. Flowering Weeds Species, Diameter of Flower Base and Insect Visitors

Flowering weeds		Insects Visitor				
Species	Flower Base Diameter (cm)	Family	Species	Parts of Plants Visited	Shannon Index Diversity	
					Pupae	Adult
A. conyzoides	1.5 – 2	Coccinellidae	*Coccinella* sp.	flower	-	0.028
S. nodiflora	0.5	Formicidae	*Dolichoderus* sp.	stem	-	0.028
C. rutidosperma	8 – 10	Pieridae	*Catopsilia scylla*	flower	-	0.028*
S. rhombifolia	0.5	Formicidae	*Dolichoderus* sp.	stem and root on the soil surface	-	0.038
M. pudica	1	Apidae	*Apis* sp.	flower	-	0.048*
C. striata	1.5	Coccinellidae	*Coccinella* sp.	flower	0.184	0.122
		Syrphidae	*Epysyrphus sp.*	flower	-	0.016
		Formicidae	*Dolichoderus* sp.	stem	-	0.150
		Pieridae	*C. scylla*	flower	-	0.038*
L. crustacea	0.2	Formicidae	*Dolichoderus* sp.	stem and root on the soil surface	-	0.122
L. camara	1.5	Syrphidae	*Epysyrphus* sp.	flower	-	0.016
		Coccinellidae	*Coccinella* sp.	flower	-	0.048
		Apidae	*Apis* sp.	flower	-	0.028*
		Pieridae	*C. scylla*	flower	-	0.028*
		Papilionidae	*Papilio demolion*	flower	-	0.028*

*Pollinator insects (Peggie and Amir, 2006).

by predatory insects depend on the nectar availability and the vicinity of refugia (Schellhorn and Silberbauer, 2002).

Conclusion

C. striata (Papilionaceae), *A.conyzoides* (Asteraceae) and *L. camara* (Verbenaceae) flowers were preferred by the predatory insects, followed by *S. nodiflora* (Asteraceae), *S. rhombifolia* (Malvaceae) and *L. crustacea* (Scrophulariaceae). *Coccinella* sp. had a high number of adult and pupae on the flowering weeds in Bantimurung-Bulusaraung National Park. This study demonstrated that flowering weeds could be used as one of the management tools for maintaining predatory insect population.

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