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Full Length Article

Preference of Ant (*Solenopsis* sp.; Hymenoptera: Formicidae) for Salted Fish and Dried Shrimps Based Artificial Foods

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Abstract

Solenopsis sp. is an aggressive predator that manages its prey. This ant species is very active and has organized nests in rice field bunds. In the field, *Solenopsis* sp. can be introduced early to control crop pests. Artificial feeding is an appropriate alternative to present *Solenopsis* sp. as a potential predator. This study aimed to determine the preference of *Solenopsis* sp. (Hymenoptera: Formicidae) for artificial food and the population of ants collected. Observations were made on food consumption and ant populations around the preferred food. The results showed that the time taken by *Solenopsis* sp. to get to salted fish + *Ageratum conyzoides* (SF2) was significantly faster than dried shrimp + tea grounds (DS1) and dried shrimp + *A. conyzoides* (DS2). These treatments were not significantly different from salted fish (SF), SF1 and DS. However, the most preferred food by *Solenopsis* sp. was dried shrimp (DS), with an average consumption of 1.46 g. Similarly, the highest ant population was found in the DS wich simultaneously attracted the highest *Solenopsis* sp. population at the 80th min with an average population of 148, 100th min with 147, 140th min with 63 and 180th min with 43. The results showed that artificial feed with dried shrimp as the main ingredient was able to attract the population of *Solenopsis* sp. © 2023 Friends Science Publishers

Keywords: Ant nest; Artificial diet; Rice field embankment; *Solenopsis* sp

Introduction

Rice (*Oryza sativa*) is the main staple food that plays important roles in Indonesian community. The crop has high nutrient contents, such as carbohydrate, vitamins, protein, fat, and fibre (Lloyd *et al.* 2000; Chaudhari *et al.* 2018). Besides that, rice is an economically important commodity because 60% of all farmers in the country are dependent upon rice for their livelihood (Hermawan 2016). Rice demands keep increasing from time to time because of the increasing thus, rice production must be continuously increased to meet the demands population (Heriqbaldi *et al.* 2015).

Efforts to increase rice productivity are always faced with numerous problems of plant disrupting organisms, especially pests. Pest attacks the rice plant, reduce the quality and quantity of crop yield. Some important rice pests in South Sulawesi Province are white rice stem borer (*Scirpophaga innotata* Walker) (Lepidoptera: Pyralidae), the brown rice planthoppers (*Nilaparvata lugens* Stahl) (Hemiptera: Delphacidae), the green rice leafhopper (*Nephotettix virescens Dist.) (Hemiptera: Cicadellidae),* and *Paraeucosmetus pallicornis* Dallas (Hemiptera: Lygaeidae) (Pathak 1977; Abdullah *et al.* 2017; Rath *et al.* 2020). The rice pests are mainly controlled by using insecticides and most farmers apply the chemicals based on schedule. This practice could cause detrimental impacts on workers, consumers, and the environment. Biological control is a promising alternative measure of pest control. This method is effective, safe, and efficient in the long run (Bale *et al.* 2008; Jaiswal *et al.* 2022).

Ants are known as one of the main predators that protect plants from pests (Philpott and Armbrecth 2006). Ants as superior predators have several advantages, including they have certain occupancy and always return to the nest, and their presence is easy to monitor and manage (Kalshoven 1981; Folgarait 1998). They have narrow tolerance to environmental changes and dominance of the biomass and function as important properties in the ecosystem (Andersen 1997; Agosti *et al.* 2000). *Solenopsis* sp. is one of the formicid predators living in colonies (Wetterer *et al.* 2006; Haneda and Yuniar 2015). The

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species is active, strong, and the most aggressive ant in searching for prey. These characters are reflected by their speed in finding their prey. *Solenopsis* sp. has been reported praying on larger insects (Abdullah *et al.* 2020b). *Solenopsis* sp. populations and nests are often found on rice field dikes (Heinze *et al.* 2001; Widyanti 2013), which are relatively less disturbed by farmers cultivation activities. Thus, the ant can manage to arrive and build its colonies early in the season by providing them stimuli in the form of artificial foods.

Artificial feed is defined as a mixture of raw materials from various sources specially formulated according to the required components. It may consist of plant extracts, ground plant materials, semi-purified proteins, lipids, polysaccharides, water, and other nutrients (Vanderzant 1969; Afrianto *et al.* 2005). Nutrition is the most fundamental issue in the development of artificial feed (Morales-Ramos *et al.* 2014). Like all living things, ants face fundamental nutritional problems. They need to find the right amount and balance of nutrients for their growth, maintenance, and reproduction (Simpson and Raubenheimer 2012). Adult ants such as foraging ants require primarily carbohydrates as a source of energy (Wilson and Eisner 1957; Markin 1970), while larval and adult ants rely heavily on protein for growth and egg laying (Markin 1970; Howard and Tschinkel 1981; Sorensen *et al.* 1981; Cassill and Tschinkel 1999; Hölldobler and Wilson 2009).

The classification and composition of artificial diets have been widely reported and developed with varying degrees of success. Ant diets are varied and can be divided into two main groups: sugars (carbohydrates) and proteins found in red and white meat, shrimp, chicken intestines, rat carcasses, and insects (Skotnicka *et al.* 2021). Several studies have investigated the ability of ant-preferred foods, mainly fish and shrimp, to increase the abundance of ants, *Oecophylla smaragdina* on cocoa plants (Indrianasari *et al.* 2020), and *Solenopsis geminata* on rice plants (Abdullah *et al.* 2020a). Other food, as described by Nugroho (1994), is a sugar solution that can be used directly as an energy source for further activities. Similarly, the predatory ant *Solenopsis invicta* prefers foods with a higher protein content (Cook *et al.* 2010). Based on this, artificial feed made from salted fish and shrimp is an appropriate choice and has the potential to be used as a staple food for *Solenopsis* sp. in the field.

The aim of this study was to determine the time it takes for *Solenopsis sp*. to find food for the first time, the level of food consumption, and the preferred food that accumulates in an ant population. Based on the above considerations, the food preference and development of *Solenopsis* sp. as an important predator in rice fields can be controlled with artificial feed made from dried fish and shrimp. This is excellent for maintaining natural enemies in their habitat, identifying suitable nest sites, encouraging ants to nest prior to or early in planting, and creating high ant populations.

Materials and Methods

Experimental details and treatments

Research on preference of *Solenopsis* sp. (Hymenoptera: Formicidae) for artificial diet was conducted during dry season (August–November 2020) at Tapieng, Boribellaya Village, Turikale District, Maros Regency, South Sulawesi, Indonesia. This research was conducted in the form of experiment with six treatments and five replications. The treatments were arranged in a Randomized Group Design. The treatments were: artificial diet based salted fish (SF), artificial diet made by salted fish+tea dregs (SF1), artificial diet based salted fish + *Ageratum conyzoides* (white weed) (SF2), artificial diet based dried shrimp (DS), artificial diet based dried shrimp+tea dregs (DS1), artificial diet based dried shrimp + *A. conyzoides* (DS2). Salted fish and waste dried shrimp were used for non-edible consumption.

The *Solenopsis* sp. artificial diet used in the research was made from the remains (waste) of Petek salted fish (*Leiognathus splendens*) and Ebi-dried shrimp (*Acetes* sp.). Tea dregs as household waste and *A.conyzoides* (white weed) dried extract was added to extend the shelf life. In addition, tea dregs and *A. conyzoides* function as antimicrobials for artificial diet.

Preparation of diet for *Solenopsis* sp.

The process of making *Solenopsis* sp. food follows the method of Abdullah *et al*. (2021), which was modified. A total of 200 g of petek salted fish (*L. splendens*) waste was mixed with 50 g of flour and 50 g of sugar, then pulverised with a blender. The same was done with 200 g of ebi-dried shrimp (*Acetes* sp). The ingredients were divided into three treatments: (1) without preservatives (2) with 10 g of dried tea dregs and (3) with 10 g of solid extract of *A. conyzoides*. All ingredients were mixed well with 75 mL of water and mashed using a mixer until they became dough. The dough was formed into flat rounds (diameter = 4 cm; thickness = 0.5 cm). The dough was placed in an oven at 150°C for 20 min.

Artificial diet application and observation

Each of the artificial diet treatments was weighed at 10 g and placed on the circular paper (15 cm diameter). Six treatments were randomly placed on the circular paper at a distance of 35 cm from the natural nest of *Solenopsis* sp. The spread of each treatment was about 10 cm. The observations began in the morning, at 7:00–10:00 am when the ant was active outside the nest. The observation parameters included: (a) time taken by *Solenopsis* sp. to find the first food (minutes), (b) food consumption of *Solenopsis* sp. based on weighing of an artificial diet before and after feeding (g), and (c) population of *Solenopsis* sp. collected based on food preference at an interval of 20 min (individual) with a total of 45 observations. Food consumption or palatability was calculated with the following formula:

Palatability = amount of diet given – remaining feed consumed (Pereira *et al.* 2007).

Statistical analysis

Data were transformed using log (x + 1) before being subjected to ANOVA. If significant differences among the treatments were detected, then the means were separated using Tukey's test ($P = 0.05$).

Results

Time for *Solenopsis* sp. to find the food

Solenopsis sp. as one of the ant genera has the ability to find, store, and distribute food effectively to all members of the colony. Based on the observation data, the difference in time taken by *Solenopsis* sp. to find food for the first time is shown in Fig. 1. The time taken by *Solenopsis* sp. to find food in the first time observed in SF2 with an average 62 sec, followed by SF1 about 67 sec, DS about 75 sec, and the last SF 80 sec. The treatments of DS1 and DS2 need more time for *Solenopsis* sp. to find it (131 and 110 sec, respectively).

Feed consumption preference by *Solenopsis* sp.

The artificial diet preference is the way researchers know about *Solenopsis* sp. consumption of the preferred food. Based on the observed data, the weight of food consumed by *Solenopsis* sp. in each treatment showed variation. Fig. 2 shows weight of food consumption in SF about 1.38 g, SF1 1.1 g, SF2 1.36 g, DS 1.46 g, DS1 1.24 g and DS2 1.02 g, respectively.

***Solenopsis* sp. population collected from food preferences**

Based on the observation of total population of *Solenopsis* sp., the largest population of ant was found in DS. The treatment simultaneously attracted a higher population of *Solenopsis* sp. at 80 min with an average population of 148 individuals, 100 min with 147 individuals, 140 min with 63 individuals, and 180 min with 43 individuals (Table 1).

Discussion

There was a general trend about the time needed for *Solenopsis* sp. to find its first food: SF2 was significantly faster than DS1 and DS2. However, the treatment was not significantly different from SF, SF1 and DS (dried shrimp). Foraging activity is arranged by three main factors: internal needs, food sources, and the physical environment. Internal needs are influenced by hunger factors (Howard and Tschinkel 1980), while the physical environment is influenced by changes in humidity, temperature, and day length. Ambient temperature is a physical factor that directly affects foraging activity (Porter and Tschinkel 1987; Lei *et al.* 2021). Ant detects food sources by sensing odour particles in the air using the sensilla on their antennae (Gronenberg 2008). The sensilla on ant antennae contain chemoreceptors, olfactory neurons that respond to a specific set of scents, high rotermoreceptors and mechanoreceptors (Altner and Prillinger 1980; Keil and Steiner 1990; Steinbrecht 1997; Ghaninia *et al.* 2018). The specific chemical compound contained in each treatment is the main reason why *Solenopsis* sp. quickly detects the presence of food.

The most preferred food of *Solenopsis* sp. was DS, with an average consumption of 1.46 g. The DS is a treatment with only basic ingredients made from dried shrimp, without preservatives. The dried shrimp has a high protein content of around 62 g per 100 g of material (Persagi 2017). It is suspected that DS is more attractive because of its high protein intake and is needed by *Solenopsis* sp. as an energy source. Abdullah *et al.* (2020a) suggested that *Solenopsis geminata* preferred DS over dried fish and chicken intestines. DS content has a strong taste and more protein than other food treatment. Ant diets are varied and can be classified into two main groups content: sugar and protein, where protein found in the red and white meat, shrimp, and chicken intestines (Gassa *et al.* 2015; Ratri *et al.* 2017).

The populace of *Solenopsis* sp. collected in the preferred DS food treatment can be influenced by several factors, including food availability and environmental suitability, and ant behaviour such as feeding, movement, and communication (Robertson 2007). Feeding behaviour of *Solenopsis* sp. is seen through stalking, approaching, and selecting food to be consumed (Keller and Gordon 2009; Ratnasari 2017; Risdayani *et al*. 2022). In the process of searching for food starting stalking behaviour, followed by approaching and communication (Hasan *et al.* 2021). Ant colony members mainly use chemicals to communicate by sending alerting pheromones to their group, resulting in a rapid exchange of information. When a foraging ant finds a food source, it will return the nest by making a shorter path. The ant leaves a pheromone trail behind, and the other ant in the group following to the food source and carry together into the nest (Li *et al.* 2014; Hölldobler and Wilson 2009). Furthermore Abdullah *et al.* (2020b) stated the speed of ant species to find food or prey is influenced by population size, where more population find the food source quickly.

Finding time and a high population of ants in an artificial diet is therefore highly useful information in the management of *Solenopsis* sp. as a possible predator in the rice field. The presence of *Solenopsis* sp. will continue to be crucial in pest insect population management in the future. Aside from preparing an artificial diet in the loss of crop on the field, the presence of *Solenopsis* sp. in rice paddies can spread to afflicted crops more easily using artificial bridges or ropes.

Table 1: Population abundance of *Solenopsis* sp. against food preferences

Artificial feed treatment	Mean *Solenopsis* sp. ant population (tails) (20 minutes Interval)									
	20	40	60	80	100	120	140	160	180	Overall mean
SF (Salted fish)	36.4±6.1b	53.6±8.8b	50.6±24.1b	44.4±14.3b	43.4±14.3b	32±12.1b	27.6±4.4b	37.6±10.6b	10.2±0.8c	37.3
SF1 (Salted fish + Tea dregs)	63±12.5ab	89.8±4.6b	79.4±15.6b	53±15.2b	34.4±13.8b	45±18.5b	41.2±7b	69.8±5.2a	6.2±2.9c	53.5
SF2 (Salted fish + *A. conyzoides*)	25.6±3.5b	80±6.6b	106.4±9.7ab	120.6±8.3a	100±13.2ab	113.4±8.3a	37.2±8.5b	49.8±7ab	26±3.6b	73.2
DS (Dried shrimp)	47.8±9.4ab	107±17.2ab	112.2±8.8ab	148±16.9a	147.6±20.6a	79±12ab	63.4±3.4a	64±13.5a	43.4±2.4a	90.3
DS1 (Dried shrimp + Tea dregs)	56±9.7ab	99±7.5ab	122.2±10ab	119±23.1a	137.6±12.7a	108.4±9a	45±7.9ab	33.4±6.8b	9.2±5.3c	81.1
DS2 (Dried shrimp + *A. conyzoides*)	66.2±9a	120.2±7a	143.4±16.3a	123±9.5a	65±18.4b	43.4±9.2b	30.2±9.4b	29.8±4.4b	10.8±2.2c	70.2

Mean ± standard deviation Values with same letter differ non-significantly ($P > 0.05$, HSD test)

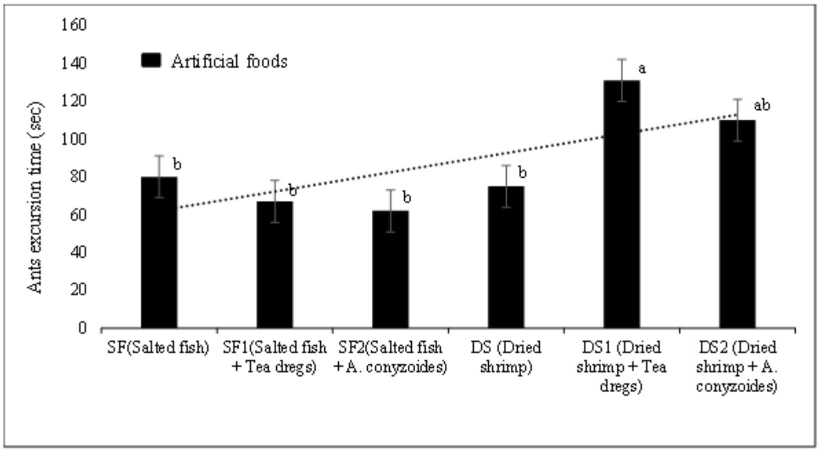

Fig. 1: Time of first *Solenopsis* sp. ants visit to artificial food treatment

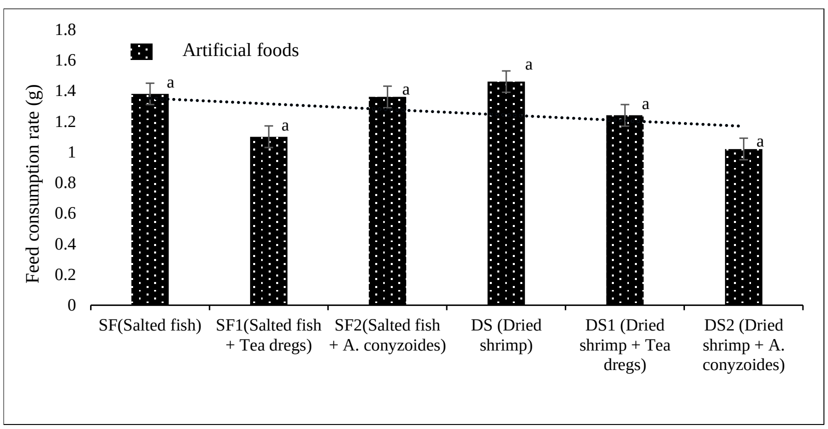

Fig. 2: Feed consumption of *Solenopsis* sp. ants of artificial food

Conclusion

Although the time difference between salted fish and dried shrimp feeding treatments on *Solenopsis* sp. in foraging, the dried shrimp-based feed attracted a larger ant population, which is directly related to the resulting feed consumption. As demonstrated in this study, further research is needed to determine the feeding mechanism of dried shrimp on the developing population.

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Author Contributions

All authors contributed equally to this research and preparation of the paper.

Conflicts of Interest

All authors declare no conflict of interest.

Data Availability

Data presented in this study will be available on a fair request to the corresponding author.

Ethics Approval

Not applicable to this paper

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